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Puccinellia distans (Jacq.) Parl. in Ojców National Park – a new element of the flora and an indication of anthropogenic changes

Abstract

*Puccinellia distans (*Jacq.) Parl. is a conditioned obligate halophyte that frequently inhabits anthropogenic roadside habitats. The aim of this study was to determine the distribution of the species within Ojców National Park (ONP) and to characterise the habitat conditions of the occupied sites. The study was conducted in June and July 2026 along the main roads in the Prądnik Valley. At six sites, phytosociological relevés were conducted along transects comprising three roadside zones differing in their distance from the road. At selected sites, soil chemical properties were also determined.

P. distans occurred primarily in the zones located closest to the road, whereas it was not recorded in the most distant zone (C). Floristic richness of the vegetation plots increased with distance from the road. The zones occupied by the species were generally characterised by higher salinity and chloride content. The results indicate the importance of anthropogenic salinisation and habitat disturbance for the occurrence of *P. distans*, as well as the role of road infrastructure in shaping the contemporary distribution of the species within ONP.

Keywords: anthropogenic habitats, halophytes, new locality, Poaceae, saline habitats, vascular flora
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Introduction

Studies of the flora of the area currently comprising Ojców National Park (southern Poland) have been conducted continuously since the 19th century. As a result of numerous floristic studies, nearly 1,000 species of vascular plants have been recorded to date, making Ojców National Park (ONP) one of the floristically richest protected areas in Poland (Michalik, 1978;

Michalik, 2008). Despite the long history of research, the Park's flora is still being supplemented with new taxa, both native species and those associated with human activity (Wiśniowski, 1992a,b; Mirek, 1994–1995; Michalik, Bąba, 1999; Szeląg, 2000, 2001, 2021, 2025; Sołtys, 2005a,b; Barabasz-Krasny et al., 2004; Sołtys-Lelek, Głowacki, 2024).

In 2009, during fieldwork conducted in the Prądnik Valley, clumps of reflexed saltmarsh grass, *Puccinellia distans* (Jacq.) Parl. (Poaceae (R. Br.) Barnh., Gramineae Juss.), were recorded growing along the roadside opposite the Wdowie Rocks in Młynnik. The plant material collected at that time was deposited in the ONP herbarium. *Puccinellia distans* is a tufted grass usually reaching 10–60 cm in height. It is characterised by a loose, spreading panicle, whose lower branches are distinctly spreading or, after flowering, bent downwards. Its leaves are flat or slightly rolled, 1.5–4 mm wide, and the spikelets usually contain 3–9 flowers. Diagnostic features of the species also include a short, membranous ligule and rough panicle branches (Rutkowski, 2011).

P. distans is a conditioned obligate halophyte associated primarily with habitats characterised by elevated salinity. Under natural conditions, it occurs in inland and coastal salt marshes; however, it now frequently inhabits anthropogenic habitats, particularly roadsides exposed to winter de-icing, roadside ditches, railway embankments, and other sites characterised by elevated substrate salinity. Its tolerance to salinity and habitat disturbance facilitates its spread and colonisation of new sites, particularly in landscapes transformed by human activity (Mirek, Trzcińska-Tacik, 1981; Święs, 1992, 1998, 2000; Wróbel et al., 2006; Šerá, 2008; Dítě, Dítětová, 2016; Fekete et al., 2022).

The natural range of *P. distans* encompasses a substantial part of Europe, Asia, and northern Africa. Outside its native range, the species has been introduced, among other regions, to North America, where it is currently established (*POWO*, 2026). In Poland, *P. distans* was historically associated primarily with inland and coastal salt marshes and was known from a relatively small number of localities (Jackowiak, 1984–1985). At present, localities of the species have been reported from many regions of the country, and in recent decades an increase has been observed in the number of sites associated with anthropogenic habitats, particularly along transportation routes (Święs, 1992, 1998, 2000; Zając, Zając, 2001; Wróbel et al., 2006; *Mapa występowania taksonu/Distribution map of the taxon – Puccinellia distans (...)* atlas-roslin.pl, 2026).

P. distans has not previously been reported from the ONP area (ATPOL grid square DF48). The nearest locality reported in the available literature is located in grid square DF4711, in Sieniczno (Urbisz, 2004). The record of *P. distans* within ONP therefore represents a new

addition to our knowledge of the Park's flora and, at the same time, forms part of the changes in the distribution of species associated with anthropogenic habitats observed over recent decades. The aim of this study is to document the occurrence of *P. distans* within Ojców National Park and to characterise its localities and occupied habitats in the context of anthropogenic transformations of the vegetation cover.

Methodology

Field studies were conducted from June to July 2026 along the main roads of the Prądnik Valley within the boundaries of Ojców National Park (ONP), on the Sułoszowa–Skała section (provincial road No. 773), the Grodzisko–Ojców–Złota Góra section (county road No. 2134K), the Ojców–Prądnik Korzkiewski section (municipal road), and along the section of national road No. 94 adjacent to the Park boundary, in the vicinity of the hamlet of Lepianka Czajowska. The distribution of *Puccinellia distans* clumps was surveyed along the roads (Fig. 1, 2 – Appendix 1).

At six localities situated along the provincial road (Nos. 1–6 in Fig. 1 – Appendix 1), three transects were established at each site, running parallel to the road and to one another (Fig. 3). Each transect was 6.0 m long and comprised three roadside zones differing in their distance from the edge of the road.

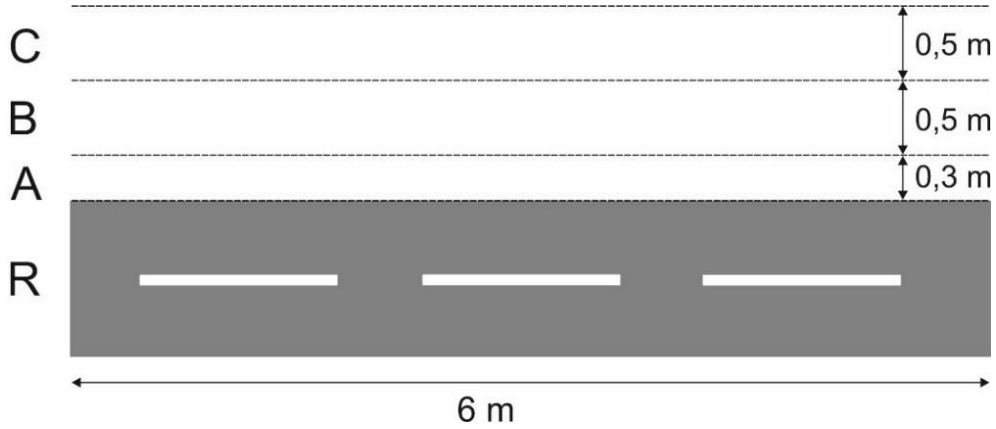


Fig. 3. Location of the study transects within the study site

Roadside zones: A – road shoulder edge directly adjacent to the carriageway (width 0.3 m, length 6.0 m); B – main road shoulder (width 0.5 m, length 6.0 m), located 0.3 m from the road edge; C – outer edge of the road shoulder (width 0.5 m, length 6.0 m), located 0.8 m from the road edge; R – road

Within each transect, a phytosociological relevé was made using the Braun-Blanquet method. At four localities situated along the provincial road (Nos. 3, 4, 5, and 6), soil samples

were collected from zones A and B. Additionally, at locality No. 7, situated along the county road, a soil sample was collected from zone A (Fig. 1 – Appendix 1). No soil samples were collected from zone C because no individuals of *P. distans* were recorded there. In each study zone, a composite soil sample was collected, consisting of material gathered from ten points within the surface soil layer at a depth of 0–20 cm.

The collected soil samples were analysed for: soil reaction (pH) in water using the potentiometric method; salinity using the conductometric method; nitrate nitrogen ($N\text{-}NO_3$), ammonium nitrogen ($N\text{-}NH_4$), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and chloride (Cl^-) content. Soil analyses were performed at the accredited laboratory of the Regional Chemical and Agricultural Station in Kraków.

The nomenclature of vascular plants follows Mirek et al. (2020). Plant species tolerant of soil salinity, classified as facultative and obligate halophytes, were identified based on ecological indicator values according to Zarzycki (Zarzycki et al., 2002).

Results

As a result of floristic surveys conducted along the roadsides of the main roads within ONP, the occurrence of *Puccinellia distans* was recorded along virtually the entire section of provincial road No. 794 within the Park boundaries, as well as along the entire section of national road No. 94 adjacent to the Park boundary, specifically along the forested section near the hamlet of Lepianka Czajowska. Individual clumps were also found along the county road, on the section extending from its intersection with the provincial road to the beginning of the Skały Ciche massif (Fig. 4 – Appendix 1). Clumps of this grass were observed mainly along the edge of the roadside, within a zone extending 0–30 cm from the road edge, and partly at a distance of approximately 0.5 m from the road edge (Tab. 1).

Tab. 1. Distribution of species in following zones of roadsides in Ojców National Park (see Fig. 3); the grey colour distinguishes the species under study

Species	Field roadsides zones		
	A	B	C
Chamomilla suaveolens	+	+	
Plantago major	+	+	
Polygonum aviculare	+	+	
Puccinellia distans	+	+	
Lolium perenne	+	+	+
Taraxacum officinale	+	+	+
Achillea millefolium		+	
Bromus hordeaceus		+	
Cichorium intybus		+	
Geranium phaeum		+	

Plantago lanceolata		+	
Alopecurus pratensis		+	+
Arrhenatherum elatius		+	+
Calamagrostis epigejos		+	+
Convolvulus arvensis		+	+
Crepis biennis		+	+
Dactylis glomerata		+	+
Festuca rubra		+	+
Geranium pratense		+	+
Holcus lanatus		+	+
Poa annua		+	+
Poa compressa		+	+
Poa trivialis		+	+
Potentilla heptaphylla		+	+
Trifolium repens		+	+
A*egopodium podagraria*			+
Brachypodium pinnatum			+
Carex sp.			+
Chenopodium album			+
Cirsium arvense			+
Cornus sanguinea			+
Coronilla varia			+
Festuca gigantea			+
Festuca pratensis			+
Fragaria vesca			+
Fraxinus excelsior			+
Galium odoratum			+
Heracleum sphondylium			+
Libanotis pyrenaica			+
Medicago lupulina			+
Myosotis arvensis			+
Pimpinella saxifraga			+
Prunu domestica			+
Ranunculus repens			+
Salvia verticillata			+
Senecio jacobaea			+
Torilis japonica			+
Viola reichenbachiana			+
Number of species in the transect	6	25	39

As a result of floristic surveys conducted at six localities situated along the roadside of the provincial road, 48 plant species were recorded. The lowest number of species was recorded in zone A, adjacent to the road edge (6 species), whereas the highest number was recorded in zone C, located 80 cm from the road edge (39 species).

In addition to *P. distans*, which is an obligate halophyte regarded as an indicator species of saline soils (Mirek, Trzcińska-Tacik, 1981; Piernik, 2003), 17 species of facultative halophytes were also recorded at the study sites (Tab. 2).

Tab. 2. Distribution of roadside halophytes in following zones of roadsides in Ojców National Park (see Fig. 1 – Appendix 1); the values of soil NaCl tolerance were adopted from Zarzycki et al. (2002); S – value of resistance to NaCl content in soil, 1 – species tolerating increased NaCl content (facultative halophyte), 2 – species growing

mainly on soils with increased NaCl content (obligatory halophyte); the grey colour distinguishes the species under study

Halophytes	S – value of resistance	Field roadsides zones		
		A	B	C
Achillea millefolium	1		+	
Arrhenatherum elatius	1		+	+
Bromus hordeaceus	1		+	
Calamagrostis epigejos	1		+	+
Cichorium intybus	1		+	
Crepis biennis	1		+	+
Festuca pratensis	1			+
Festuca rubra	1		+	+
Heracleum sphondylium	1			+
Holcus lanatus	1		+	+
Lolium perenne	1	+	+	+
Plantago lanceolata	1		+	
Plantago major	1	+	+	
Puccinellia distans	2	+	+	
Ranunculus repens	1			+
Taraxacum officinale	1	+	+	+
Trifolium repens	1		+	+
Total number of halophytes	17	4	14	11

These accounted for approximately 35% of all taxa identified at the sites. The majority of halophytes occurred on the road verge itself, and their abundance gradually decreased with increasing distance from the road edge. They constituted the most numerous group among all plant species observed in zones A and B (Fig. 5).

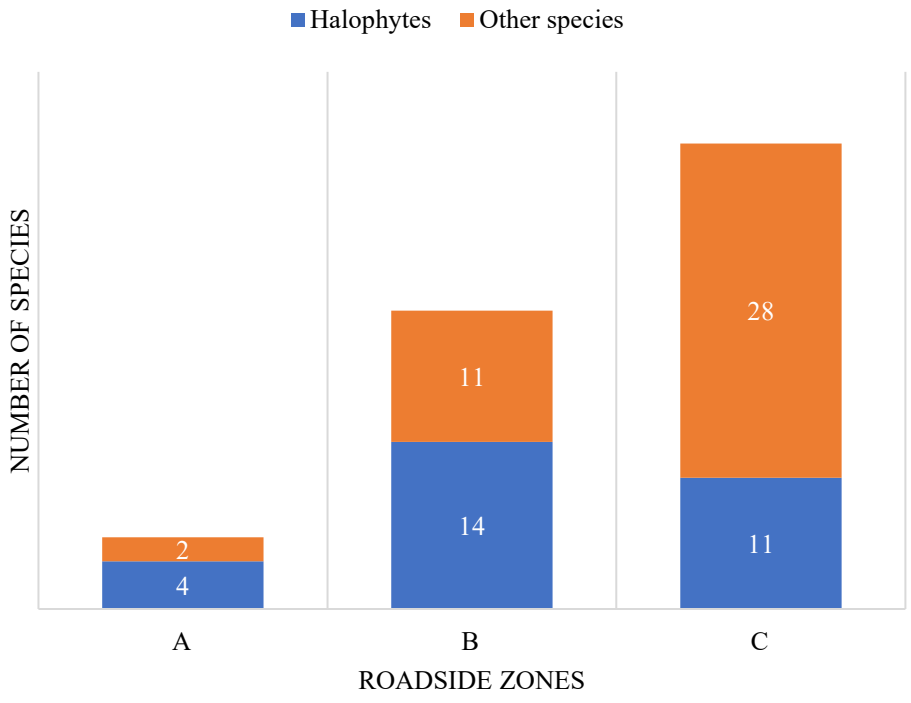


Fig. 5. Participation of halophytes in total number of species observed in following zones of roadsides A, B and C (see also Fig. 3)

Soil analysis confirmed the presence of saline soils at the study sites, with salinity ranging from 0.14 to 1.09 g NaCl/dm³, a soil property that influences the occurrence of halophytes (Tab. 3). A general trend of decreasing salinity from the road edge (zone A) towards the roadside verge (zone B) was observed at sites 3–5, with the exception of site 6, where salinity increased from 0.21 to 0.38 g NaCl/dm³.

Tab. 3. Selected properties of roadside soils: pH, soil salinity, and the contents of nitrate nitrogen (N-NO_3), ammonium nitrogen (N-NH_4), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and chloride (Cl^-) (see Fig. 1, 2 – Appendix 1)

				Nutrient content in mg/dm³ of soil						
Localities number	**Transect zone**	**pH in H_2O**	**Salinity in g NaCl/dm³**	**$N-NO_3$ nitrate nitrogen**	**$N-NH_4$ ammonium nitrogen**	**P Phosphorus**	**K Potassium**	**Ca Calcium**	**Mg Magnesium**	**Cl^- Chlorine**
3	A	8.59	1.09	<14	<15	27	60	2360	179	168
3	B	8.40	0.92	39	<15	38	145	3200	290	92
4	A	9.24	0.65	140	<15	35	40	4500	84	28
4	B	8.87	0.54	78	15	38	90	4300	105	<27
5	A	8.57	0.20	89	<15	31	20	4760	95	<27
5	B	7.90	0.14	51	<15	29	35	4640	129	<27
6	A	8.79	0.21	124	<15	31	20	4700	84	<27
6	B	9.11	0.38	135	<15	30	40	4940	78	27
7	A	8.76	0.69	110	<15	36	45	4850	123	65

On average, salinity was slightly higher in zone A (0.538) than in zone B (0.495 g NaCl/dm³). The highest salinity was recorded at site 3, where the value exceeded 1 g NaCl/dm³, whereas the lowest was recorded at site 5. Site 7, in zone A, was also relatively strongly salinised (0.69 g NaCl/dm³), although this value was not extreme. When salinity is compared with chloride content, a certain relationship between NaCl and Cl^- can be observed. The highest NaCl values were accompanied by the highest Cl^- values, particularly at site 3.

The high calcium content (Ca = 2360–4940 mg/dm³) results from the calcareous substrate at the study sites and contributes to the alkaline reaction of the soil. The analyses also indicate that higher salinity co-occurred with lower availability of nitrate nitrogen. At the most saline site (site 3), the $N-NO_3$ content in zone A was only <14 mg/dm³. The other soil parameters analysed, apart from chloride content, showed no clear relationship with salinity. This suggests that the key factor for halophytes is the presence of NaCl/Cl^- in the soil originating from road

salt. Overall, the results indicate stronger salt pressure in the immediate vicinity of the road. In addition, the analyses showed that zone B was richer than zone A in terms of the available Ca and Mg content.

Discussion

The record of *Puccinellia distans* within Ojców National Park expands the previously known floristic list of the Park. The results of the inventory indicate that *P. distans* is currently more widely distributed in the Prądnik Valley. Numerous clumps were recorded along parts of the provincial road, where in some places the species forms almost monospecific strips of vegetation. Individual specimens were also recorded along county road No. 2134K. Their presence may indicate a gradual southward expansion along the Prądnik Valley; however, confirmation of the direction and rate of expansion would require further observations.

The contemporary distribution of *P. distans* should be considered in the context of the role of transport infrastructure in shaping the flora of anthropogenic habitats. Roads, railway lines, and associated verges, embankments, and drainage ditches form an extensive network of habitats and potential dispersal pathways, facilitating the movement of organisms over considerable distances (Forman, Alexander, 1998). In the case of plants, transport infrastructure may serve a dual function, acting both as a pathway for the dispersal of diaspores and as a substitute habitat. In addition, vehicle traffic may facilitate the transport of lightweight diaspores by air currents (von der Lippe, Kowarik, 2007). This process is particularly important in protected areas, where roads may facilitate the arrival of new elements of the flora and contribute to changes in the species composition of vegetation.

One of the most important factors promoting the occurrence of halophytes along roads is winter road maintenance. The regular application of de-icing salt leads to increased soil salinity in the immediate vicinity of roads, creating conditions favourable to species tolerant of elevated salt concentrations. Habitats formed in this way may function as substitutes for plants associated with natural salt marshes (von der Lippe, Kowarik, 2007; Fekete et al., 2022). In many regions of Europe, *P. distans*, *Spergularia salina*, *Atriplex prostrata*, and *Plantago coronopus* have been recorded along road networks (Scott, Davison, 1982; Šerá, 2008; Fekete et al., 2021). In Hungary, at least one halophytic species was recorded at more than 70% of the sites analysed, and *P. distans* was among the most frequently recorded species (Fekete et al., 2022). The authors also indicated the importance of traffic intensity and the presence of populations in the surrounding landscape for the occurrence of roadside halophytes.

Similar relationships have also been observed in Poland and Slovakia. Studies conducted in Western Pomerania demonstrated the occurrence of numerous halophytic species along forest and field roads, with *P. distans* being the only obligate halophyte recorded in the studied communities (Wróbel et al., 2006). Other studies of *P. distans* populations in Poland have likewise demonstrated strong associations with anthropogenic habitats, including sites affected by human-induced salinisation (Lembicz, Olejniczak, 2009; Lembicz et al., 2011). In northern Slovakia, the occurrence of halophytes along roadsides was associated with the intensity of road salting. Communities containing *P. distans* were classified as the *Puccinellio-Chenopodietum glauci* Krippelová 1971 association and developed primarily at sites regularly exposed to salt (Dítě, Dítětová, 2016).

Plant communities

The results of the analysis of the phytosociological relevés indicate that zone A is characterised by very low species richness, with 2–6 vascular plant species recorded in individual relevés. These plots are pioneer in character and are clearly dominated by *Puccinellia distans*. In the literature, communities dominated by this species have been described, among others, as *Puccinellio-Chenopodietum glauci* (currently *Chenopodio glauci-Puccinellietum* Krippelová 1971 nom. invers. prop.), *Puccinellietum distantis* R. Knapp 1948 ex Fijałkowski 1978, or as the *Puccinellia distans* community (Jarolímek et al., 1997; Dítě, Dítětová, 2016). In Poland, Waldon (1998) classified *Puccinellio-Chenopodietum glauci* as vegetation of trampled habitats, within the formerly distinguished alliance *Matricario-Polygonion avicularis* of the class *Polygono arenastri-Poetea annuae* Rivas-Martínez 1975. Święs (2000), in turn, distinguished syntaxonomic units at the subassociation level in which *P. distans* occurs as a dominant or co-dominant species, including *Potentilletum anserinae* Rapaics 1927 em. Pass. 1964 *puccinellietosum*, *Lolio-Plantaginetum* Beger 1932 em. Sissingh 1969 *puccinellietosum*, and *Polygono-Matricarietum discoideae puccinellietosum*. At the same time, the author emphasised that not every plot with a high proportion of *P. distans* should be regarded as a distinct plant association.

In ONP, the analysed plots can therefore be described as trampled, secondarily salinised communities with *P. distans*, related to the vegetation of the *Polygono arenastri-Poetea annuae* class mentioned above. Their impoverished floristic composition and heterogeneous character are similar to those of the communities described by Święs (2000). The structure of the analysed plots is primarily determined by *P. distans*, *Plantago major*, *Polygonum aviculare*, *Lolium perenne*, *Matricaria discoidea*, and *Taraxacum officinale* (Tab. 1). However, due to the small

number of relevés and the lack of a comprehensive syntaxonomic analysis, there are insufficient grounds for assigning the studied plots unequivocally to a particular plant association.

Vegetation variation along the distance gradient from the roadway

A particularly clear spatial pattern can be observed in the occurrence of *P. distans* across the analysed roadside zones. The species was recorded in zones A and B, whereas it was absent from zone C, the zone furthest from the road. At the same time, overall floristic richness increased with increasing distance from the road edge, from 6 species in zone A to 25 in zone B and 39 in zone C (Tab. 1). These results indicate clear differentiation in habitat conditions across the roadside.

Zone A, directly adjacent to the road, was characterised by the lowest floristic richness, slightly higher pH, and, at most of the sites analysed, higher salinity and chloride content than zone B (Tab. 3). This may be related to the direct influence of the road, including the input of salt used for winter road maintenance. A similar relationship between the intensity of road salting and the occurrence of halophytes was demonstrated in northern Slovakia (Dítě, Dítětová, 2016), while studies conducted in Hungary confirmed the widespread occurrence of halophytes along roadsides and the frequent occurrence of *P. distans* (Fekete et al., 2022).

In zone B, where salinity was generally lower, numerous grass species with some degree of salinity tolerance were recorded, including *Lolium perenne*, *Arrhenatherum elatius*, *Bromus hordeaceus*, *Calamagrostis epigejos*, *Festuca rubra*, *Holcus lanatus*, *Poa annua*, *P. compressa*, *P. trivialis*, *Alopecurus pratensis*, and *Dactylis glomerata* (Tab. 1, 2). Their presence may indicate a gradual decrease in habitat stress with increasing distance from the road. At the same time, the absence of *P. distans* from zone C suggests that the species prefers conditions occurring in the immediate vicinity of the road.

However, caution should be exercised when attributing the observed floristic gradient solely to salinity. Zone A also differed from zone B in terms of mineral nutrient content, with lower concentrations of K, Ca, and Mg and a higher concentration of $N\text{-}NO_3$ recorded in zone A (Tab. 3). Vegetation composition may also have been influenced by more frequent mechanical disturbance, periodic drying, and limited opportunities for organic matter accumulation. The higher concentrations of K, Ca, and Mg in zone B may, in turn, reflect different conditions of organic matter accumulation and simultaneously promote the development of more competitive species. The observed pattern should therefore be regarded as the result of interactions among several environmental factors, among which salinity may play an important selective role.

Salinity and the occurrence of *Puccinellia distans*

The results obtained indicate a clear relationship between the occurrence of *P. distans* and the conditions prevailing in the immediate vicinity of the road. At three of the four sites analysed, salinity was higher in zone A than in zone B, with the highest value recorded in zone A at site 3 (1.09 g NaCl/dm³) (Tab. 3). At the same time, *P. distans* occurred in zones A and B but was not recorded in zone C. The difference in mean salinity between zones A and B was relatively small (1.09 and 0.92 g NaCl/dm³, respectively), whereas the difference in species richness was substantial (Tab. 1). This may indicate that even relatively small differences in habitat conditions in the immediate vicinity of the road can influence vegetation structure. However, this alone does not justify concluding that salinity is the only factor responsible for the observed gradient, as indicated above.

It should be emphasised that the data obtained in this study are not directly comparable with the NaCl concentrations applied in physiological experiments. Scalia et al. (2009) exposed plants to solutions containing 85, 275 and 600 mM NaCl, whereas soil salinity in the present research was assessed conductometrically and expressed in g/dm³. Accordingly, these measurements should be regarded primarily as indicators of relative salinity differences among the investigated zones rather than as equivalents of concentrations used under laboratory conditions.

Soil NaCl content varied from 0.14 to 1.09 g/dm³, with a slightly higher mean in zone A, adjacent to the road edge (0.538 g/dm³), compared with zone B (0.495 g/dm³) (Tab. 3). Halophytes accounted for the largest proportion of the vegetation in both zones. Among them, the obligate halophyte *Puccinellia distans* occurred predominantly within 30 cm of the road edge. Its distribution is likely associated with secondary soil salinisation caused by winter road de-icing. Salt reaches roadside verges through surface runoff and splash dispersal, leading to increased concentrations of Na^+ and Cl^- ions in the soil. This creates environmental conditions that favour salt-tolerant species by reducing competition from less tolerant plants. The association between halophyte distribution and the intensity of winter road salting was also documented by Dítě and Dítětová (2016). In addition to obligate halophytes, facultative species such as *Plantago major* and *Lolium perenne* can also colonise roadside habitats due to their ability to tolerate elevated salinity.

It can therefore be assumed that repeated salt inputs during successive winter seasons favour the persistence of *P. distans* in the vicinity of roads. At the same time, strong habitat disturbance and reduced competition from species less tolerant of salinity may further enhance its colonisation potential. In this context, *P. distans* may be regarded as a species characteristic

of anthropogenic habitats subject to short-term or regular salinisation. However, it should not be described as an "indicator of recent salinisation" without more extensive data on the temporal dynamics of salinity.

The significance of roads for the spread of *Puccinellia distansin* Ojców National Park

The distribution of *P. distans* in ONP, together with the characteristics of the habitats it occupies, indicates a probable association between its occurrence and the road network. Numerous clusters along the provincial road and individual localities along the county road may be consistent with a scenario of gradual colonisation of successive sections of transport infrastructure. However, based on a single field survey, it is not possible to determine the direction or rate of this process unequivocally.

European studies indicate that the seeds of this species may be transported on vehicle tyres and undercarriages and subsequently dispersed along roads by air currents generated by traffic (Scott, Davison, 1985; Taylor et al., 2012). Experimental evidence has also demonstrated that air turbulence generated by passing vehicles can facilitate seed dispersal over considerable distances (von der Lippe et al., 2013). Roadside mowing equipment may constitute an additional dispersal vector, contributing to the transfer of diaspores beyond their original locations (Chaudron, Isselin-Nondedeu, 2017).

In Ojców National Park, road infrastructure may contribute to the expansion of *P. distans* by facilitating diaspore dispersal and creating suitable habitat conditions. Winter road de-icing leads to secondary soil salinisation, reducing competition from less salt-tolerant species and facilitating the establishment of halophytes. Consequently, road verges serve both as dispersal corridors and as habitats conducive to plant establishment and growth. The role of road infrastructure in the spread of *P. distans* is also reflected in European studies, including genetic and cytogeographical analyses (Fekete et al., 2022; Kúr et al., 2023; Schmidt et al., 2023).

Conclusions

In the case of Ojców National Park, the continuity of roadside habitats and the presence of road sections that may potentially facilitate its spread may be of particular importance for the distribution of *Puccinellia distans*. The individual specimens of reflexed saltmarsh grass recorded along the county road indicate the possibility of colonisation of new localities;

however, confirmation of this process requires repeated observations and an assessment of the population size of this species in subsequent years.

The results confirm that *P. distans* in the OPN area is primarily associated with heavily disturbed roadside habitats, where elevated salinity and soil disturbance favour its persistence and expansion. Anthropogenic habitats associated with road infrastructure thus play a dual role in shaping local vegetation. Secondary soil salinisation and the dispersal of diaspores along transport routes facilitate the spread of halophytes. On the other hand, the creation of new roadside habitats enables these plants to colonise areas they did not previously occupy. This process may lead to changes in the structure and species composition of local plant communities, including an increased proportion of species associated with anthropogenic habitats and alterations in competitive interactions among native species. Road infrastructure may therefore initiate local changes in plant community composition and structure even within protected areas.

These observations are consistent with the broader phenomenon, documented across Europe, of halophyte dispersal along transport infrastructure. From a nature conservation perspective, it is therefore advisable to monitor changes in the distribution of this species within the Park, particularly along roads subject to regular winter maintenance. The establishment of monitoring transects is recommended to assess, among other parameters, the population size of *P. distans*, its spatial distribution, reproductive status, and changes in habitat conditions within the occupied sites.

Ackonwledgements

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Conflict of interest

The authors declare no conflict of interest related to this article.

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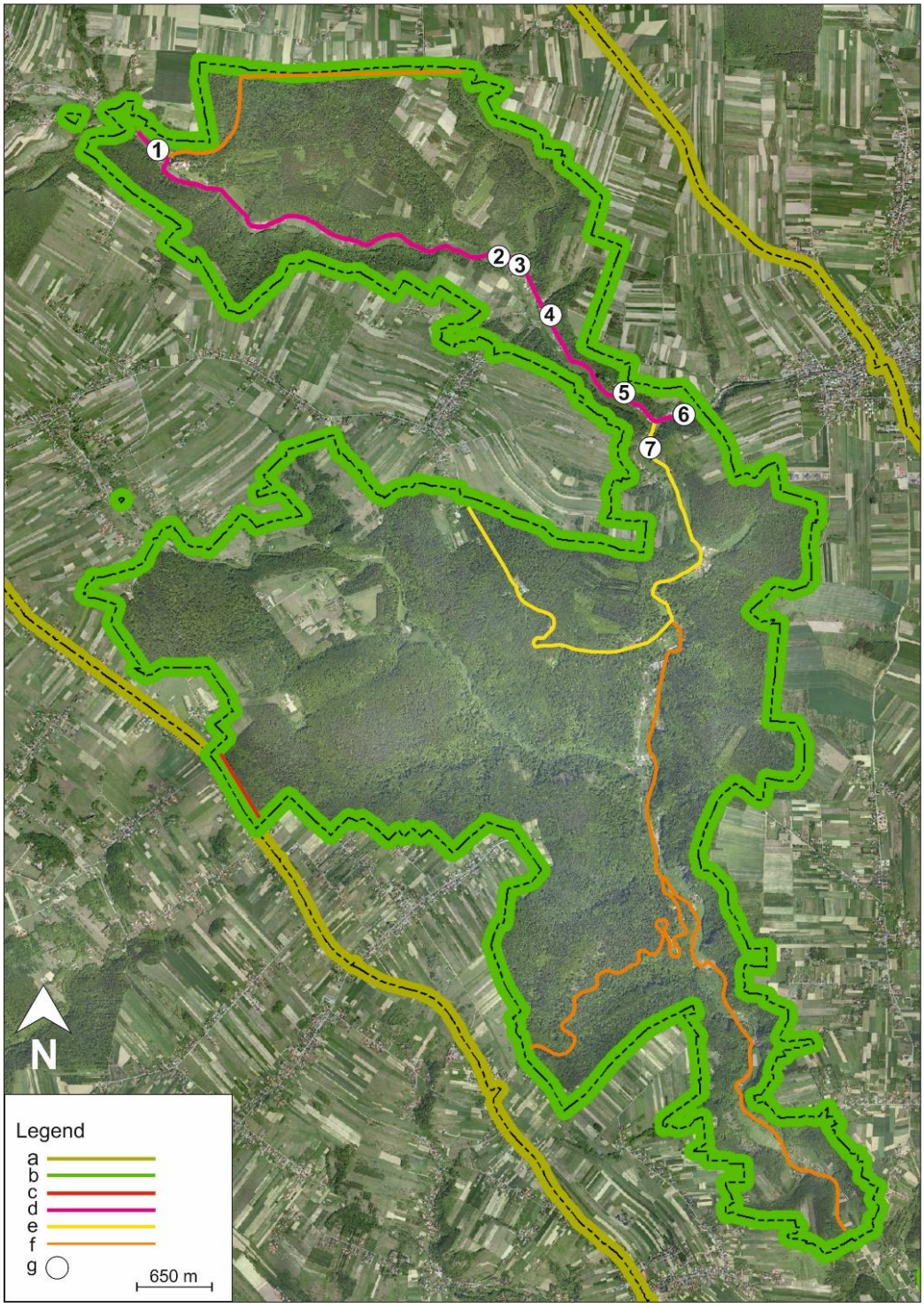


Fig. 1. The surveyed road sections within Ojców National Park

Legend: a – boundary of the Park's buffer zone; b – boundary of Ojców National Park; c – National Road No. 94; d – Voivodeship Road No. 794; e – county roads; f – municipal roads; g – locations of the study sites (sites 1–6 – phytosociological relevés; sites 3–7 – soil sampling); name of study sites: 1 – Pieskowa Skała hamlet, 2 – Młynnik hamlet, opposite Słoneczna Góra, 3 – the mouth of the Zachwyt Valley, 4 – near the mouth of the Pilny Dół ravine, 5 – Grodzisko hamlet, 6 – Skała city, near the former quarry, 7 – Grodzisko hamlet, near the small bay by the Ciche Skały rocks



Fig. 2. Examples of *Puccinellia distans* (Jacq.) Parl. sites in the study area: A – near the mouth of the Pilny Dół ravine, B – Skała city, near the former quarry, C – the mouth of the Zachwyt Valley (Photo. Anna Sołtys-Lelek)

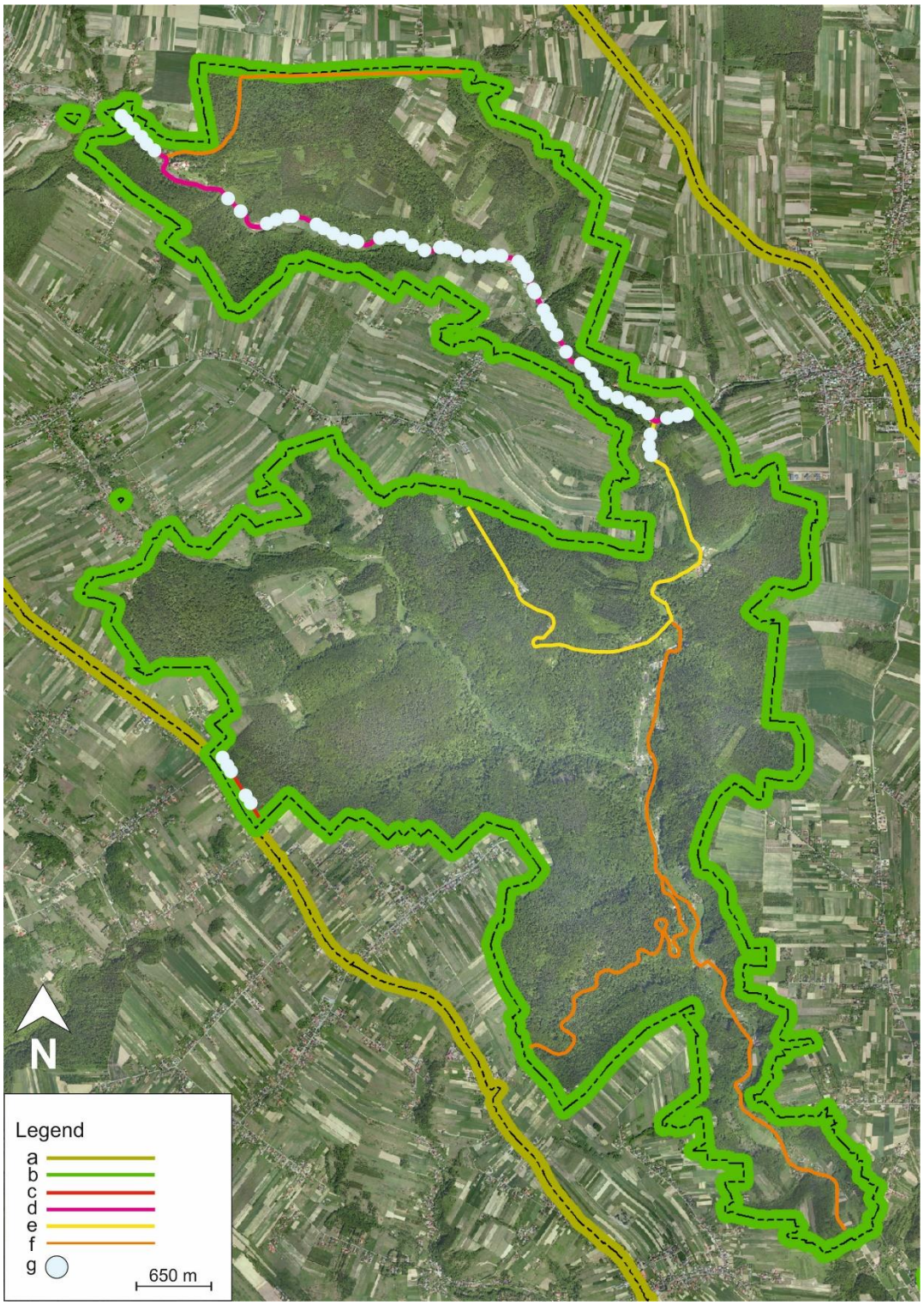


Fig. 4. The distribution of *Puccinellia distans* (Jacq.) Parl. sites within Ojców National Park

Legend: a – boundary of the Park's buffer zone; b – boundary of Ojców National Park; c – National Road No. 94; d – Voivodeship Road No. 794; e – county roads; f – municipal roads; g – locations of *P. distans* sites

Puccinellia distans (Jacq.) Parl. w Ojcowskim Parku Narodowym – nowy element flory i przejaw antropogenicznych przemian

Streszczenie

Puccinellia distans (Jacq.) Parl. jest halofitem obligatoryjnym, często zasiedlającym antropogeniczne siedliska przydrożne. Celem podjętych badań było określenie rozmieszczenia gatunku na terenie Ojcowskiego Parku Narodowego (OPN) oraz charakterystyka warunków siedliskowych zajmowanych stanowisk. Badania przeprowadzono w czerwcu i lipcu 2026 r. wzdłuż głównych dróg doliny Prądnika. Na sześciu wykonano zdjęcia fitosocjologiczne w transektach obejmujących trzy strefy pobocza, różniące się odległością od jezdni. Na wybranych stanowiskach oznaczono również właściwości chemiczne gleby.

P. distans występowała przede wszystkim w strefach położonych najbliżej jezdni, natomiast nie została stwierdzona w najbardziej oddalonej strefie C. Wraz ze wzrostem odległości od drogi wyraźnie zwiększało się bogactwo florystyczne płatów. Strefy zajmowane przez gatunek charakteryzowały się na ogół wyższym zasoleniem i zawartością chlorków. Wyniki wskazują na znaczenie antropogenicznego zasolenia i zaburzeń siedliskowych dla występowania *P. distans* oraz na rolę infrastruktury drogowej w kształtowaniu współczesnego rozmieszczenia gatunku na terenie OPN.

Słowa kluczowe: siedliska antropogeniczne, halofity, nowe stanowisko, Poaceae, siedliska zasolone, flora roślin naczyniowych

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