

Anthropogenic features of salt marsh flora with varying substrate salinity, human impact and abundance of halophytes

Wiesława Karasińska¹, Andrzej Nienartowicz^{1,*}, Mieczysław Kunz², Agnieszka Piernik¹,

Anna Filbrandt-Czaja¹, Dariusz Kamiński¹, Lucjan Rutkowski¹

Nicolaus Copernicus University in Toruń,

¹Faculty of Biology and Veterinary Sciences, Department of Geobotany and Landscape Planning

**²Faculty of Earth Sciences and Spatial Management, Department of Cartography and Geomatics,
Lwowska st. 1, 87-100 Toruń, Poland**

Appendix 1

Table A1. Values of indices of anthropogenic changes in the flora of saline meadows of Western Kuyavia and floras of different habitats in other regions of Poland, developed under conditions of varying intensity of human impact.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Region	West- ern Kuya- via	Tu- chola Forest	Pome- rania, Sło- wiń- skie Coast	Grea- ter Po- land (Wiel- kopol- ska)	Grea- ter Po- land	Pome- rania, Baltic coast	Pome- rania, Baltic coast	South- ern Kuya- via	NE Grea- ter Po- land (NE Wiel- kopol- ska)	Pome- rania, Baltic coast near Gdy- nia city	Pome- rania, Cheł- mno Land	Grea- ter Po- land, the vil- lage of Folusz	Grea- ter Po- land, Gnie- zno Lake- land	West- ern Pomer- ania	West- ern Kuya- via	West- ern Kuya- via	Pome- rania, Żuła- wy Wiś- lane	West- ern Kuya- via	Pome- rania and Kuya- via	Pome- rania	Kuya- via, Gniew- -kowo terrain depres- -sions	NE Grea- ter Po- land	Po- land	East- ern Kuya- via	Pome- rania	Pome- rania, Sło- wiń- ski Na- tional Park	Grea- ter Po- land, Głów- na River catch- ment	Grea- ter Po- land
Object of flori- stic re- search	‘Żród- ła rzeki Gą- saw- ki’ natu- re reser- ve	‘Uro- czys- ko Kiel- piniek’ ecol- gical site	Sło- wiński National Park and Bio- sphere Reser- ve	plan- ned nature reser- ve ‘Łąki Pyzdri- skie’	Wiel- kopol- ska National Park	coast- al ha- lophyte com- muni- ties	coast- al salt mar- shes fed by brine	vege- tation of hydro- genic soils, anthro- pogenic origin	all natu- re reser- ves	‘Me- che- liń- skie Łąki’ nature reser- ve	‘Zbo- cza Płu- tow- skie’ nature reser- ve	plan- ned nature reser- ve of xero- ther- mic vegeta- tion	total flora	small water bodies in agri- cultu- ral land- scape	‘Ost- rów Małe Rudy’ habi- tat in the Noteć River valley xero- ther- mic flora	Gopło Mil- len- nium Land- scape Park	banks of the Wisła Króle- wiec- ka River and the estu- ary of Szkar- pawa River	saline mea- dows in the Noteć river valley	small water bodies in agri- cultu- ral land- scape – kettle- holes	west- ern coast of the Bay of Puck	shores of perio- dic flood- plains in agri- cultu- ral land- scape	flora of pro- tected areas	flora of inland salt mar- shes	Zgło- wiącz- ka river valley	south- east- ern shore of the Vistu- la La- goon	flora of former milita- ry area	total flora	flora of non- pro- tected areas
Symbol of flora	P1f	E1	P2s	M1s	P3	S1	S2	K1w	P4	P5s	P6x	X1	V1	K2w	X2	P7s	G1s	S3	K3w	V2s	K4w	P8	S4	M2s	G2s	R1t	V3	O1v
Index																												
WSc	36.44	36.90	43.35	46.76	49.11	50.33	51.72	54.14	54.64	56.25	58.37	59.41	59.48	59.80	61.74	62.60	62.83	62.96	63.41	64.04	65.00	65.92	66.67	67.14	67.56	68.50	68.51	68.83
WSt	36.16	36.90	38.98	46.45	44.17	50.33	51.72	54.14	54.28	55.94	57.87	59.24	56.37	58.70	61.74	59.19	61.59	62.96	63.41	62.57	64.75	62.50	65.35	66.06	66.41	67.61	65.69	64.43
WAp	31.11	32.47	22.21	41.18	22.05	49.01	50.86	50.38	49.34	48.26	43.54	53.14	35.98	40.86	59.73	37.28	44.84	54.32	54.15	46.07	55.71	39.94	49.52	48.76	51.22	53.15	39.97	39.31
WApt	31.25	32.47	23.91	41.42	26.84	49.01	50.86	50.38	49.73	48.60	44.07	53.36	38.74	41.98	59.73	40.68	46.34	54.32	54.15	47.95	56.12	43.95	51.49	50.36	53.03	54.66	43.56	44.86
WAp	32.86	33.98	28.15	43.61	32.46	49.66	51.30	52.34	52.10	52.45	51.12	56.70	47.04	50.41	60.96	49.92	54.68	59.46	59.68	56.16	61.42	53.96	59.77	59.74	61.22	62.79	55.94	55.77
WAnc	5.33	4.43	21.16	5.59	24.64	1.32	0.86	3.76	5.31	7.99	14.83	6.28	23.50	18.94	2.01	25.32	17.99	8.64	9.27	17.98	9.29	25.98	17.14	18.37	16.34	15.35	28.53	29.52
WAnt	4.91	4.43	15.07	5.03	17.34	1.32	0.86	3.76	4.55	7.34	13.80	5.88	17.63	16.72	2.01	18.50	15.24	8.64	9.27	14.62	8.63	18.55	13.86	15.69	13.38	12.96	22.13	19.57
WArc	0.44	2.95	8.67	4.12	8.84	0.66	0.86	3.01	0.80	4.51	10.05	3.75	9.16	9.97	0.67	10.22	8.26	6.17	5.37	8.61	6.43	9.78	8.10	11.66	6.83	8.66	9.77	9.61
WArt	0.45	2.95	9.34	4.14	9.96	0.66	0.86	3.01	0.80	4.55	10.17	3.36	9.86	10.24	0.67	11.15	8.54	6.17	5.37	8.97	6.47	10.76	8.42	12.04	7.07	8.91	10.64	10.97
WKnc	4.44	1.48	5.32	0.88	6.96	0.66	0.00	0.75	3.71	2.78	3.59	2.51	7.22	6.31	1.34	6.74	6.49	2.47	3.90	5.43	2.14	7.08	5.24	3.53	6.10	3.94	10.54	7.53
WKnt	4.46	1.48	5.73	0.89	7.64	0.66	0.00	0.75	3.74	2.80	3.63	2.52	7.77	6.48	1.34	7.35	6.71	2.47	3.90	5.65	2.16	7.79	5.45	3.65	6.31	4.05	11.48	8.60
WM	90.91	33.33	38.02	17.65	44.06	50.00	0.00	20.00	82.35	38.10	26.32	42.86	44.07	38.78	66.67	13.73	44.00	28.57	42.11	38.67	25.00	41.99	39.29	23.26	47.17	31.25	51.90	43.94
WF	0.44	0.00	7.17	0.59	8.84	0.00	0.00	0.00	0.80	0.69	1.20	0.42	7.12	2.66	0.00	8.36	3.24	0.00	0.00	3.93	0.71	9.12	3.81	3.18	3.41	2.76	8.23	12.38
Number of species																												
T	225	271	865	340	1120	151	116	133	377	288	418	239	1081	301	149	861	339	81	205	534	140	1074	210	283	410	254	778	1155
Sp	143	171	490	181	570	75	56	61	171	126	174	97	438	121	57	322	126	30	75	192	49	366	70	93	133	80	245	360
Ap	70	88	192	140	274	74	59	67	186	139	182	127	389	123	89	321	152	44	111	246	78	429	104	138	210	135	311	454
Ar	1	8	75	14	99	1	1	4	3	13	42	8	99	30	1	88	28	5	11	46	9	105	17	33	28	22	76	111
Kn	10	4	46	3	78	1	0	1	14	8	15	6	78	19	2	58	22	2	8	29	3	76	11	10	25	10	82	87
Df	1	0	62	2	99	0	0	0	3	2	5	1	77	8	0	72	11	0	0	21	1	98	8	9	14	7	64	143
A	12	12	183	19	276	2	1	5	20	23	62	15	254	57	3	218	61	7	19	96	13	279	36	52	67	39	222	341
M	11	12	121	17	177	2	1	5	17	21	57	14	177	49	3	146	50	7	19	75	12	181	28	43	53	32	158	198

No.	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
Region	Pome- rania, Żuła- wy Wiśla- ne	Grea- ter Po- land, the city of Poz- nań	Grea- ter Po- land, Główna River, catch- ment	Kuya- via	Pome- rania, South Baltic Lake- land	Grea- ter Po- land, Główna River, catch- ment	Kuya- via	Lesser Po- land, Kra- ków	Pome- rania	Pome- rania, Żuła- wy Wiśla- ne	Grea- ter Po- land, Główna River catch- ment	Lesser Po- land, Kra- ków	West- ern Kuya- via	Grea- ter Po- land, Główna River catch- ment	Grea- ter Po- land, Główna River catch- ment	Pome- rania, Żuła- wy Wiśla- ne	West- ern Pome- rania, the town of Ma- szewo	Grea- ter Po- land, Konin Brow- n Coal Basin	Kuya- via, Aleksan- drów, Nie- szawa and Wło- ławek	Grea- ter Po- land, the town of Nowy To- myśl	West- ern Kuya- via, the vil- lage of Małe Rudy	West- ern Pome- rania	Grea- ter Po- land, Główna River catch- ment	Grea- ter Po- land, Główna River catch- ment	West- ern Pome- rania	Grea- ter Po- land, Główna River catch- ment	West- ern Kuya- via; Mą- twy and Jani- kowo towns	Lesser Po- land, Kra- ków
Object of floristic research	estu- arine sec- tion of the Vistu- la	‘Bog- dan- ka I’ and ‘Bog- dan- ka II’ ecolo- gical sites	littoral flora of water reser- voirs	halo- phytic com- muni- ties of Kuya- via	shores of water bodies and ponds in agri- cultural land- scape	flora of humid grass- lands	‘Cie- choci- nek’ nature reser- ve of halo- phytes in 1954– 1965	mea- dows in Wie- licz- ka flood- ed by brine	Lower Vistu- la Val- ley Land- scape Park, synan- thropic flora	flora of bank pro- tec- tion struc- tures of the Wisła Śmia- ła River	an- thro- poge- nic bio- topes with aqua- tic and reed vege- tation	mea- dows near the ‘Bo- narka’ super- thoma- -sine facto- ry	salt- marsh vege- tation on the banks of the Noteć River and the Noteć Canal	bioto- pes with herba- ceous, mea- dow, grass- land & ru- deral vege- tation	meso- philo- us mea- dows and grass- lands	sege- tal flora of the entire region and rude- ral flora of villa- ges	flora of gravel pit	<i>Plan- tagi- ne- talia majo- ris</i> plant com- muni- ties	rude- ral plant com- muni- ties of three towns	syn- an- thro- pic flora of the city	sege- tal weed flora of root crops	seve- ral years old fallow land	flora of fallow land	syn- an- thro- pic flora of rural and urban settle- ments	flora of winter cereal crops	flora of arable fields	lime- stone heaps and salty lime sludge depos- its	flora of set- tling ponds of Cra- cow soda plants
Symbol of flora	W1	E2	W2	S5	K5w	M3	P9s	S6	P10	W3s	W4	M4	N-S7	M5	M6	A1	I1	I2s	U1	U2	A2	A3	A4	U3	A5	A6	H1s	H2s
Index																												
WSc	69.50	70.56	70.79	71.43	71.63	72.12	73.00	73.03	74.34	74.36	76.71	77.14	81.20	83.11	87.46	89.10	92.52	93.30	94.17	94.58	95.19	95.45	96.24	96.53	97.09	97.59	100.00	100.00
WSt	67.55	72.13	70.35	71.22	71.63	71.84	73.00	73.03	71.56	73.80	76.39	78.64	81.20	82.58	86.87	88.54	92.52	92.98	93.98	94.01	95.19	95.29	96.11	96.31	97.02	97.48	100.00	100.00
WAp	49.50	49.66	58.91	62.14	61.70	56.41	67.31	62.92	48.37	61.54	63.01	75.24	62.39	58.86	62.70	49.62	75.70	58.10	56.50	63.75	45.19	70.63	61.29	57.60	59.30	59.84	73.90	77.97
WApt	52.66	50.34	59.80	62.59	61.70	59.96	67.31	62.92	53.61	62.88	63.89	75.24	62.39	60.67	65.66	52.17	75.70	60.82	58.33	70.51	45.19	73.19	63.33	61.36	60.71	62.60	74.49	79.64
WAp	61.88	62.78	66.85	68.50	68.51	66.92	71.43	70.00	65.34	70.59	73.02	76.70	76.84	77.70	83.33	89.99	91.01	89.66	90.65	92.17	90.38	93.95	94.21	94.32	95.33	96.13	100.00	100.00
WAnc	20.00	20.90	11.88	9.29	9.93	15.70	5.77	10.11	25.97	12.82	13.70	1.90	18.80	24.25	24.76	39.47	16.82	35.20	37.67	30.83	50.00	24.83	34.95	38.93	37.79	37.75	26.10	22.03
WAnt	14.89	19.82	10.55	8.63	9.93	14.89	5.77	10.11	17.95	10.92	12.50	1.90	18.80	21.91	21.21	36.36	16.82	32.16	35.65	21.25	50.00	22.10	32.78	34.94	36.31	34.87	25.51	20.36
WArc	7.50	7.19	5.45	7.14	6.38	8.33	4.81	7.87	9.36	5.98	5.48	1.90	13.68	11.44	9.97	27.44	11.21	24.02	24.22	11.25	42.31	16.08	23.66	17.33	30.81	25.30	17.27	11.19
WArt	7.98	7.29	5.53	7.19	6.38	8.41	4.81	7.87	10.37	6.11	5.56	1.90	13.68	11.80	10.44	28.85	11.21	25.15	25.00	12.44	42.31	16.67	24.44	18.46	31.55	26.47	17.41	11.43
WKnc	6.50	12.36	4.95	1.43	3.55	6.41	0.96	2.25	6.83	4.70	6.85	0.00	5.13	9.81	10.29	7.14	5.61	6.70	10.31	10.00	7.69	5.24	8.06	15.47	4.65	8.03	8.03	8.74
WKnt	6.91	12.53	5.03	1.44	3.55	6.47	0.96	2.25	7.58	4.80	6.94	0.00	5.13	10.11	10.77	7.51	5.61	7.02	10.65	11.06	7.69	5.43	8.33	16.48	4.76	8.40	8.10	8.93
WM	46.43	63.22	47.62	16.67	35.71	43.48	16.67	22.22	42.21	44.00	55.56	0.00	27.27	46.15	50.79	20.65	33.33	21.82	29.87	47.06	15.38	24.59	25.42	47.15	12.50	24.10	31.75	43.86
WF	6.00	1.35	1.49	0.71	0.00	0.96	0.00	0.00	9.78	2.14	1.37	0.00	0.00	3.00	4.50	4.89	0.00	4.47	3.14	9.58	0.00	3.50	3.23	6.13	2.33	4.42	0.80	2.10
Number of species																												
T	400	445	202	140	141	312	104	89	951	234	146	105	117	367	311	266	107	179	223	240	104	286	186	375	172	249	249	286
Sp	122	131	59	40	40	87	28	24	244	60	34	24	22	62	39	29	8	12	13	13	5	13	7	13	5	6	0	0
Ap	198	221	119	87	87	176	70	56	460	144	92	79	73	216	195	132	81	104	126	153	47	168	114	216	92	149	184	223
Ar	30	32	11	10	9	26	5	7	89	14	8	2	16	42	31	73	12	43	54	27	44	46	44	65	53	63	43	32
Kn	26	55	10	2	5	20	1	2	65	11	10	0	6	36	32	19	6	12	23	24	8	15	15	58	8	20	20	25
Df	24	6	3	1	0	3	0	0	93	5	2	0	0	11	14	13	0	8	7	23	0	10	6	23	4	11	2	6
A	80	93	24	13	14	49	6	9	247	30	20	2	22	89	77	105	18	63	84	74	52	71	65	146	65	94	65	63
M	56	87	21	12	14	46	6	9	154	25	18	2	22	78	63	92	18	55	77	51	52	61	59	123	61	83	63	57

Note : source of data for evaluation of flora No: 1- Korczyńska-Krasicka & Korczyński (2003a); 2 – Czarniecki et al. (2002); 3 – Piotrowska et al. (1997); 4 – Brzeg (1998); 5 – Żukowski et al. (1995); 6 – Piotrowska (1974); 7 – Bosiacka (2011a); Bosiacka et al. (2011); Ćwikliński (1977); 8 – Kucharski (1993); 9, 22, 28 – Kutyna et al. (2013); 10 – Meissner et al. (2004), Żółkoś et al. (2007); 11 – Rapacka-Gackowska (2003); 12 – Banaszak et al. (2004); 13 – Chmiel (1993); 14 – Bosiacka (2011b); 15 – Krasicka-Korczyńska & Korczyński (2003b); Chmiel (1999); 17 – Afranowicz & Zgoda-Unlauff (2010); 18 – Wilkoń-Michalska (1957); 19 – Kaźmierczak et al. (1995), Kaźmierczak (1997); 20 – Wszalek-Rożek & Markowski (2010); 21 – Wilkoń-Michalska & Dymitrenko (1974); 23 – Piernik (2012); 24 – Pisarek (1995); 25 – Afranowicz & Markowski (2004); 26 – Żółkoś (2001); 27, 31, 34, 39, 42, 43, 51, 52, 54 – Ratyńska (2003); 29 – Lazarus & Markowski (2010); 30 – Dyderski et al. (2014); 32 – Wilkoń-Michalska (1963); 33 – Kępczyński & Rutkowski (1993); 35 – Wilkoń-Michalska (1970); 36 – Dąbrowska & Świeboda (1977); 37 Korczyński & Misiewicz (2003); 38 Markowski & Stasiak (1980); 40 – Świeboda (1970); 41 – Karasińska (2004), this study; 44 – Hołdyński et al. (2001); 45 – Konopska (2012); 46 – Pawlak (1997); 47 – Czaplewska (1980); 48 – Klimko & Bozio (2003); 49 – Krasicka-Korczyńska (1991); 50, 53 – Kutyna & Malinowska (2011); 55 – Wilkoń-Michalska & Sokół (1969); 56 – Trzecińska-Tacik (1966).

The names of the regions according to the Committee on Standardization of Geographical Names Outside the Republic of Poland of 27/12/2021 (<https://www.gov.pl/web/gugik/ksng>).