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FACTORS AFFECTING DEVELOPMENT OF PIONEERING PSAMMOPHILOUS DUNE VEGETATION ON PRZYTORSKA SANDBAR (NATURE 2000 SITE „WOLIN AND UZNAM" PLH320019)

CZYNNIKI KSZTAŁTUJĄCE ROZWÓJ PIONIERSKIEJ PSAMMOFILNEJ ROŚLINNOŚCI WYDMOWEJ NA MIERZEI PRZYTORSKIEJ (OBSZAR NATURA 2000 „WOLIN I UZNAM" PLH320019)

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Streszczenie. Wpływ wybranych czynników środowiskowych na kształtowanie się piaszczystych siedlisk plażowych, będących miejscem rozwoju roślinności psammofilnej i halofilnej, był celem badań przeprowadzonych w latach 2013–2014 na Mierzei Przytorskiej (obszar Natura 2000 „Wolin i Uznam" PLH320019). Badania prowadzono na wyłączonym z użytkowania rekreacyjnego odcinku plaży przylegającym do basenu portu zewnętrznego budowanego terminala skroplonego gazu ziemnego, gdzie ograniczone zostało także abrazyjne oddziaływanie fal sztormowych. Wyniki badań wykazały dominujący wpływ akumulacji eolicznej materiału piaszczystego w kształtowaniu się wydm embrionalnych, zasiedlanych przez gatunki pionierskich psammofitów i halofitów – *Elymus farctus* subsp. *boreoatlanticus* i *Honckenya peploides,* gatunków charakterystycznych dla zespołu roślinnego *Honckenyo-Agropyretum juncei* R.Tx. 1955, identyfikujących chronione siedlisko przyrodnicze inicjalnych stadiów nadmorskich wydm białych (kod siedliska: 2110), którego płaty na badanym terenie obserwowano w klasycznie wykształconej postaci. Obecność *Ammophila arenaria* i *Leymus arenarius*, tworzących inicjalne postaci traworoślowego zespołu *Elymo-Ammophiletum* wskazywała na postępującą stabilizację wydm embrionalnych ewoluujących w wał wydmy przedniej. Silna akumulacja morska materiału piaszczystego, przy jednoczesnym osłabieniu abrazyjnego oddziaływania falowania sztormowego, umożliwiła rozwój obcego ekologicznie i geograficznie gatunku *Salix daphnoides*, którego diaspory zostały osadzone w strefie plaży dolnej.

Key words: aeolic accumulation, critically endangered species, *Elymus farctus* subsp. *boreoatlanticus*, embryonic dunes, initial stages of white coastal dunes, marine accumulation, Nature 2000 site „Wolin i Uznam" PLH 320019.
Słowa kluczowe: akumulacja eoliczna, akumulacja morska, *Elymus farctus* subsp. *boreoatlanticus*, gatunki krytycznie zagrożone, inicjalne stadia nadmorskich wydm białych, obszar Natura 2000, „Wolin i Uznam" PLH 320019, wydmy embrionalne.

INTRODUCTION

The examination of environmental influences, such as: ground salinity, moisture, reaction, content of general nitrogen, and the intensity of marine or aeolic accumulation processes in creating beach sand habitats, being the place for psammophilous and halophilous plant

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growth, was performed in the years 2013–2014. The examination sites were located on the East side of Świna breakwater in the neighbourhood of a shield breakwater building investment for the external harbour, being the part of the Liquid Natural Gas terminal under construction, made in the years 2011–2014 by the Szczecin and Świnoujście Seaports Authority. Investment implementation limited the recreational use of a beach bordering with the refuge port basin along an area about 1.8 ha, and at the same time created an observation site for the processes related to spontaneous formation of sand beach habitats formed by aeolic or marine accumulation of mineral material. In this section of the beach, abrasive influence of storm surges, having a considerable impact on the creation of habitat environment in the zone of the so-called "lower beach", subject to sea surge influence, was also observed.

Decrease in the strength of sea currents and the change of their direction in the external harbour basin, caused a change in the course of the coastline of this section as well as a considerable increase of summer beach areas, which in the widest part reached 70 metres length – counting from the coastline in the lower beach part up to the foredune base on the border of the upper beach zone.

The results of the research performed in such an unique research site not only enriches the actual knowledge state concerning the flora connected with the accumulative fragment of the Polish Baltic coastline, but also enables foreseeing the trends in processing changes of dune habitats resulting from natural and anthropogenic influences, enable the evaluation of their intensity and taking effective actions to protect the endangered psammophilous and halophilous plant habitats in Poland.

MATERIAL AND METHODS

Research sites were located in the developed plant areas in the distance of approx. 5–55 m from the foredune base in the direction of coastline in the area of the so-called "summer beach" excluded from recreational use. This approx. 1.8 ha area since 2011 bordered with the facilities of shield breakwater building site and also performed a function of a buffer zone, which limited the possibility of penetration in the construction site by tourists. 6 points were located in the zone of the lower beach bordering with the coastline on sandy slopes and in a moist beach slacks, in which sea water stagnated. Another 6 were placed in the zone of the upper beach, on embryo dune slopes, which bordered with the foredune.

In the selected research points phytosociological records were taken using Braun-Blanquet method, which afterward were compared in an analytical table using tabular-comparative method (Table 1) (Dzwonko 2007). Syntaxonomy plant system was adopted after Matuszkiewcz (2004), and the nomenclature of vascular plants after Mirek at al. (2002). The description of each picture, with the exception of species specification and analytical feature of phytocenosis information, included: date of taking the picture, area, covering of particular layers building up the habitat, number of species and the value of Shannon-Wiener Species Diversity Index (Dzwonko 2007).

Table 1. Communities of coastal dune vegetation within the area of investigations (Przytorska Sandbar)
Tabela 1. Zbiorowiska roślinności wydmowej na badanym terenie (Mierzeja Przytorska)

Successive number of phytosociological record Nr kolejny zdjęcia fiotosocjologicznego	1	2	3	4	5	6	7	8	9	10	11	12
Kind of accumulation Rodzaj akumulacji	AE	AE	AE	AE	AE	AE	AM	AM	AM	AM	AM	AM
Shannon-Wiener's Index Wskaźnik Shannona--Wienera	1.796	2.137	2.137	2.352	2.557	2.210	2.699	2.556	2.370	2.392	2.397	2.086
Reaction pH Odczyn pH	8.8	8.8	8.8	8.8	8.8	8.8	8.3	8.3	8.3	8.7	8.7	8.7
Soil salinity NaCl Zasolenie podłoża NaCl $[g \cdot dcm^{-3}]$	0.09	0.09	0.09	0.09	0.09	0.09	1.67	1.67	1.67	0.14	0.14	0.14
N_{total} $N_{ogólny}$ $[g \cdot kg^{-1}]$	0.9	0.9	0.9	0.9	0.9	0.9	29	29	29	0.3	0.3	0.3
Soil humidity Uwilgotnienie podłoża [H]	1	1	2	2	1	2	5	5	5	4	4	3
Date: Day/Month/Year Data: dzień/miesiąc/rok	16.07.2014											
Area of record Powierzchnia zdjęcia [m^2]	30	45	80	60	45	50	150	120	150	120	120	150
Cover of herb layer c Pokrycie warstwy c [%]	60	50	60	70	10	25	20	15	45	70	60	70
Number of species in record Liczba gatunków w zdjęciu	4	5	5	6	6	5	7	6	6	6	6	5
ChAss.,All. *Honckenyo-Agropyretum juncei, Agropyro-Honckenyion peploidis*												
Honckenya peploides	.	.	**3**	**4**	**1**	**2**	.	.	.	.	.	.
Elymus farctus ssp. *boreoatlanticus*	.	+	**1**	**2**	**+**	**+**	.	.	.	.	.	.
ChAss.,All.,Cl. *Elymo-Ammophiletum, Ammophilion borealis, Ammophiletea*												
Ammophila arenaria	**3**	**3**	+	+	1	1	.	.	.	.	.	.
Festuca villosa	**2**	**1**	1	.	+	+	.	.	.	+	.	.
Leymus arenarius	**+**	**1**	.	+	+	.	.	.	.	.	.	.
ChO.,Cl. *Atriplicetalia littoralis, Cakiletea maritimae*												
Cakile maritima	+	.	.	.	+	+	**+**	**+**	**+**	.	+	+
Salsola kali ssp.*kali*	.	+	+	1	.	.	**+**	.	**+**	.	.	.
Atriplex prostrata	.	.	.	.	.	.	**+**	**1**	**+**	.	.	.
Polygonum oxyspermum	.	.	.	.	.	.	**+**	**+**	.	.	.	.
Accompanying species **Gatunki towarzyszące**												
Salix daphnoides	.	.	.	.	.	.	.	.	.	**3**	**3**	**4**
Conyza canadensis	.	.	.	+	.	.	.	.	.	2	1	1
Rumex acetosella	.	.	.	.	.	.	.	.	.	1	+	1
Senecio vulgaris f.*litoralis*	.	.	.	.	.	.	+	.	.	+	1	+
Chenopodium rubrum	.	.	.	.	.	.	**2**	**1**	**3**	.	.	.
Chenopodium glaucum	.	.	.	.	.	.	**+**	**1**	**+**	.	.	.
Juncus bufonius	.	.	.	.	.	.	.	+	1	.	.	.
Tussilago farfara	.	.	.	.	.	.	.	.	.	+	+	.

Explanations – Objaśnienia: AE – aeolic accumulation – akumulacja eoliczna, AM – marine accumulation – akumulacja morska, + – few specimens – nieliczne okazy, · – lack of specimens – brak okazów.

In the collected cumulative soil samples, taken using soil probe rod from the surface layer of sandy base (0.20 m), soil-habitat conditions prevailing in the researched area were determined. Moreover, the state of ground moisture, according to Bednarek et al. (2004), was given and the value of pH in H_2O was determined, the content of general nitrogen in $g \cdot kg^{-1}$ was evaluated according to a modified Kjeldahl method as well as NaCl content in $g \cdot dcm^{-3}$ of sandy soil and also its origin were indicated as a result of marine or aeolic accumulation. Chemical analyses of soil samples were performed at the Local Chemical-Agricultural Station in Szczecin.

Based on the phytosociological documentation from 12 research points, a variation standard of analysed data was defined (diversification of psammophilous and halophilous plant areas), which is at largest explained by the considered environmental variables (base reaction, its salinity, moisture, content of general nitrogen, character of mineral material's accumulation). For this purpose a technique of Canonical Correspondence Analysis (CCA) was used, and calculation performed using MVSP package, after previous transformation of phytosociological records to an ordinal scale according to van der Maarel (Maarel 1979; Jongman et al.1987; Kovach 1985–1999; Piernik 2008). For the evaluation and comparison of bio-diversity of each sample (phytosociological records), Shannon-Wiener Species Diversity Index (*H*) was calculated and its value was placed at the head of phytosociological table.

$$H = -\sum_{i=1}^{S} (p_i \log_2 p_i)$$

where:

S – total number of species in a sample,

p_i – fraction of the *i*-th species in a sample

$$p_i = n_i / N$$

where:

n_i – number of individuals of the *i*-th species in a sample,

N – total number of all individuals in a sample.

RESULTS

The results of numerical analysis of 12 phytosociological records taken in the researched area, where the influence of given environmental variables on the development of phytonecoses connected to sand beach habitats was analysed, had shown the existence of 2 associations, one habitat, and one plant aggregation representing 2 class flora (Matuszkiewicz 2004) – Table 1, Fig.1.

The first subsection (I) differentiated two groups of plant habitats present in separated zones of the sand beach, formed as a result of influential prevalence of marine or aeolic accumulation of sand material. The areas of *Elymo-Ammophiletum* association (Fig.1, subsection III, IV: samples 1–2) and *Honckenyo-Agropyretum juncei* (Fig. 1, subsection III, V: samples 3–6) are related to the slopes of dry, and moved higher as a result of aeolic sand accumulation embryo dunes placed in the upper summer beach zone and a more massive foredune being formed. The second group of phytonecoses is related to the lower-based zone of the summer beach, subject to a direct influence of marine surges and shaped by the marine accumulation of sand material. This part of beach habitats is periodically flooded with sea water on the occasion of increased storm states, where its stagnation is also observed in the slacks behind the sandy berm. Areas of ephemeral, incomplete phytocenosis agglomerating species characteristic of *Cakiletea maritimae* class (Fig. 1, subsection II,VI: samples 7–9) and an aggregate agglomeration of daphne willow *Salix daphnoides* seedings appearance (Fig. 1, subsection II,VII: samples 10–12).

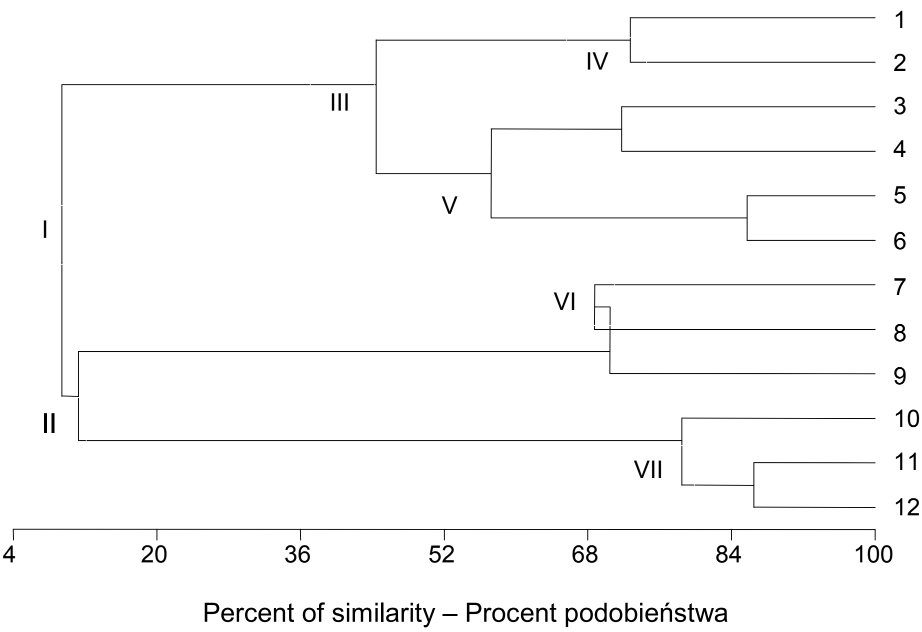

Fig.1. Hierarchical classification of phytosociological records of phytocoenoses within the area of investigations. I – VII subsections, 1–12 – phytosociological records (samples)
Ryc.1. Klasyfikacja hierarchiczna zdjęć fitosocjologicznych wykonanych w fitocenozach wykształconych na badanym terenie. I – VII – podziały, 1–12 – zdjęcia fitosocjologiczne (próby)

Using Canonical Correspondence Analysis, as a technique of direct ordinance, enabled sample ordering (phytosociological records) documenting the varieties of phytocenoses developed in the research area by selected environmental variables: base reaction (pH), moisture (H), salinity (NaCl), base content of general nitrogen (N), environmental pressure in the form of aeolic (AE) and marine (AM) accumulation of the sand material. Table 2 features weighted averages, standard deviations, and inflation coefficients of the analysed environmental variables based on the results of chemical analyses of soil base from all of the research points and evaluations of remaining parameters during field studies. The value of inflation coefficient in each of the analysed variables was > 1.0; thus the assumption of a strong correlation of a given variable with other environmental variables could have been discarded.

Own values of the first two ordinance axes (> 0.7) prove the unimodal structure of date (Table 3). The first axis explains almost 36%, and the second about 35% of the direct variability in species' occurrence in samples (phytosociological records), caused by the analysed environmental variables. High values of correlation rate between the sample indexes and environmental variables prove a strong relation between species occurring in samples and the base reaction, salinity, content of general nitrogen, moisture as well as intensity of observed marine or aeolic accumulation in the researched area.

Table 2. Descriptive statistics for environmental variables
Tabela 2. Statystyki opisowe zmiennych środowiskowych

Environmental variables Zmienne środowiskowe	Weighted mean Średnia ważona	Weighted SD Odchylenie standardowe	Inflation factor Współczynnik inflacji
pH	8.652	0.202	1.019
NaCl	0.484	0.668	1.820
N	7.488	12.104	10.334
H	2.841	1.376	17.809
AE	2.601	1.695	1.102
AM	2.837	1.803	4.770

Explanations: – Objaśnienia: pH – soil reaction – odczyn podłoża, NaCl – soil salinity – zasolenie podłoża, N – base content of general nitrogen – zawartość azotu ogólnego w podłożu, H – soil moisture – uwilgotnienie podłoża, AE – aeolic accumulation – akumulacja eoliczna, AM – marine accumulation – akumulacja morska .

Table 3. Canonical eigenvalues, percentage and cumulative percentage of explained variance and coefficient of correlation between species and environmental variables
Tabela 3. Wartości własne osi kanonicznych, procent i procent skumulowany wyjaśnionej wariancji oraz współczynnik korelacji między gatunkami a zmiennymi środowiskowymi

Ordination indices Wskaźnik ordynacyjny	Canonical ordination axes Kanoniczne osi ordynacyjne		
	axis 1 oś 1	axis 2 oś 2	axis 3 oś 3
Eigenvalues Wartość własna	0.815	0.792	0.252
Percentage Procent	35.933	34.926	11.124
Cumulative percentage Procent skumulowany	35.933	70.858	81.982
Coefficient of correlation Współczynnik korelacji	0.998	0.995	0.932

Correlation rates of the environmental variables along with sample indexes, counted as weighted averages of species' indexes, are included in Table 4. Along the 1st ordinance axis the strongest correlation between environmental variables and the location of samples (phytosociological rcords) is present for the variable of marine accumulation intensity (positive correlation) – AM variable explains 92% of plant's variability, and for the aeolic accumulation intensity (negative correlation) – AE variable differentiates plants in 84%. Along the 2nd ordinance axis – a positive correlation is present for the variables of general nitrogen N content and base NaCl salinity (each of which explains about 84% and 82% of plant variability, respectively).

Table 4. Coefficients of the correlation of environmental variables with sample indices
Tabela 4. Współczynniki korelacji zmiennych środowiskowych ze wskaźnikami prób

Environmental variables Zmienne środowiskowe	Canonical ordination axes Kanoniczne osi ordynacyjne		
	axis 1 oś 1	axis 2 oś 2	axis 3 oś 3
pH	– 0.408	– 0.906	– 0.009
NaCl	0.240	0.908	0.007
N	0.189	0.917	0.006
H	0.585	0.774	– 0.210
AE	– 0.920	– 0.345	0.165
AM	0.965	0.158	0.015

Explanations see Table 2 – Objaśnienia: zob. tab. 2.

The occurrence of samples in the ordinance space is presented in Fig.1. In this drawing, vectors of marine accumulation (AM) and aeolic accumulation (AE) intensity variables are the longest, and are at the same time strongly correlated to the first ordinance axis, which is proved by a small inclination angle of vectors to this axis. The values of AM variable at the diagram grow from left side of the ordinance space to the right, the values of AE variable are inverse, and the directions of AM and AE variables' vectors are oppositely directed to each other. The second ordinance axis is optimised by the variables of NaCl and N vectors, and they are very strongly correlated between each other, which can be seen in very small angles between their vectors (Fig. 2).

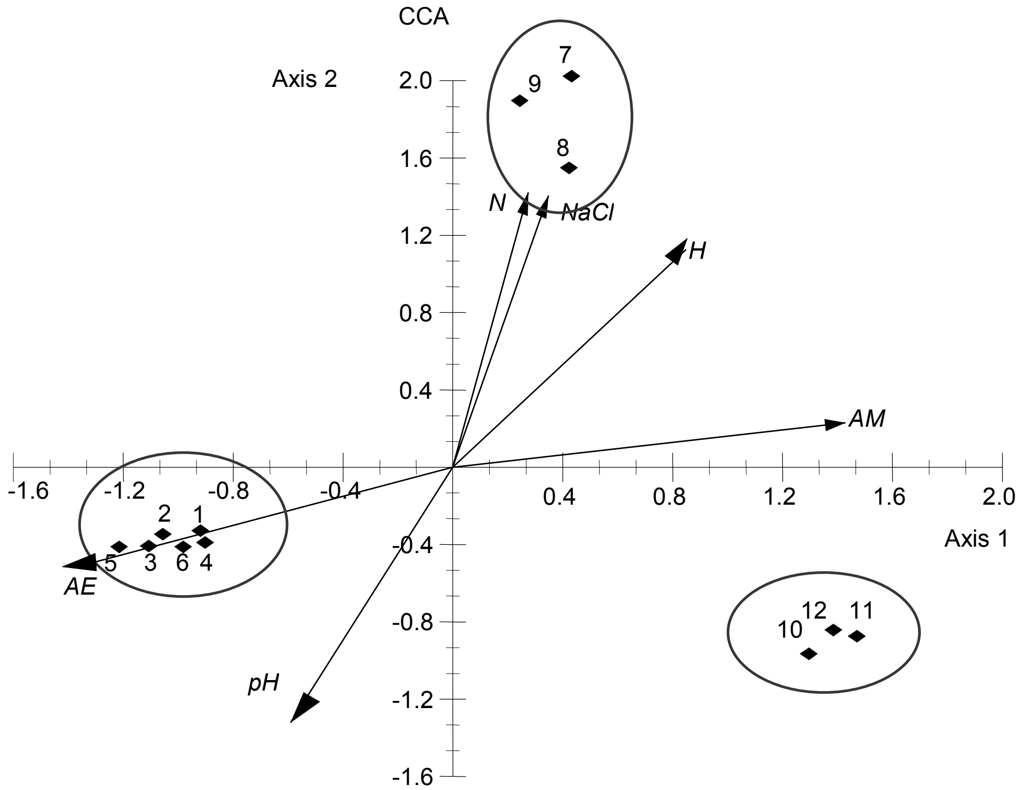

Fig. 2. The influence of environmental variables on distribution of the samples documenting diversity of phytocoenoses within the area of investigations. CCA – Canonical Correspondence Analysis; pH, NaCl, N, H, AE, AM – vectors of environmental variables; axis 1 – first canonical ordination axis; axis 2 – second canonical ordination axis; ◆ 1–12 – próby (phytosociological records)
Ryc. 2. Wpływ zmiennych środowiskowych na rozmieszczenie w przestrzeni ordynacyjnej prób dokumentujących zróżnicowanie fitocenoz na badanym terenie. CCA – kanoniczna analiza zgodności; pH, NaCl, N, H, AE, AM – wektory zmiennych środowiskowych; axis 1 – pierwsza kanoniczna oś ordynacyjna; axis 2 – druga kanoniczna oś ordynacyjna; ◆ 1–12 – próby (zdjęcia fitosocjologiczne)

In the right part of the diagram, below the 1st ordinance axis, located are the samples (Table 1 – phytosociological records 10, 11, 12) relating to the vector of AM variable, representing the growth of daphne willow *Salix daphnoides* and species relating to hungry, sand habitats developed here from the diaspora drifted along with sand material as a result of intense marine accumulation. These are species that are ecologically and geographically foreign to sand beach habitats (*Salix daphnoides*, *Conyza canadensis, Rumex acetosella*). Below the 1st ordinance axis, in the left part of the diagram a clear agglomeration relating to EA variable vector is created by samples that document phytocenosis of *Honckenyo--Agropyretum juncei* association with the presence of *Honckenya peploides* and *Elymus farctus* subsp. *boreoatlanticus* – species characteristic of this phytocenosis (Table 1 – phytosociological records 3, 4, 5, 6), and at the higher placed sandy dune slopes, being the effect of intense aeolic sand accumulation – areas of *Elymo-Ammophiletum* association of grassy vegetation (Table 1 – phytosociological records 1, 2).

In the top part of the diagram, on the right side of the 2nd ordinance axis at the variable vectors of salinity (NaCl) and content of nitrogen compounds in the base (N), exists an aggregation of samples documenting incomplete form of nitrophilous and halophile community of annual therophytes from *Cakiletea maritimae* class such as: *Cakile maritima, Salsola kali* subsp. *kali, Atriplex prostrata* or *Polygonum oxyspermum* inhabiting slacks that are lower-placed, periodically flooded or filled with stagnating marine water (Table 1 – phytosociological records 7, 8, 9).

DISCUSSION

The results of research indicate to the character of mineral material accumulation as a factor having the biggest influence on the development of psammophilous and halophilous plants on sand beach habitats. Aeolic accumulation in the zone of upper beach enabled forming embryo dune mounds stabilised by the key pioneer perennial species, such as: *Honckenya peploides* and *Elymus farctus* subsp. *boreatlanticus,* creating areas of *Honckenyo-Agropyretum juncei* association, and stimulated the development of a protected natural habitat of initial staged of the seaside white dunes (habitat code: 2110) (Łabuz 2002; Matuszkiewicz 2004; The Regulation of the Minister for the Environment of 13 April 2010). Among the particularly valuable species observed in this habitat was the sand couch grass *Elymus farctus* (Viv.) Runemark *ex* Melderis subsp. *boreoatlanticus* (Simonet & Guin.) Melderis – critically endangered perennial grass, long stolon, smooth blade reaching 60–70 cm length and simple ear infloresence (Markowski and Buliński 2004; Zarzycki and Szeląg 2006; Frey 2014). Its population on Mierzeja Przytorska sandbar is one of the biggest in the Polish Baltic seaside, among the currently confirmed areas (Stasiak 1988; Frey 1999; Frey and Szczepaniak 2001; Mizianty and Frey 2006).

The species of perennial expansive grasses *Ammophila arenaria* and *Leymus arenarius* entering this habitat and adapted for stabilising movable base as well as creating areas of grassy vegetation association *Elymo-Ammophiletum*, affected the formation and stabilisation of the deeper-located, massive foredune and the development of another natural habitat in a successive order – seaside white dune (habitat code 2120) – Łabuz (2005).

Both the areas of *Honckenyo-Agropyretum juncei* association and *Elymo-Ammophiletum* grassy vegetations created almost exclusively characteristic species with remarkable abilities to proliferation and dynamic expansion observed in favourable habitat conditions, which was confirmed by the low values of Shannon-Wiener Species Diversity Index for these samples (Table 1) (Harris and Davy 1986; Łabuz 2002; Miller at al. 2010).

Marine accumulation of sand material forced in by prevailing winds and sea surges in the North-East direction had a deciding influence on shaping habitat conditions in the zone of lower beach – with the periodically stagnating sea water and more saline base (Łabuz 2005). Communities of different species of nitrophilous and halophile therophytes (*Cakile maritima, Salsola kali* subsp. *kali, Atriplex prostrata, Polygonum oxyspermum)* representing *Cakiletea maritimae* class developed in this dynamically changing part of the beach. The values of Shannon-Wiener Species Diversity Index for these samples were distinctly higher (Table 1). Low salinity of Baltic marine waters in the Polish section of the seaside as well as strong human impact on the environment hinders the development of species characteristic of phytocenoses uniquely identifying the natural habitat of strandline vegetation at the sea shore (habitat code 1210), and the very *Atriplicetum littoralis* association is regarded as ephemeral or even extinct at our seaside (Piotrowska and Celiński 1965; Piotrowska 1988, 2001; Matuszkiewicz 2004; Markowski and Olszewski 2014). Diaspores of ecologically and geographically foreign species – both annual (*Conyza canadensis*) and perennial (*Salix daphnoides*) – also settle in the material accumulated in the lower part of the beach. They are usually washed out as a result of abrasion of this beach part during severe storms, however, diminished surges in the basin of external harbour fostered marine accumulation of sand material and the undisturbed development of, among others, willow *Salix daphnoides* growth in the lower and mid part of the summer beach in the researched area.

CONCLUSIONS

1. Aeolic accumulation of sand material had a deciding influence on shaping habitat conditions and the development of psammophilous and halophilous plants, identifying the natural habitat of initial stages of coastal white dunes in the upper part of the summer beach in the research area.
2. Marine accumulation shaping habitat conditions in the lower part of the summer beach was the source of, among others, ecologically and geographically foreign diasporas of species for sand dune habitats in the research area, and the moist slacks with periodically stagnating marine water in this part of the beach fostered the development of incomplete forms of nitrophilous and halophile therophyte communities.
3. Strong marine accumulation of sand material with a simultaneous decrease of abrasive storm surge influence in the basin of external harbour, enabled the development of ecologically and geographically foreign species of *Salix daphnoides*, the diaspora of which were situated in the lower zone of the summer beach in the research area.

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Abstract. The influence of selected environmental factors on shaping sandy beach habitats as a place for the growth of psammophilous and halophilous plants were the purpose of a research performed in the years 2013–2014 on Przytorska Sandbar (Natura 2000 area „Wolin and Uznam" PLH320019). The research was performed on a beach section, which was excluded from recreational use, and closely bordered with the external port basin of the Liquid Natural Gas terminal under construction, where also the abrasive influence of storm surges had been diminished. Research results indicated a dominant influence of aeolian sand material accumulation in shaping embryo dunes inhabited by pioneer species of psammophilous and halophilous plants - *Elymus farctus* subsp. *boreoatlanticus* and *Honckenya peploides* – species characteristic of the plant association of *Honckenyo-Agropyretum juncei* R.Tx. 1955, identifying the natural habitat of the initial stages of coastal white dunes (habitat code: 2110), the parts of which had been observed in the research area as a classically shaped form. The presence of *Ammophila arenaria* and *Leymus arenarius* creating initial forms of grassy vegetation association of *Elymo-Ammophiletum* indicated a proceeding stabilisation of embryo dunes – evolving into a foredune. A strong sea accumulation of sand material and simultaneous decrease of abrasive storm-tide influence enabled the development of an ecologically and geographically foreign species *Salix daphnoides*, diasporas of which were located in the area of lower beach.