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Individual natural environment features and landscape and tourist values of the *Cephalantero rubrae-Fagetum* habitat on Wolin Island

Abstract: The cliffed coast in Wolin National Park is especially valued in terms of biogeography. The coastal area is highly valuable not only in view of the abiotic advantages offered by the natural environment but also due to the presence of valuable plant associations. A coastal orchid beech forest – the *Cephalanthero rubrae-Fagetum* habitat – is a site that is unique in Poland, in Europe and in the whole world. This plant association is found only on the cliffed coast of Wolin Island in Poland in specific hydrometeorological, morphodynamic and soil conditions. The main aim of this study was a qualitative and quantitative description of the *Cephalanthero rubra-Fagetum* site, including determining its present range and species composition. In addition, the studied cliffed coast area was evaluated in terms of its visual attractiveness based on the aspects of geodiversity and biodiversity of landscape. Field studies corroborated the outstanding landscape values determining the attractiveness of the study area to tourists. The cliffed coast section, Grodno-Biała Góra, features unique environmental characteristics that are absent from the remaining part of the coastal area of the Baltic. A peculiar characteristic of geodiversity in that zone is the presence of the highest seashore in Poland where natural hydrodynamic and geomorphological processes occur free of human interference. This is the only part of the seashore featuring a unique soil, the so-called cliff naspa, on which orchid birch forests grow. This biodiverse plant community comprised 113 species of vascular plants among which 7 species of *Orchidaceae* were identified. The landscape values of the studied area of the Wolin National Park are further enhanced by two attractive tourist hiking trails and a vantage point on top of Gosań hill.
Keywords: *Cephalanthero rubrae-Fagetum*, Wolin National Park, orchids, cliffed coast, coastal habitats

1. Introduction

Due to its landscape (Cieśliński, 2010), bioclimatic (Tylkowski, 2017) and biotic values (Piotrowska and Olaczek, 1976; Piotrowska 2003), the Baltic coast is very attractive to tourists. The coastal area of Wolin Island also has unique natural values due to the diversity of coast types and plant communities. Thus, the geodiversity (Kot, 2006; Zwoliński, 2009; Kostrzewski, 2011) and biodiversity (Oleksyn and Reich, 2002) of Wolin Island are also measures of the attractiveness of this region to tourists. The cliffed coast, and especially the part extending between Grodno and Biała Góra, features geographical environment characteristics that are peculiar on a supra-regional scale. This seashore zone is home to a unique plant community – *Cephalanthero rubrae-Fagetum* (Czubiński and Urbański, 1951; Matuszkiewicz, 2000; Piotrowska, 1955, 1993). Furthermore, the cliffed coast within the area of the Wolin National Park is free of any erosion control facilities, which fosters natural development of the terrain relief. The analysed seashore section is accessible to tourists within two tourist hiking trails. Thus, the unique natural values of the highest cliffed coast in Poland can be explored by visitors to Wolin Island and are without any doubt a tourist amenity.

On a global scale, tourism has become one of the major branches of industry (Ghosh, 2011). In Poland, in 2018 income from tourism accounted for 4% GDP (Czernicki et al., 2020).

About 40% of the world's population live in sea coast zones (Burke et al., 2001) and are strongly dependent on the development of the tourist industry. Currently, the Polish coast of the Baltic is also under strong pressure of developing tourist services, yet these may contribute to degrading the natural environment. Therefore, it is essential that, together with promoting tourist attractions at the seaside, rules of sustainable development of tourist services, including ecotourism, are observed (Diamantis, 2010).

This study mainly aimed at presenting the individual natural environment features of the cliffed coast within the *Cepahalanthero rubrae-Fagetum* site and emphasizing its attractiveness in terms of landscape. A detailed phytosociological survey of the studied habitat was carried out focusing on the specific characteristics of geomorphological processes underlying its development. In addition, the studied cliffed coast zone was classified in view of its landscape value and attractiveness of tourist trails.

2. Area descriptions, methods and material studied

2.1. Research area

The cliffed coast of Wolin Island is a very important element of the landscape structure of the South Baltic Sea Coast. The cliffed coast of Wolin Island, which is 15 kilometres long and has a maximum elevation of 95 m asl (Gosań Hill), has natural environment characteristics peculiar on a supra-regional scale.

The study area is a cliffed coast zone from km 407.5 and km 410.1 of the seashore (as measured by the Maritime Office), (Fig. 1). This

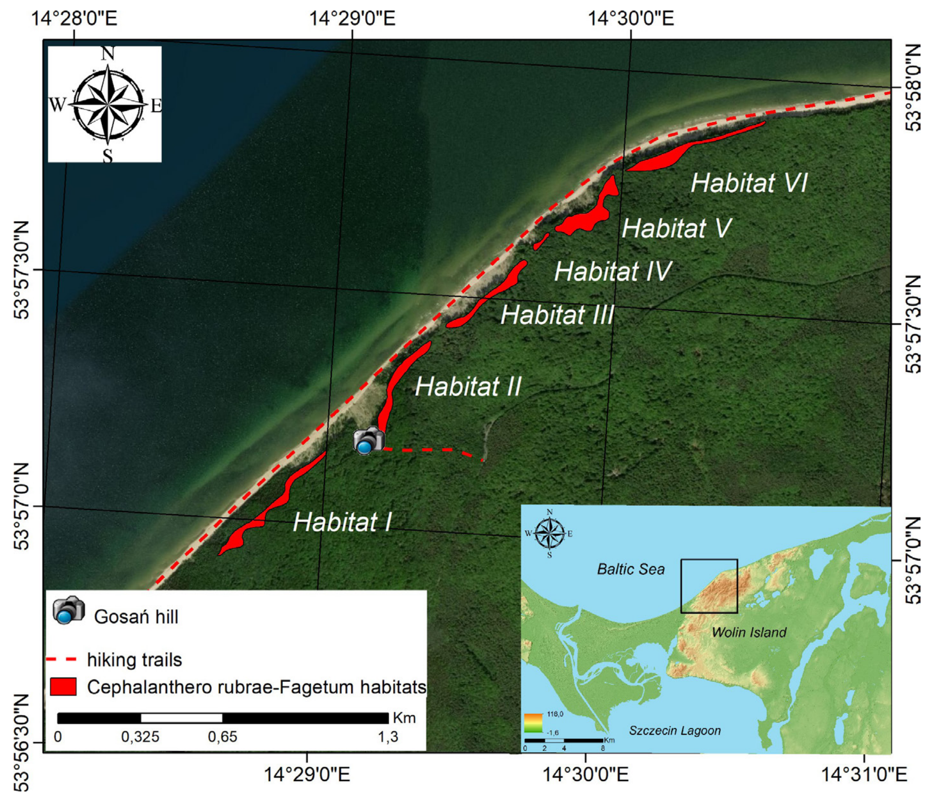

Figure 1. Study area – the cliffed coast of Wolin Island and the Cephalanhtero rubrae-Fagetum site (based on the author's own study)

Figure 2. The cliffed coast of Wolin Island near Świdna Kępa (photo by M. Winowski)

zone features the highest seashore in Poland. It shows a unique physiographic diversity determined by its geological structure, morphometry and morphology (Fig. 2). The study area is not subject to forms of anti-erosion protection and illustrates excellently the effects of interaction between sea and land. The denuded surface of exposed clay and sand face of the cliff clearly shows the geological structure of the main geomorphological unit of Wolin Island, that is, the Wolin Terminal Moraine. Due to the big diversity of the geological structure, on the studied 2.6 km long section, all geodynamic cliffed coast types found on the Polish Baltic coast (Subotowicz, 1982): formed by rockfall, landslips, landslides and runoffs, can be seen. The erosive nature of the coast leads to the presence of narrow, often coarse-grained beaches. Boulders exposed by storms provide a valuable testimony of the rich geological past of this area.

The cliffed coast is situated within the reach of the *Luzulo pilosae-Fagetum* forest community which is rare in the Polish Plain. In the coastal strip between Biała Góra and Grodno an exceptionally rare habitat of *Cephalanthero rubrae-Fagetum,* Natura 2000 code 9150-5, was documented as the only such site in Poland.

The studied section of the seashore is situated within the Wolin National Park and its most valuable part, comprising the *Cephalanthero rubrae-Fagetum* habitat, is a strict protection area named after Zygmunt Czubiński. The Coastal Orchid Beech Forests of Wolin Island is a peculiar natural oddity. This is the most distinct of five such habitats occurring in Poland (Matuszkiewicz, 2020). The habitat of *Cephalanthero rubrae-Fagetum* covers a narrow strip between the ridge of the cliff and the Pomeranian acidic beech forest association (*Luzulo pilosae-Fagetum)*. The existence of this natural phenomenon is closely linked with the presence of a specific type of soil – the cliff naspa (Prusinkiewicz, 1971). The soil rich in calcium carbonate creates ideal conditions for species from the *Orchidaceae* family on the top of the cliff. The formation of cliff naspa is closely linked with marine erosion processes affecting the cliffed coast leading to intense geomorphological processes on the cliff downslope. The slope of the cliff is exposed to wind which blows fine-grained and very fine-grained sand and carbonate rock dust onto the top of the cliff. As a result, there is a fertile layered soil consisting of aeolian mineral material cyclically overblown from the cliff slope and organic layers formed by the falling leaves of *Fagus sylvatica*. The spatial range of the mineral layer being overblown onto the cliff hinterland (within the reach of the *Cephalanthero rubrae-Fagetum* site) sometimes reaches 100-150 m and is closely linked with the morphodynamics of a cliffed coast. The height of the cliff is also very important for the development of the studied plant association. A fully developed habitat of *Cephalanthero rubrae-Fagetum* can also be seen within reach of the highest parts of the coast. This is connected with the fact that the bigger the cliff face surface is, the bigger the amount of aeolian material containing calcium carbonate is supplied to the top of the cliff (Piotrowska, 1993). In addition, the orchid beech forest features different topoclimatic conditions than deep forests do. Increased supply of light from the side of the sea fosters the development of undergrowth species richness. This is host to both heliophilous species typical of meadows and sand grasslands as well as species typical of forestland. Strong wind also affects tree stand development. Beeches are relatively short trees with low-growing branches and often contorted tops (Piotrowska, 1993).

The study area is a location of Natura 2000 sites that are also protected areas on the Wolin and Uznam Islands – PLH320019:

- 1230 – Cliffs of the Baltic Coast. This is a very dynamic habitat in which erosion and denudation processes lead to damage of the cliff slope and its vegetation, followed by the re-initiation of plant succession. This habitat can be classified as two sub-habitats: 1230-1 active cliffs and 1230-2 inactive cliffs. The species of plants growing on the cliff are classified as: *Poo-Tussilaginetum farfarae*, *Trifolio-Anthylidetum maritimae*, *Hippophaëtum rhamnoides and Ficario-Ulmetum violetosum odoratae* associations,
- 9110 – *Luzulo Fagetum* beech forests that, compared to the Baltic orchid beech forests, feature a sparse understory with poor floral diversity and a thick litter cover. The habitat forms a plant association called *Luzulo pilosae-Fagetum* with characteristic species including *Trientalis europaea* and *Luzula pilosa*.
- 9150-5 Baltic orchid beech forests – *Cephalanthero rubrae-Fagetum* that in comparison with the above-mentioned habitats is considerably richer in plant species. The locally occurring species include representatives of various forest and non-forest communities: beech forests growing on acid soils, acidophilous oak forests, pine forests, meadows and psammophilous grasslands.

The study area is accessible to tourists who can enjoy hiking trails and a vantage point (Fig. 1). A red trail runs at the foot of the cliff from Wisełka to Międzyzdroje. Alternatively, on the top parts of the cliff a vantage point on Gosań Hill, situated in the close neighbourhood of an orchid beech forest, is available to tourists. From this spot, which is the highest point on the Polish coast of the Baltic, there extends a wide panoramic view of the Pomeranian Bay and the Wolin and Uznam Islands.

2.2. Methods

The individual geographic features of the *Cephalantero rubrae-Fagetum* habitat were evaluated based on field mapping carried out in 2018-2020 in the coastal strip of the forest divisions Międzyzdroje 11-16. The habitat was explored in three stages:

- Stage one comprised outlining the reach of the habitat. To this end, the occurrence of the indicator orchid species *Cephalantero rubrae* (red helleborine) was identified (Fig. 3). All the above-mentioned forest divisions were investigated in detail for its occurrence and the GPS coordinates were recorded for each shoot/plant found. The obtained data was used in order to create a map of the habitat (Fig. 1).
- At stage two, field mapping of vegetation was carried out involving an inventory of all the discovered vascular plant species with a particular focus on the *Orchidaceae.*
- At the third stage phytosociological photos were taken using the Braun-Blanquet method within the area of typical patches of the study site. Nine test areas were set up in which phytosociological photographs were taken. Each of the images underwent full phytosociological analysis. The following characteristics were determined: value of vegetation cover in respective layers of the tree stand (a - trees, b – understory, c – undergrowth); plan community structure expressed as species cover percentage using the Braun-Blanquet approach; structure of the flora (systematic, geographical and historical and continental and Raunkiaer's life forms classification); share of

Figure 3. *Cephalanthero rubra* – the indicator species of the *Cephalanthero rubrae-Fagetum habitat* (photo by P. Czyryca)

old-growth forest species; geographic element of the flora.

Landscape attractiveness of the studied coastal area constituting an orchid beech forest site was evaluated using the methodology developed by Cymerman and Hopfer (1988) and applied by Mirowska and Krysiak (2015), among other authors. This paper evaluates the landscape bases on an image recorded on photographs taken mainly using a drone in March and June 2019. The natural valuation of the cliffed coast within reach of the *Cephalantero rubrae-Fagetum* habitat extending on an area of 1.25 km^2 (2.5 km long and 0.5 km wide), within an array of five 0.5 x 0.5 km squares (Fig. 4).

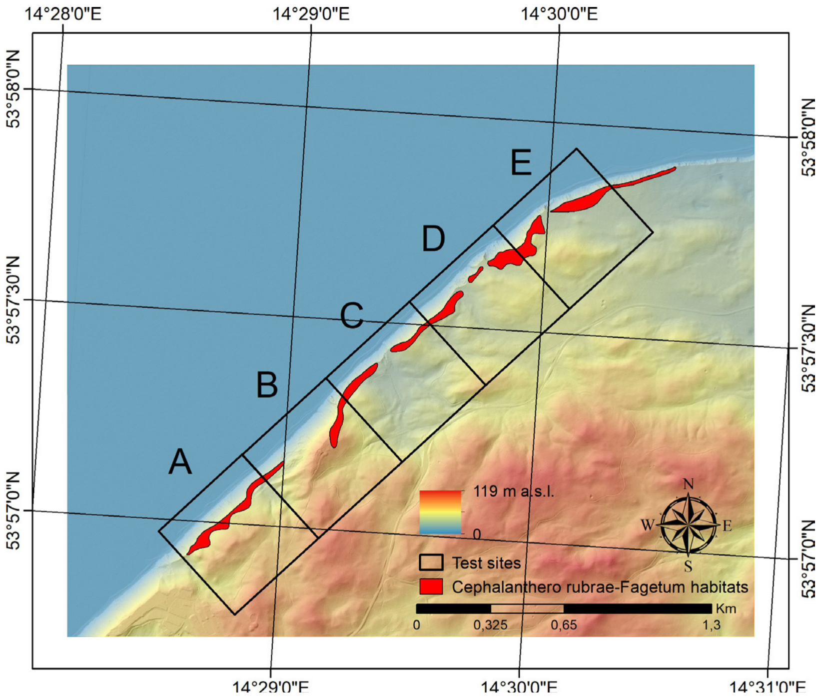

Figure 4. Grounds for testing the attractiveness of the cliffed coast within the reach of *Cephalanthero rubrae-Fagetum* (based on the author's own study)

Landscape attractiveness was evaluated based on selected criteria as proposed by Skarżyński (1992), (Table 1). According to such criteria, the specific testing ground could score from 1 to 32 points. Scoring took into account five classes of visual attractiveness of landscape: ≤7 visually unattractive area, 8-13 area with low visual attractiveness, 14-19 area with average visual attractiveness; 20-25 area with high visual attractiveness and ≥25 area with very high visual attractiveness.

Table 1 . Criteria for evaluating the visual attractiveness of landscape (based on Skarżyński 1992, changed)

Criterion		Scoring
Number of planes in the landscape	Three planes	5
	Two clear planes with a third plane showing through	4
	Two planes	3
	One plane with another plane showing through	2
	One plane	1
Number of landscape-forming elements	Varied landscape – more than 8 elements	5
	Medium varied landscape – 6–8 elements	3
	Poorly varied landscape – less than 6 elements	1
Diversity of landscape-forming elements	Water bodies	
	Dominant in landscape	5
	Noticeable – present but not predominant	3
	Absence of water bodies	1
	Vegetation	
	Presence of a dense forest in the landscape, single trees or tree concentrations	3
	Presence of a dense forest, single trees or tree concentrations only	2
	Shrubs	1
	Absence of woody plants and shrubs	0
	Terrain relief –height differences and downslopes	
	Height differences and downslopes – Dominant in landscape	5
	Noticeable – present but not predominant	3
	Grounds with low height differences and downslopes	1
	Plains	0
Individual natural or anthropogenic objects or their assemblies	Positive enhancing value, e.g., monuments of architecture, old cemeteries, neat buildings, monuments of nature, picturesque roads)	1
	Neutral (having no influence on landscape, e.g., part of catenary lines, roads, houses, and fences)	0
	Negative (decreasing value, e.g., unkempt buildings, landfills, clearly visible catenary lines etc.)	-1
	Extremely negative (blatantly unesthetic buildings, groups of anthropogenic objects predominant in the landscape, e.g., unesthetic farms, rows of barracks, exceptionally unkempt buildings)	-2
Landscape harmony	Harmonious landscape	5
	Landscape with partly disturbed harmony	3
	Landscape with strongly disturbed harmony	1
	Landscape with completely disturbed harmony	0
Vertical structure of landscape	Well developed	3
	Medium developed	2
	Poorly developed	1

On the other hand, the attractiveness of a coastal tourist trail situated at the foot of the cliff and a trail leading to the vantage point on Gosań Hill was evaluated using the methodology by Rogowski (2012). It was a four-class evaluation of trail effectiveness: ≤5 not very attractive, 5.1-8 moderately attractive, 8.1-11 attractive and >11 outstandingly attractive. The natural valuation took into account the criteria connected with tourist values, transport availability and development for the purposes of tourism.

3. Results

3.1. Phytosociological properties of the *Cephalanthero rubrae – Fagetum habitat*

Red helleborine (*Cephalanthera rubra*) as a thermophilous species growing in well-lit deciduous forests on fertile soils rich in calcium, at the same time being a species characteristic of the studied assemblage is a relevant indicator of the range of the orchid beech forest on Wolin Island. Based on field mapping and GPS positioning it was found that currently the habitat of *Cephalanthero rubrae-Fagetum* covering a total area of about 7 ha consists of six separate sites (Fig. 1) under different stages of development.

A habitat with a typical species composition developed on sites II, III, IV, V and VI. On the other hand, site I shows characteristics of a decaying habitat. The count of *Cephalanthera rubra* found on sites with a typical species composition ranged between 15 shoots per hectare on site VI and 50 shoots per hectare on site IV. On site I only four shoots per hectare were found. Sites II, III, IV, V and VI feature good conditions for the development of the habitat. The face of the cliff along them is exposed with visible aeolian deposition processes, which fosters the formation of cliff naspa (Fig. 5). Good lighting conditions support the development of a rich variety of undergrowth species. Seven species of orchids: *Cephalanthera rubra, Cephalanthera damasonium, Corallorhiza trifida, Epipactis atrorubens, Epipactis helleborine, Neottia nidus-avis, and Platanthera bifolia* were found on the five sites.

Figure 5. Aeolian deposition on *Cephalanthero rubrae-Fagetum* site VI (photo by J. Tylkowski)

Site I has distinct morphodynamics. It is situated on the so-called "dead cliff" that for many years has been free of the processes of marine erosion and blowing of the mineral material onto the top of the cliff. The slope of the cliff is overgrown with a dense pine tree stand (*Pinus sylvestris*) aged about 35 years. The variety of undergrowth species is poor and a few representatives of *Cephalanthera rubra* can testify to the local existence of an orchid beech forest in the past. Thus, site I illustrates the importance of the cliff's geomorphological activity processes leading to deposition of aeolian sediments rich in calcium carbonate on the top of the cliff for the existence of *Cephalanthero rubrae-Fagetum* habitats.

A detailed phytosociological analysis reveals the uniqueness and species richness of the *Cephalanthero rubrae-Fagetum association.* Its complex structure consists of five layers: a1, a2, b1, b2, and c. The layer of trees taller than 15 m (a1) is well-developed. It covered

40-95% of the surveyed test areas (nine phytosociological photographs). On the other hand, a layer of shorter trees (a2) was identified for two test areas only. Layer a2 is less well developed than layer a1, since trees cover 15-50% of the test area and a layer of trees shorter than 15 m was absent from most of the surface. The layer of trees on all test areas is composed of European beech (*Fagus sylvatica*) only. On the other hand, few pines (*Pinus sylvestris*) grow throughout the habitat. The layer of shrubs (b1) visible on five phytosociological photographs consisted of a *Fagus sylvatica* sapling stand covering from 5% to 75% of the area. On the other hand, *Fagus sylvatica* saplings in some test areas were well developed (5-50% of the area) but in four areas they did not grow at all. The ground cover (c) is well developed but at some points the percentage of coverage was low. In test areas 7 and 8, the herbaceous plant cover was 5 and 10% only. In other areas the plant cover in the undergrowth was 50-95% (Table 2).

Table 2. Vegetation cover [%] in test areas (phytosociological photographs) within the *Cephalanthero rubrae-Fagetum* habitat (based on the author's own study)

Forest layer symbol		Phytosociological photograph number								
1		2	3	4	5	6	7	8	9	
a	a1	50	75	90	80	90	95	70	60	40
	a2	-	-	15	-	-	-	50	-	-
b	b1	-	-	-	5	10	-	5	75	50
	b2	-	20	5	-	25	-	5	-	50
c		90	95	50	70	50	95	5	10	50

The ground cover was dominated by species from the *Poaceae* family, including false brome (*Brachypodium sylvaticum*), cock's-foot (*Dactylis glomerata*) and wood bluegrass (*Poa nemoralis*). Other numerously represented species were: peach-leaved bellflower (*Campanula persicifolia*), lily of the valley (*Convallaria maialis*), common yarrow (*Achillea millefolium*) and orchids characteristic of this type of habitat such as red helleborine (*Cephalanthera rubra*), white helleborine (*Cephalanthera damasonium*) and dark-red helleborine (*Epipactis atrorubens*).

The litter cover varied depending on the coast section. It ranged from 25% to 95%. A layer of organic matter was mainly composed of beech leaves and to a much smaller extent contained the remains of herbaceous plants. Beech leaves, due to their coriaceous structure, decompose slowly, so they tend to accumulate in large amounts. Aeolian deposition is visible – the litter is covered with a large volume of sand and dust, a layer of which is also deposited on plants (Fig. 5).

Within the reach of the *Cephalanthero rubrae-Fagetum* habitat 113 species of vascular plants were discovered. On the other hand, in all test areas (nine phytosociological photographs) the total count of vascular plant species was 92. Species richness testifying to biodiversity of the habitat in respective test areas ranged from 37 to 60 species of plants (Table 3).

Table 3. Species richness of plants found in forest layers within the *Cephalanthero rubrae–Fagetum* habitat (based on the author's own study)

Forest layer symbol		Phytosociological photograph number								
1		2	3	4	5	6	7	8	9	
a	a1	1	1	1	1	1	1	1	1	1
	a2			1				1		
b	b1			1	1	1		1	1	1
	b2		1	1		1		1		1
c		59	52	43	39	41	46	38	41	34
Total		60	54	47	41	44	47	42	43	37

The rich flora of the *Cephalanthero rubrae-Fagetum* habitat is an association of 113 species of vascular plants representing two divisions – *Pteridiophyta* and *Spermatophyta*. As regards *Pteridiophyta*, four species were recorded: *Dryopteris carthusiana, Dryopteris filix-mas, Polypodium vulgare* and *Pteridium aquilinum.* On the other hand, the *Spermathophyta* division was represented by three classes: *Pinopsida* (two species: *Juniperus communis* and *Pinus sylvestris*), *Magnoliopsida* (23 orders, 29 families and 81 species) and *Liliopsida* (three orders, six families and 26 species). The families richest in species are: *Poaceae* (14) *Asteraceae* (13) *Fabaceae* (10), *Orchidaceae* (7) and *Rosaceae* (6).

In the *Cephalanthero rubrae-Fagetum* habitat forest species characteristic of fertile and acidic beech forests, acidophilous oak forests, and coniferous forests co-exist with species characteristic of meadows and psammophilous grasslands, e.g., *Artemisia campestris* and *Hieracium umbellatum*. Special syntaxonomic importance is attached to species of orchids typical of calciphilous beech forests *Cephalanthero–Fagenion*, including seven taxons (*Cephalanthera damasonium*, *Cephalanthera rubra*, *Corallorhiza trifida, Epipactis atrorubens, Epipactis helleborine, Neottia nidus-avis, and Platanthera bifolia*). In addition, species representing the following syntaxons were found: *Querco-Fagetea* (including *Hepatica nobilis*, *Anemone nemorosa*, *Poa nemoralis*), *Vaccinio-Piceetea* (including *Pyrola minor*, *Vaccinium myrtillus*, *Trientalis europaea*), *Festuco-Brometea* (including *Anthyllis vulneraria*, *Dianthus carthusianorum*, *Scabiosa columbaria*), *Molinio-Arrhenatheretea* (including *Cerastium holosteoides*, *Trifolium pratense*, *Prunella vulgaris*) and *Artemisietea vulgaris* (including *Cirsium aevense*).

The flora of the studied habitat comprises representatives of six main categories of life forms. The biggest species share was noted for hemicryptophytes (67, including *Brachypodium sylvaticum*, *Campanula persicifolia*), followed by geophytes (18, including *Cephalanthera rubra*, *Epipaptis atrorubens*), therophytes (13, including *Vicia sepium*, *Trifolium dubium*), chamaephytes (11, including *Artemisia campestris*, *Orthilia secunda*), nanophanerophytes (11, including *Lonicera xylosteum*, *Rosa canina*), megaphanerophytes (5, including *Fagus sylvatica*, *Fraxinus excelsior*). If a plant had two life forms (12 species,) both forms were taken into account.

The flora of the habitat was outstandingly natural as 109 native species (76 spontaneophytes and 33 apophytes) and only 4 alien species (two archeophytes *Vicia sepium* and *Fallopia convolulus* and two kenophytes *Impatiens parviflora and Cytisus scoparius*) were identified. The highest share among alien plant species was that of *Impatiens parviflora* which formed vast fields near the Gosań vantage point. Other alien species were found sporadically. It may be assumed that the degree of synathropisation was low, amounting to only 4%.

Within the habitat 36 species characteristic of old-growth forests (including *Convallaria majalis*, *Polygonatum odoratum*) were identified that, according to the definition, testify to the existence of a forest habitat for at least 200 years. Their share in respective test areas ranged from 28% to 49%, while within the reach of the whole orchid beech forest habitat it was 32%. Such a high share of old-growth forest species emphasizes the naturalness of the *Cephalanthero rubrae-Fagetum* habitat.

The flora of *Cephalanthero rubrae-Fagetum* can be classified as one of three geographic elements: linking (62 species), Holarctic (49 species) and an element with cosmopolitan distribution (two species, *Pinus sylvestris* and *Pterydium aquilinum*). The linking element had the largest species share of two sub-elements: Eurosiberian-Mediterranean-Iranian (19, e.g., *Brachypodium sylvaticum*, *Galium odoratum*), temperate European-Mediterranean (16, e.g., *Campanula persicifolia*, *Cephalanthera rubra*). On the other hand, the sub-elements of the Holarctic element had the following species share: Eurosiberian (26, e.g., *Lonicera periclymenum*, *Epipactis atrorubens*), circumboreal (17, e.g., *Poa nemoralis*, *Corallorhiza trifida*) and temperate European (8, e.g., *Centaurea stoebe*, *Cardaminopsis arenosa*).

3.2. Tourist attractiveness of the cliffed coast landscape within reach of the *Cephalanthero rubrae-Fagetum* habitat

The analysed cliffed coast zone is situated on the northern downslope of the Wolin Terminal Moraine. This unit features very rhythmical terrain relief with numerous hills and depressions that are often landlocked.

All testing grounds (A-E, Fig. 4) are very attractive in visual terms. The total score was 28 (testing ground A) and 29 (testing grounds B-E). For the majority of criteria (Table 1), the testing grounds scored the maximum number of points. Only in the number of landscape-forming elements, were the objects classified as medium class (3 pts), and for testing ground A the vertical structure of landscape was medium developed (2 pts). The analysis of the images and numerical terrain model made it possible to describe selected geographic elements having an influence on geodiversity and landscape attractiveness (Table 4). The visual attractiveness of landscape for selected testing grounds is presented in Figure 6.

Table 4. Morphodynamic characteristics of the cliffed coast (based on the author's own study).

Testing ground	Hypsometry [m asl]		Falls [%]	Exposures	Morphodynamics of the cliff slope	Morphological diversity of the cliff hinterland (including the *Cephalanthero rubrae-Fagetum* habitat)
	Maximum height	Medium height	Strongly inclined and steep (19-45°)	Predominant		
A	100	61	74	63% N	Dead cliff; overgrown with pine forest	Quite considerable relief dynamics; terrain relief masked by forest communities
B	102	62	78	61% N	Active cliff; scarcely vegetated; landslip type; the highest type	Quite considerable relief dynamics; big height differences, a large rotating landslide (break) within the cliff and rather monotonous landslip slopes
C	74	39	67	55% N	Active cliff; scarcely vegetated; landslide-runoff type in the western part and landslip type in the eastern part	Relatively low terrain relief dynamics; landslip zone only on the western part of the cliff, the rest of slopes are quite monotonous.
D	73	44	67	51% N	Active cliff; scarcely vegetated; landslip type in the western part and landslide-runoff type in the eastern zone	Moderate terrain relief dynamics; monotonous slopes on the western part of the cliff, and highly varied central and eastern part – landslides
E	67	40	54	58% N	Active cliff; scarcely vegetated; landslip type in the western part, rockfall type in the central part, and landslide-runoff type in the eastern part	Quite considerable terrain relief dynamics; a mosaic of geomorphological forms

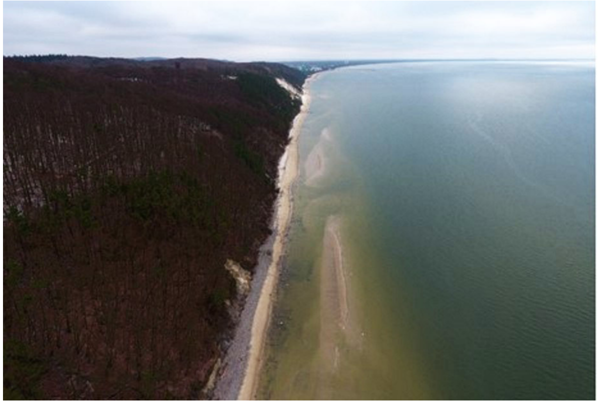


Figure 6. Cliffed coast landscape – testing grounds A (left) and D (right) (photo by M. Winowski)

Table 5 presents an evaluation of attractiveness of tourist trails. Both the coastal trail at the foot of the cliff and the trail leading to the Gosań vantage point on the top part of the cliff feature outstanding tourist values (class IV). The highest class for this criterion reflects the unique landscape, sightseeing and hiking values of both trails. The coastal trail scored better for development for the purposes of tourism (class IV) and transport accessibility (class III) than the trail leading to the top of Gosań Hill – class III and II, respectively. In the above-mentioned evaluation, the biggest drawback was poor accessibility of the trail leading to Gosań Hill. However, the end evaluation presents their unique attractiveness to tourists – the coastal trail was assigned to the highest class as an outstandingly attractive trail, while the trail to Gosań Hill was evaluated as attractive.

Table 5. Attractiveness of tourist trails (based on the author's own study, after Rogowski 2012)

Tourist trail	Tourist values	Transport accessibility	Development for the purposes of tourism	Trail attractiveness
Coastal	IV	III	IV	11.5 pts outstandingly attractive
Gosań	IV	II	III	10.5 pts attractive

4. Discussion

The study area can be classified as a glacial hilly lowland with predominant soils being brunic arenosols and luvisols and more rarely cambisols. In the land part there are no bodies of surface water and groundwaters are found at considerable depths. Potential vegetation comprises oak-hornbeam forests and mixed forests (Richling and Ostaszewska, 1992). According to Chmielewski et. al. (2015), the study area features mainly two types of landscape: surface waters (maritime) and forest (with predominant forest habitats). Woodless landscape, that is, the beach, has a considerably smaller spatial range.

The orchid beech forest of Wolin Island is a peculiar plant community which, in view of its location within an erosive cliffed coast zone, is subject to continuing spatial transformations. However, a secular, not very intense erosion of the coast, has no negative impact on the status of the habitat and is even necessary for its development. A peculiar mechanism has come into existence here without which the *Cephalanthero rubrae-Fagetum* association could not develop. The high rate of aeolian deposition fostering the development of cliff naspa is a priority factor underlying the development of orchid beech forests. In the case of geomorphological stabilisation of the cliff face, the supply of aeolian matter containing calcium carbonate necessary for the development of species from the *Orchidaceae* family is reduced. On the other hand, strong marine erosion of the cliff can cause an excessively accelerated retreat of the cliff top leading to a loss of large patches of the habitat. However, due to an increase in heat resources and the uncertainty of atmospheric precipitation, in the 21st century climate change poses a relatively higher risk to the functioning of the studied habitat than sea coast erosion (Tylkowski et al., 2021). Growth trends in mean annual air temperature, extended vegetation season and increased thermal resources may contribute to the transformation of forest phytocenoses in the Polish coastal area of the Baltic Sea. Considering the dynamics of an increase in mean air temperature (0.3°C/10 years), in the current half century the coastal area will feature potentially good conditions for the dynamic development of forest communities of the *Fagetum* type, and, at the same time, air temperature will be too high for forest communities of the *Piceetum* type. However, if the present upward trend in air temperature and thermal resources lasted for a very long time, then in the 22nd century the conditions in Southern Baltic coastal regions would be especially advantageous for predominant forest communities with high thermal requirements, such as *Castanetum* (Tylkowski, 2015). Thus, in the 21st century thermal conditions will most likely foster the development of thermophilic orchid beech forests, but in the following century they will be too challenging for the growth of *Cephalanthero rubrae-Fagetum*.

Studies of aeolian processes in the area of the Baltic coast enabled determining the most likely values for elements of the weather (Hojan et al., 2018) triggering aeolian processes on the cliff through cliff slope erosion, transport of mineral matter and its accumulation on the top of the cliff and, as a consequence, the development of cliff naspa. On average in one year (2009-2014) there were six days which satisfied the meteorological criteria for the occurrence of aeolian processes on the cliff of Wolin Island. The best meteorological conditions for the occurrence of aeolian processes were found in autumn and winter with relatively higher wind speed and low efficiency of precipitation. At that time, niveo-aeolian processes were also noted. In turn, aeolian processes on the cliff were relatively rarer in the spring and summer season when wind speed was lower and atmospheric precipitation was more efficient (Tylkowski, 2018).

Floristic analysis demonstrated that the species composition of the habitat changed little in the last half century – compared to studies carried out in the 1970s (Piotrowska, 1993). At that time, nine species from the *Orchidaceae family were identified.* On the other hand, in 2018-2020 seven species of orchids were found there. In addition, a definite majority of vascular plant species listed by Piotrowska (1993) were identified.

According to data from Statistics Poland (GUS, 2019), every year Wolin National Park is visited by 1.5 million tourists. Evidence of the high attractiveness of the vantage point on Gosań Hill to tourists is the 21-34 thousand car park tickets sold every year (2007-2009) and more than 800 tourists visiting it every day in summer (Dusza et al., 2013). A big problem is the absence of a hiking or cycling trail by which non-motorised tourists from Międzyzdroje could reach Gosań. Tourists hiking or cycling along regional road number 102 put their safety at high risk, the more so since tourist traffic on the trail to Gosań is about 100 thousand people a year with an upward trend. Therefore, concepts of a new tourist trail to connect Międzyzdroje to the vantage point on Kawcza Góra with educational facilities in Biała Góra and ultimately to the vantage point on Gosań Hill have appeared (Samołyk, 2016). Such a proposal is worth considering in order to improve tourist safety and the infrastructure of the analysed object.

5. Conclusions

The environmental analysis of the cliffed coast of Wolin Island leads to the following general conclusions:

- The occurrence of the *Cephalanthero rubrae-Fagetum* habitat in the studied coast area is very valuable and unique. This is the only orchid beech forest site on the Polish coast of the Baltic. Phytosociological analysis revealed a rich species composition of the habitat, which is manifested in the occurrence of 113 species of vascular plants, including seven species of orchids,

– The study area has outstanding natural values, which is reflected in its large biodiversity and geodiversity,
– The analysed landscape of the sea coast area is highly attractive in visual terms and is available to tourists as two hiking trails and a vantage point.
– It should be emphasised that the habitat of *Cephalanthero rubrae-Fagetum* is not directly accessible to tourists since it is situated within a strict protection area of the Wolin National Park. Therefore, in order to popularise this unique natural object, noticeboards should be set up at the vantage point of Gosań Hill informing about the existence of this valuable plant habitat.

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