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Plant communities of the Admiralty Bay region (King George Island, South Shetland Islands, Antarctic) I. Jasnorzewski Gardens *

ABSTRACT: Paper presents the description and floristic and ecological characteristics of three plant communities on the area of Jasnorzewski Gardens in the region of Arctowski Station (Polish Academy of Sciences) on King George Island. They are: 1) *Deschampsio antarctici-Colobanthetum quitensis*, 2) *Polytrichetum alpini*, 3) *Calliergidio austro-straminei-Calliergonetum sarmentosi*. All communities show a considerable differentiation to several variants.

Distribution of plant communities on the studied area is presented on a map based on computer analysis of multispectral air photographs.

KEY WORDS: Antarctica, Admiralty Bay, phytosociology, photointerpretation, remote sensing

1. Introduction

Studies of plant communities in Antarctic have a very short, only several years old history. However, numerous areas have already excellent descriptions of their vegetation, e.g. South Shetlands (Lindsay 1971), Signy Island (Smith 1972), Argentine Islands (Smith and Corner 1973), Elephant Island (Allison and Smith 1973) or region of McMurdo Sound (Longton 1973). These papers contain detailed description of vegetation units, their physiognomic, floristic and ecological characteristics, and supply numerous information on their developmental dynamics. But there is a lack of maps of distribution of plant communities on larger areas, apart from sketches for small fragments of the terrain. Only the paper by Rudolph (1963) contains a scematic map of plant distribution in the region of Hallet Station (Victoria Land, Antarctic).

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The present paper attempts at the application of the remote sensing of the environment by multispectral photography for the determination of the plant communities distribution in the region of Arctowski Station. The studied area (Fig. 1), called by B i r k e n m a j e r (1980) the Jasnorzewski Gardens, contacts directly buildings of the Station and covers a flat acumulative area risen above the sea level on the average of 4 m, and separated from the waters of Admiralty Bay by a coastel embankment. It is a wetland area, covered mainly by herbs and mosses, which form distinct plant communities. The paper presents the description, floristic and ecological characteristics, dynamics of development and the map of distribution of plant communities on the Jasnorzewski Gardens.

Plant communities occurring on the studied area have facial character, showed by the dominance of one or two plant species in particular stands. These stands are clearly visible in the terrain, especially due to their color. However, very mosaic character of these stands causes great difficulties and not precise charting while applying traditional methods. That was the reason why the authors decided upon the application of air photography while making the map of the plant communities distribution.

The studied area is in a way an experimental area, where the cartographical method of vegetation mapping with the help of automatic analysis of multispectral air photographs was tested. The method will help, in future, to make similar maps of plant communities in other areas, free of ice, in the region of Admiralty Bay on the King George Island.

2. Terrain, equipment and methods

Multispectral air photographs were used to draw the distribution map of plant communities distribution. The pictures were taken from helicopter Mi-2 in February 1979 with the help of multispectral camera, constructed at Gdańsk University, which took picture in violet; blue, green and red channels (F u r m a ń c z y k 1980).

Analysis of pictures was made by the method of supervised analysis of multispectral air photographs, also at Gdańsk University. Pictures taken in four channels were converted into the numerical form with the help of Digital Scanner Convertor of Image CSPO-01/GIII-P, described in detail by Furmańczyk et al. (in press) and Chabowski and Furmańczyk (in press).

Each photograph is divided in the convertor to rectangular elementary fields, the so called pixels, in this case 0.20 by 0.25 mm, which fill up a complete area of the picture. Optical density of each pixel is measured. As a result of the operation, each photograph is presented in the form of perforated tape with numerical from. Pictures taken by all four channels were treated that way.

Further analysis of pictures taken was performed with the help of EMC Odra 1204. Analysed fragment of a picture taken on one of the channels is presented at Figure 2, and its equivalent printout at Figure 3.

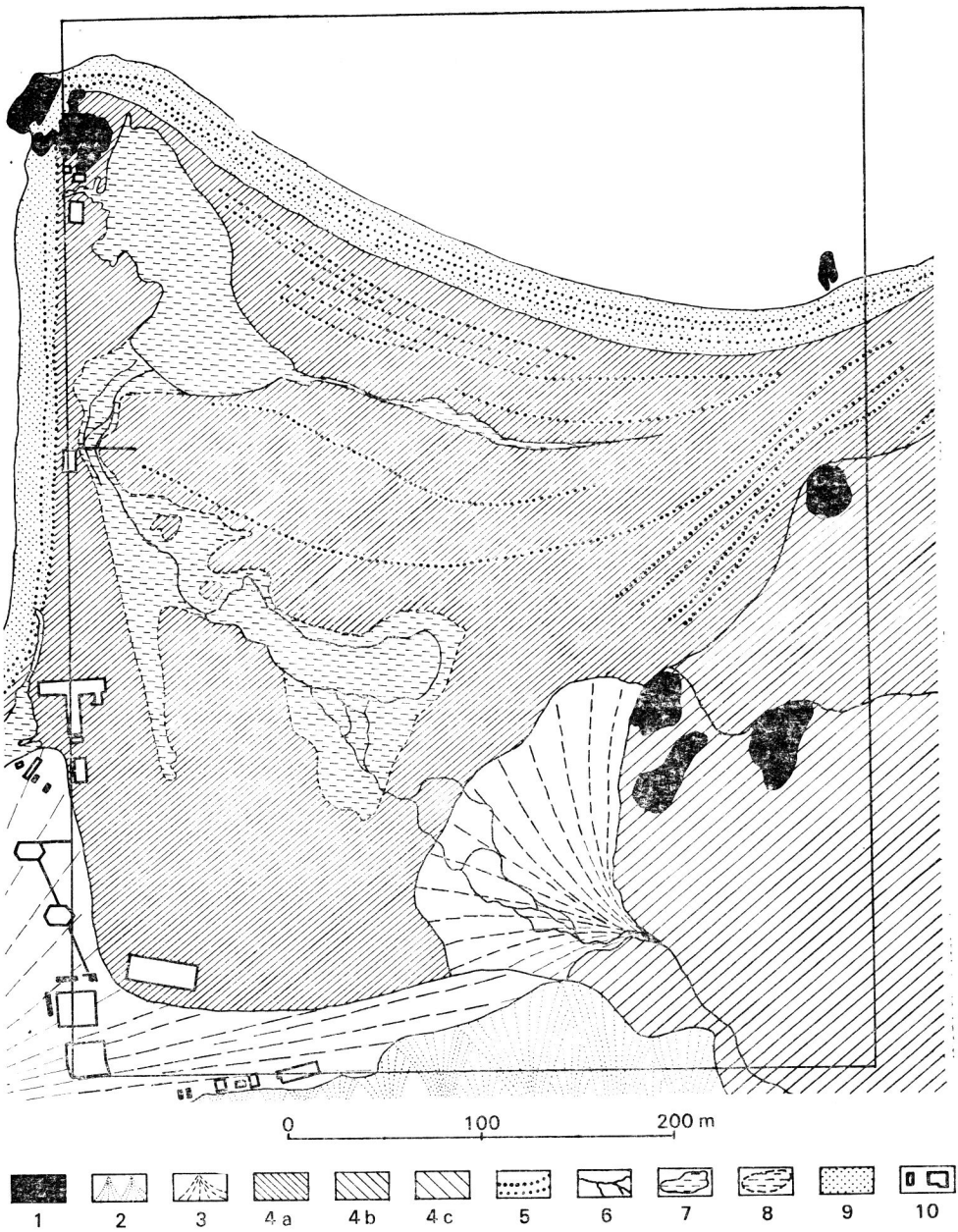

Fig. 1. Morphological sketch of the Jasnorzewski Gardens region acc. to Petelski

1 — Rocks outcrops, *2* — scree cones *3* — alluvial cones *4* — shorefare terraces I, II, III, *5* — coastel embankments *6* — streams, *7* — lakes, *8* — wetlands, *9* — beach, *10* — buildings of Arctowski Station

The frame indicates the area studied

The cartometric printout of the picture devided into 8 ranges of optical density, with different marks of the computer printer designated to each range, were obtained after the introductory analysis of pictures with programs described by Furmańczyk and Chabowski (in press).

The rectangular test areas (the so called clusters), where the field studies were made and some areas of undoubted kind of cover, as the sea, lakes and areas without vegetation were marked on the obtained numerical form of the picture.

Fig. 2. A multispectral air photograph (green channel) of the Jasnorzewski Gardens taken on 13 February 1979. Photo K. Furmańczyk

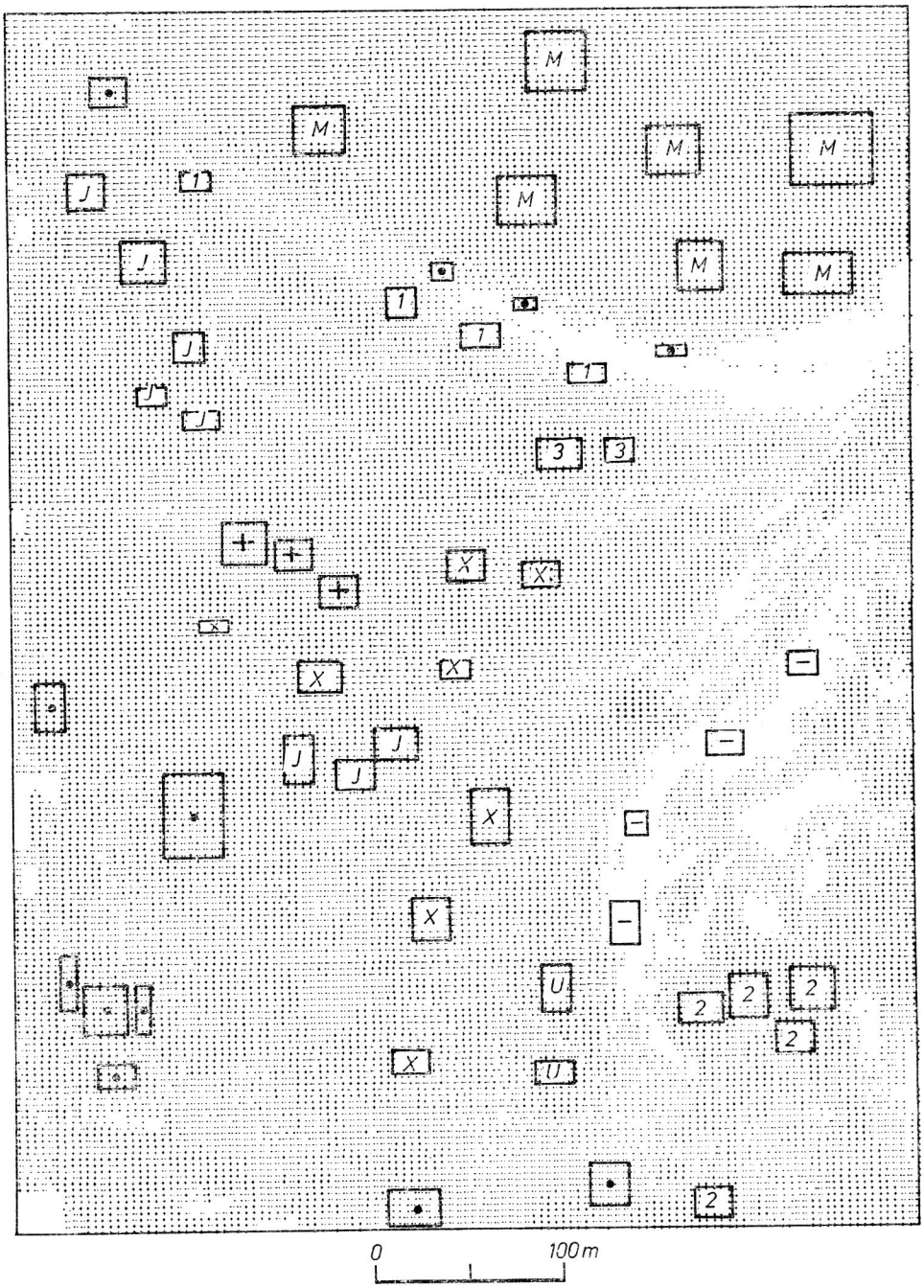

Fig. 3. The printout of an air photograph in a numerical form with indicated test cluster areas

Designations: "M" — the sea "J" — lakes, "." — not overgrown land, "1, 2, 3, X, U, +, —" — plant communities described in text

Further analysis relying on the supervised interpretation of multispectral pictures was carried out on the basis of programs described in paper by Furmańczyk and Chabowski (in press). Its principle is evaluation by computer of the characteristics of test clusters determined at Figure 3 for all channels and finding similar ones according to the determined criteria. The obtained result is in the form of a subject interpretation map presented in the numerical form (Fig. 4). On this map each plant community is designated by different symbol of the printer.

The field study of the vegetation of the Jasnorzewski Gardens was carried ou in summer during the IV Antarctic Expedition of PAS in 1979/1980. These studies covered phytosociological studies of vegetation stands by means of a clasic method of Braun-Blanquet (B r a u n - B l a n q u e t 1964) of analysing the vegetation stands (determination of the floristic composition, quantitative relations, ecological observations etc.).

A commonly applied classification of Antarctic plant communities of G i m i n g h a m and S m i t h (1970) was used in this paper. The names of associations were determined in accordance with the rules of phytosociological nomenclature, but with consideration to the dominant species, and their names form a name of an association in the presently accepted classification of G i m i n g h a m and S m i t h (1970). A term "sociation" was replaced here by an equivalent term "variant". A still open case is the classification and hierarchy of higher phytosociological units of Antarctic vegetation, i.e. of alliances, orders and classes.

3. Description of plant communities of the studied area

The region of Shag Point, where Polish Arctowski Antarctic Station is located, is one of the richest in the Admiralty Bay from the point of view of as well the number of species as the variety of plant communities. For these reasons this region is the most suitable for all kinds of botanical studies, the floristic, phytosociological and ecological ones.

Three following plant associations, differentiated in sequence to the units of lower order, i.e. to variants, were distinguished on the studied area of Jasnorzewski Gardens: 1) *Deschampsio antarctici-Colobanthetum quitensis*, 2) *Polytrichetum alpini* and 3) *Calliergidio austro-straminei-Calliergonetum sarmentosi*. They represent in the classification of Antarctic plant communities by L o n g t o n (1979) (see also G i m i n g h a m and S m i t h 1970, S m i t h 1972): Antarctic herb tundra formation (*Deschampsio-Colobanthetum*) and Antarctic non-vascular cryptogam tundra formation, in fact its moss carpet sub-formation (*Calliergidio-Calliergonetum*) and the moss turf sub-formation (*Polytrichetum alpini*) respectively.

1) *Deschampsio antarctici-Colobanthetum quitensis* (Longton 1967) G i m i n g h a m and S m i t h 1970 — stands of this association are marked with numbers 1, 2, and 3 at the Figure 4.

Deschampsia antarctica Desv. and *Colobanthus quitensis* (Kunth) Bartl., both native for Antarctic vascular plants, are quite common plants in the region of Admiralty Bay on King George Island. However, only in few cases they form pure, nearly monospecific stands, which are acc.

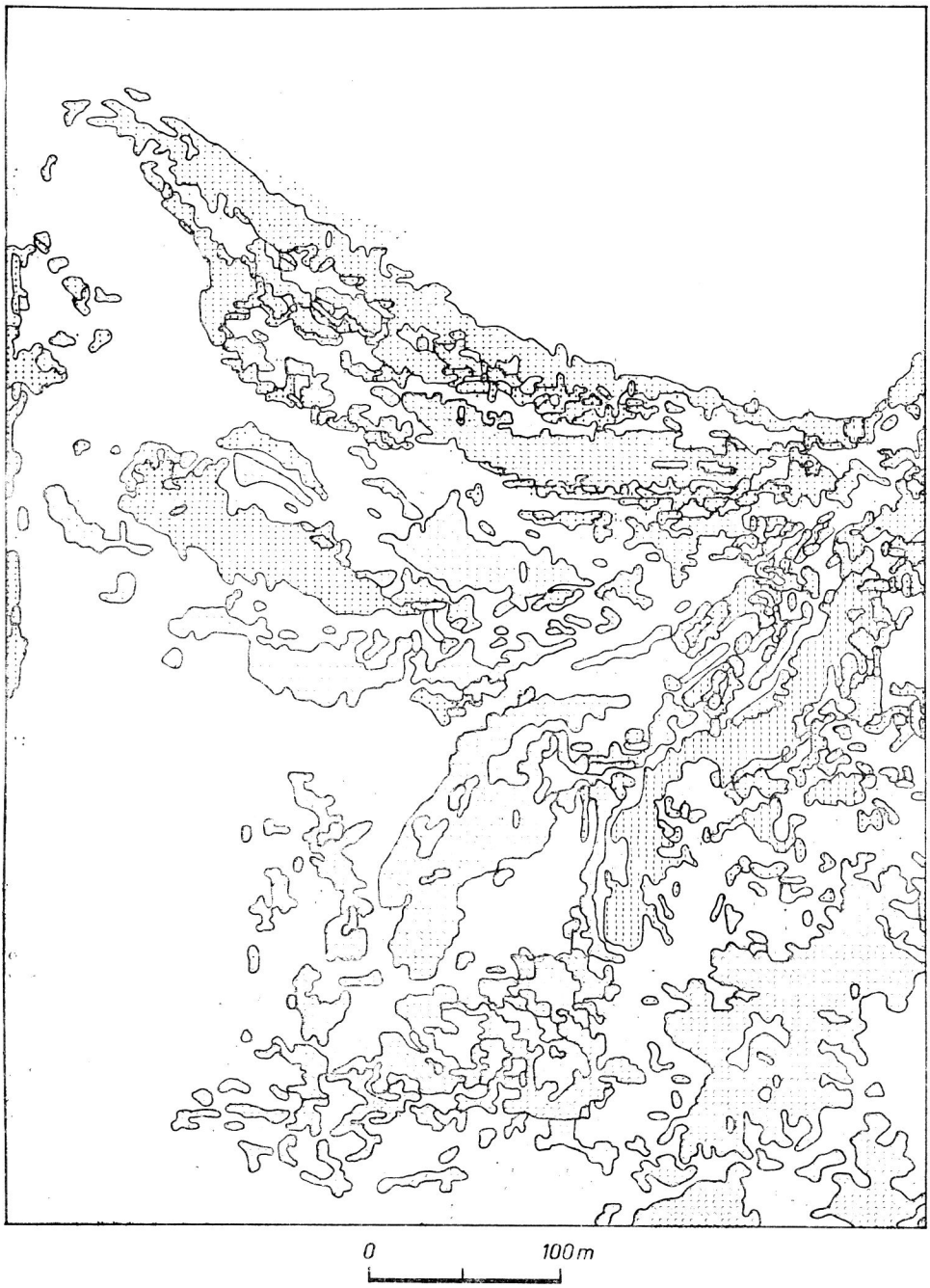

Fig. 4. An analog form of the map of plant communities distribution in region of Jasnorzewski Gardens, made on the basis of the numerical map shown at Fig. 3

to Smith (1972) a formation of Antarctic herb tundra. Such stands occupy small areas, especially on the slopes below the nests of penguines and petrels (*Macronectes giganteus* Gmelin), in places enriched significantly with nitrogen. These stands occupy very small area covered by the presented map (order of 5 m^{-2}) and for this reason were not considered.

Stands of communties with dominance of both vascular plants, and especially of *Deschampsia antarctica*, are developed on the large area of stony places above Halfmoon Cove. These plants are commonly accompanied by mosses, and by lichenes in drier places. Three variants of this associations can be distinguished, dependent on the dominance of particular species, conditioned by environmental differences:

a) Typical variant — stands at Figure 4 determined by number 1. According to classification of Smith (1972) it is a sociation with low cover of *Drepanocladus uncinatus* (Hedw.) Warnst. Particular phytocenoses of this variant develop in drier places, on the slopes of the coastal embankment, and are marked by fairly numerous occurrence of tufts of *Deschampsia antarctica* with quite numerous cushions of *Colobanthus quintensis*. *Drepanocladus uncinatus* occurs the most often in the moss layer, reaching usually 15—20% of cover. The remaining mosses, e.g. *Polytrichium alpinum* Hedw., *P. juniperinum* Hedw., *Pohlia nutans* (Hedw.) Lindb., *Ceratodon grossiretis* Card., *Tortula grossiretis* Card. occur as a not important admixture. The lichens occur in some places, mainly *Psoroma hypnorum* (Vahl) Gray, *Cladonia* sp., *Sphaerophorus globosus* (Huds.) Vain., and on the stones sometimes *Acarospora macrocyclos* Vain. Quite numerous fungi (*Omphalina antarctica* Sing.) occured in stands of this association in the second fortnight of January.

b) Variant with *Drepanocladus uncinatus* — its stands are determined at Figure 4 by number 2, is corresponding with a sociation with high cover of *Drepanocladus uncinatus* Smith (1972). From the floristic point of view the stands of this variant are similar to previously described typical variant. They are characterized by dominance of *Deschampsia antarctica* and *Drepanocladus uncinatus*, which reach the same degree of cover. Other species, as e.g. *Colobanthus quitensis* and *Polytrichum alpinum* occur as only an insignificant admixture. Among the lichens only *Psoroma hypnorum* was observed. Stands of the discussed variant look like a dense carpet of moss and grass which occured in slightly wet places, on the quite flat terrain.

c) Variant with *Polytrichum alpinum* — its stands are determined at Figure 4 by numbers 3 — has a transistional character between associations *Deschampsio-Colobanthetum* and *Polytrichetum alpini*. There are quite numerous turfs of *Polytrichum alpinum* in particular stands of this variant, but this species does not form such large turfs as in stands of *Polytrichetum alpini*. *Deschampsia quitensis* occurs there in masses, and *Colobanthus quitensis* and *Drepanocladus uncinatus* less often. Habitats occupied by stands of this variant are moderately wet, and their substrates quite rocky.

2) *Polytrichetum alpini* (Longton 1967) Gimingham and Smith (1970) — stands of this association are determined at Figure 4 by symbols "—" and "+".

This association represents a subformation of moss turf in the presently commonly accepted classification of terrestrial Antarctic plant communities of Gimingham and Smith (1970). Its phytocenoses are formed in well drained places on the gravel or stony substrates. Large tussocs of *Polytrichum alpinum*, sometimes up to 1 m diameter, give a specific image to this community, allowing an easy recognition of its stands in the area. *Polytrichum alpinum* has a very broad ecological range and occures as a permanent component of numerous other Antarctic plant communities (Smith 1972). However, it does not form dense compact turfs of peat forming character apart from this particular association.

This association occures in two variants in Jasnorzewski Gardens:

a) Typical variant — its stands are determined at Figure 4 by symbol "—". These stands occur in fairly dry, higher places, in stony places close to the nests of penguins and petrels. The associated moss species are scarce and include usually *Drepanocladus uncinatus*, *Ceratodon grossiretis* and *Pohlia nutans*. Permanent beating out of this association stands by penguins results in such destruction, that the association becomes a form of quite isolated stands of *Polytrichum alpinum* separated by stony ground covered by masses of nitrophilous *Prasiola crispa* (Lightf.) Menegh.

b) Variant with *Drepanocladus uncinatus* — its stands are determined at Figure 4 by symbol "+". It developes in slightly wetter places, where *Drepanocladus uncinatus* co-dominating with *Polytrichum alpinum* reaches a large degree of cover in certain stands. *Deschampsia antarctica* is quite numerous in certain places. Crustose lichens, mainly the species from genera *Buellia* and *Lecanora* occur commonly in stony places. Epiphytic *Ochrolechia frigida* (Sw.) Lynge, and fruticose species of *Cladonia* sp., and even small tussocs of *Usnea antarctic* DuRietz.

3) *Calliergidio austro-straminei-Calliergonetum sarmentosi* Ochyra, nomen novum (*Brachythecium antarcticum-Callierogon sarmentosum--Drapanocladus uncinatus* association Gimingham and Smith 1970) — its stands are determined at Figure 4 by letters "U" and "X".

This is an association quite common in the whole maritime Antarctic (Longton 1979), representing a moss carpet sub-formation, which has also a peat forming character. Particular stands of this association are composed of large pleurocarpous mosses, forming carpets from the dense, directed upward, lower part and branches. Particular stands of this association develop in flooded areas, with stagnant water, the species forming this association are mainly *Calliergidium sarmentosum* (C. Muell.) Bartr., *Calliergon sarmentosum* (Wahlenb.) Kindb. and *Drepanocladus uncinatus*. Liverwort *Cephaloziella varians* (Gott.) Douin. occurs here always as a small admixture. Two variants of this association can be distinguished in the studied area:

a) Variant with *Calliergidium austro-stramineum* — its stands are determined at Figure 4 by letter "U" — its particular phytocenoses develop in the wettest places, where a small stream flows into the peat bog from the slope. It is characterised by the mass occurrence of *Callier-*

qidium austro-stramineum with a small admixture of *Calliergon sarmentosum* and *Drepanocladus uncinatus*. These stands are distinguished in the terrain by intense living green color.

b) Variant with *Drepanocladus uncinatus* — its stands are determined at the Figure 4 by letter "X". Its stands are dominated by *Drepanocladus uncinatus* and develop on large areas in wet places, but not so wet as previously described variant with *Calliergidium austro-stramineum*. These stands look like very dense, compact light-brown or brown-green carpets. Scarce stands of *Calliergon sarmentosum* and *Calliergidium austro-stramineum* penetrate particular stands of this variant.

4. Discussion

The description of vegetation of the Jasnorzewski Gardens, a small peat-bog located in the direct neighbourhood of Polish Antarctics Station on King George Island shows clearly that hydrophilous plant communities of this area show great similarities with communities described for other parts of maritime Antarctic, e.g. on Signy Island (Smith 1972) or on the whole archipelago of South Shetlands (Lindsay 1971, Allison and Smith 1973). This shows a great similarity of plant communities in the whole Western Antarctic, from the point view of floristic composition and also from the conditions of their occurrence and developmental tendencies.

Particular stands of peat forming communities are composed usually from one or two domonant species, accompanied by other species which are not significant in particular stands. Access to water has a considerable influence on the character and development of a plant community. The above was clearly noticed on the studied area of Jasnorzewski Gardens. It is a wast accumulative area, partialy covered with water, and permanently irrigated by waters from streams flowing from the patches of snow melting on the nearby slopes.

The stands of the most hydrophilous of all Antarctic terrestrial communities, *Calliergidio-Calliergonetum sarmentosi*, develop in the wettest places, permanently covered with water. This community is replaced by stands of communities characteristic for fairly wet areas when the distance from stagnant water bodies and from areas covered with water increases. There occur analogous, substitutional variants with *Drepanocladus uncinatus* of *Polytrichetum alpini* and *Deschampio-Colobanthetum* associations.

In the driest places, where water inflow is only seasonal and origins mainly from precipitation, climax associations of *Polytrichetum alpini* and *Deschampsio-Colobanthetum* develop in their typical forms. They are similar from the ecological point of view, but they differ significantly by their floristic composition, mainly by the occurrence of vascular plants in one of them.

All plant communities occuring on the studied area have a peat forming character. However, quick decomposition of organic matter results in small thickness of peat bed. Analogous situation was observed by Collins (1976) on Signy Island.

The basic feature of plant communities in Antarctic is their very mosaic character resulting mainly from ecological factors, as edaphic conditions, pH of the substrate, access to water. These cause great difficulties for charting of particular stands of plant communities with classical cartographic methods. That was the reason why the authors made an attempt to plot a map of a small area on the basis of multispectral air photography.

The basic compartive feature of this method is the colour of photographed objects. Particular stands of vegetation have their colour differentiated because of their different species composition. The result of automatic supervised analysis of air photographs is presented at Figure 3 as a subject interpretation of numerical map. Because of the small surface areas of elementary surface units (pixels) of about 8 m^2, the printout of the map of plant communities distribution gives an image of mossic allocation of vegetation stands. So detailed image is practically imposible to obtain by classical cartographic methods.

A specific feature of the supervised interpretation is combaining an automatic analysis with field studies, which relay on precise choice of test cluster areas characteristic for particular communities (Fig. 3).

It was already mentioned, that colour is a comparative feature of this method. Analysed elementary unit will be counted by computer as a one similar to one of the test cluster areas, if its mean colour is similar to the mean colour of the test area. That is why it is possible that sporadically small stands of plant communities are shown in places where they do not occur. This means, that colour of the terrain in these pixels is similar to the one of a certain community. This is an error of the method, which can not be avoided, but which can be eliminated in the majority of cases.

An analog form of the map can be made easily by drowing the boundary lines for particular stands of plant communities (Fig. 4) at the map presented in numerical form (Fig. 3). Such a new map dissembles slightly the mosaic character of plant communities, but is easier to read.

The applied here supervised interpretation of multispectral photographs for charting of plant communities on the area of Jasnorzewski Gardens seems to be an optimum one, especially in Antarctic conditions, where the vegetation season is very short. The basic advantage of the method is a possibility of taking the pictures of a large area in a short time, and limitation of the land reference studies only to the test cluster areas. This shortenes the time for field studies significantly and allows to cover much larger area than in the case of traditional charting, and is especially important and adventageous in expedition studies.

5. Summary

A study of the vegetation cover in the region of Admiralty Bay on the King George Island was made during the Antarctic Expedition of the Polish Academy of Sciences (1979/1980). The present paper contains the characteristics and a distribution map of plant communities distribution on the area of the Jasnorzewski Gardens. It is a small wetland area covered completely by a peatbog. Three associa-

tions differentiated into the variants were distinguished there on the basis of plant stands analysis with the help of commonly applied phytosociological method of Braun-Blanquet.

In the wettest places there occurred the stands of *Calliergidio-austro-straminei — Calliergonetum sarmentosi.* The hydrophilous mosses *Calliergidium austro-stramineum, Calliergon sarmentosum* and *Drepanocladus uncinatus* were the main species forming this association.

In well irrigated places on the rocky or gravely substrates developed the phytocenoses of *Polytrichetum alpini,* with dominance of large stands of *Polytrichum alpinum.* This species is accompanied permanently by *Drepanocladus uncinatus, Ceratodon grossiretis* and by *Pohlia nutans.*

In the rocky and slightly wet places develop the stands of *Deschampsio antarctici-Colobanthetum quitensis,* an association dominated by the only vascular plants in Antarctic: *Colobanthus quitensis* and *Deschampsia antarctica.* The vascular plants are accompanied frequently by mosses, of which the highest degree of cover is reached by *Drepanocladus uncinatus, Polytrichum alpinum, Polytrichum juniperinum, Pohlia nutans* and *Tortula grossiretis* and lichens (*Psoroma hypnorum, Sphaerophorus globosus, Cladonia* sp.). Three variants of this association were distinguished on the basis of the dominance of particular species and on hydrological conditions: a) typical one, b) with *Drepanocladus uncinatus,* c) with *Polytrichum alpinum,* which is a transition to *Polytrichetum alpini.*

All three associations have a peat forming character, but a quick decomposition of organic matter results in thin layers of peat. Phytocenoses of the discussed associations and of their variants have a mosaic character, which causes great difficulties for ploting their maps.

On the basis of the above mentioned field studies and on the basis of the analysis of multispectral air photographs a map was made of the distribution of plant communities on the area of Jasnorzewski Gardens.

6. Резюме

В течение Антрактической Экспедиции ПАН (1979/1980) были проведены исследования растительного покрова в районе Залива Адмиралты, на Острове Кинг Джордж, в пределах т. наз. Парка Ясножевского. Это небольшая, сильно подмокшая площадь, которую целиком занимают гидрофильные ассоциации. На основании анализа полос растительности, проведенного с помощью широко применяемого метода Браун-Бланкета, были выделены 3 растительных ассоциации и их варианты.

В сильно подмокших местах развиваются компоненты ассоциации *Calliergidio austro -straminei—Calliergonetum sarmentosi.* Главными видами этой ассоциации являются мхи:- *Calliergidium austro-stramineum, Calliergon sarmentosum, Drepanocladus uncius.*

В местах хорошо увлажненыых на каменистой или хращевой почве развиваются фитоценозы *Polytrichetum alpini,* в которых прибладает вид *Polytrichum alpinum,* растущий огромными купами. Он сопровождается обычно *Drepanocladus uncinatus, Ceratodon grossiretis* и *Pohlia nutans.*

В каменистых и легко увлажненных местах развиваются компоненты *Deschampsio antarctici-Colobanthetum quitensis,* ассоциации, в которой яреобладают единственные в Антарктике сосудистые растения: *Colobanthus quitensis* и *Deschampsia antarctica.* Наряду с этими, выступают мхи, из которых найболее широко распространены: *Drepanocladus uncinatus*

Polytrichium alpinum, *Polytrichum juniperinum*, *Pohlia nutans*, *Tortula grossiretis* а также лишайники (*Psoroma hypnorum*, *Sphaerophorus globosus*, *Cladonia* sp.). В зависимости от преобладания определенных видов и гидрологических условий были выделены з варианта ассоциации: а) типический, б) с *Drepanocladus uncinatus*, в) с *Polytrichum alpinum*, промежуточный на пути к *Polytrichetum alpini*.

Все три ассоциации носят торфообразный характер, однако в результате сильной декомпозиции органической материи созданные ими залежи торфа очень тонки. Фитоценозы обсужденных ассоциаций и их вариантов характеризуются сильной мозаичностью, что вызывает огромные трудности при их картировании.

На основании обсужденных полевых исследований и анализа многоспектральных аэрофотоснимков была создана цифровая карта распределения ассоциаций в районе Парка Ясножевского.

7. Streszczenie

W czasie trwania Wyprawy Antarktycznej PAN (1979/1980) przeprowadzono badania szaty roślinnej w rejonie Zatoki Admiralicji na Wyspie Króla Jerzego. W niniejszej prasy przedstawiono charakterystykę i mapę rozmieszczenia zbiorowisk roślinnych na obszarze Parku Jasnorzewskiego. Jest to niewielki, silnie podmokły teren, zajęty w całości przez zbiorowiska hydrofilne. Na podstawie analizy płatów roślinnych przy użyciu powszechnie stosowanej metody fitosocjologicznej Braun-Blanqueta wyróżniono tu trzy zespoły zróżnicowane na warianty.

W miejscach najbardziej podmokłych występują płaty *Calliergidio austro-straminei — Calliergonetum sarmentosi*. Głównymi gatunkami budującymi zespół są hydrofilne mchy: *Calliergidium austro-stramineum*, *Calliergon sarmentosum* oraz *Drepanocladus uncinatus*.

W miejscach dobrze nawodnionych na podłożu kamienistym lub żwirowym rozwijają się fitocenozy *Polytrichetum alpini*, w których dominuje tworzący potężne kępy *Polytrichum alpinum*. Towarzyszą mu stale *Drepanocladus uncinatus*, *Ceratodon grossiretis* i *Pohlia nutans*.

W miejscach kamienistych i nieco wilgotnych rozwijają się płaty *Deschampsio antarctici-Colobanthetum quitensis*, zespołu w którym dominują jedyne w Antarktyce rośliny naczyniowe: *Colobanthus quitensis* i *Deschampsia antarctica*. Roślinom naczyniowym towarzyszą często mchy, w których największy stopień pokrycia osiągają *Drepanocladus uncinatus*, *Polytrichum alpinum*, *Polytrichum junperinum*, *Pohlia nutans*, *Tortula grossiretis* oraz porosty (*Psoroma hypnorum*, *Sphaerophorus globosus*, *Cladonia* sp.). W zależności od dominacji określonych gatunków i warunków hydrologicznych wyróżniono trzy warianty zespołu: a) typowy, b) z *Drepanocladus uncinatus*, c) z *Polytrichum alpinum* stanowiący przejście do *Polytrichetum alpini*.

Wszystkie trzy zespoły mają charakter torfotwórczy, jednak silna dekompozycja materii organicznej sprawia. że utworzone przez nie pokłady torfu są bardzo cienkie. Fitocenozy omawianych zespołów i ich wariantów odznaczają się dużą mozaikowatością co sprawia duże trudności przy ich kartowaniu.

W oparciu o powyższe badania terenowe i analizę wielospektralnych zdjęć lotniczych sporządzono mapę rozmieszczenia zbiorowisk roślinnych na obszarze Parku Jasnorzewskiego.

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