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RESEARCH/REVIEW ARTICLE

Characterization and mapping of plant communities at Hennequin Point, King George Island, Antarctica

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Abstract

King George Island is the largest island and the principal area used for research bases in Antarctica. Argentina, Brazil, Chile, China, Poland, Russia, South Korea and Uruguay have permanent open bases on this island. Other countries have seasonal summer stations on different parts of this island, which demonstrates that human impact is strong on King George Island relative to other areas in the maritime and continental Antarctica. The objective of this work was to present a phytosociological approach for ice-free areas of Hennequin Point, eastern coast of Admiralty Bay, King George Island. The study started with the classification and description of the plant communities based primarily on phytosociological and biodiversity data. The area was mapped using an Astech Promark II® DGPS, yielding sub-metric precision after post-processing with software. The plant communities were described as follows: (1) lichen and moss cushion formation; (2) moss carpet formation; (3) fellfield formation; (4) grass and cushion chamaephyte formation; and (5) *Deschampsia Antarctica*–lichen formation. Characterizations and distributions of the plant communities are presented on a map at a scale of 1:5000. The plant communities found at Hennequin Point, in general, differ from those found in other areas of the Admiralty Bay region, probably because of the concentration of skua nests in the area and the relief singularities. We conclude by highlighting the importance of the study of plant species found in the ice-free areas of the Antarctic with respect to environmental monitoring and for evaluating global climate and environmental changes.

The Antarctic flora is composed mainly of bryophytes and lichen species adapted to short summers and low temperatures (Putzke & Pereira 2001). Such climatic conditions inhibit the reproductive cycle, limiting the diversity and the gene pool, especially for flowering plants (Pereira & Putzke 1994; Vincent 2000). The Antarctic hair grass (*Deschampsia antarctica* Desv.) and the Antarctic pearlwort (*Colobanthus quitensis* [Kunth.] Bartl.) are the only native angiosperms growing in Antarctica, but are restricted to the maritime Antarctica, which experience a shorter daylight period, warmer temperatures and higher water availability in comparison to continental Antarctica.

Several studies, such as those by Bednarek-Ochyra et al. (2000), Ochyra et al. (2008), Putzke & Pereira (2001), Redón (1985) and Øvstedal & Lewis-Smith (2001), have contributed to a fairly good understanding of the species composition and structure of the plant and lichen communities in ice-free areas of the maritime Antarctica. However, there are very few maps showing the spatial distribution of such communities. Based on satellite images, Furmanczyk & Ochyra (1982) produced a map of moss distribution for the south-western shore of Admiralty Bay, King George Island. Although this has been very useful in orientating botanic studies in this area, the broad mapping scale limits its practical use in

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monitoring and ecological studies. Victoria et al. (2009) produced a finer scale map of the moss communities in the south-west of Admiralty Bay for monitoring the succession of plant communities colonizing this area.

High-resolution vegetation mapping is critical for a better understanding of the impacts of environmental factors that control vegetation development, allowing for the future monitoring of these communities. The extremely dynamic aspect of geomorphic surfaces and related soils under periglacial and paraglacial conditions results in a high variation in plant communities within the scale of a metre. Differences in species composition can be found within a small area (Victoria et al. 2009) due the heterogeneity in terrain, microtopography, substrate type and soil chemistry in small ice-free areas. This makes map scale a very important factor to be considered when producing a cartographic base for future monitoring studies.

The maritime Antarctic zone is characterized by higher mean air temperatures and water availability than continental Antarctica. According to data sets from 1982 to 2002, acquired at the Brazilian Comandante Ferraz Station (Setzer et al. 2004), the mean air temperature varies from $-6.4°C$ in July to 2.3°C in February. Positive air temperatures occur from November until March. Mean annual precipitation is 366.7 mm rainfall equivalent, falling as snow and rain. During the last decade, there has been an increase in mean annual temperature of 0.2–0.6°C, contributing significantly to the retreat of glaciers over this period in the Admiralty Bay region (Rakusa-Suszczewski et al. 1993).

The main objective of this work is the first characterization and fine-scale mapping of the plant communities colonizing Hennequin Point, along the eastern coast of Admiralty Bay, King George Island (62° 03′ 40′′–62° 05′ 40′′ S and 58° 23′ 30′′–58° 24′ 30′′ W; Fig. 1). By helping in the monitoring studies of plant communities in the area, this will aid the evaluation of the environmental impacts that are occurring with the expansion of ice-free areas in Antarctica.

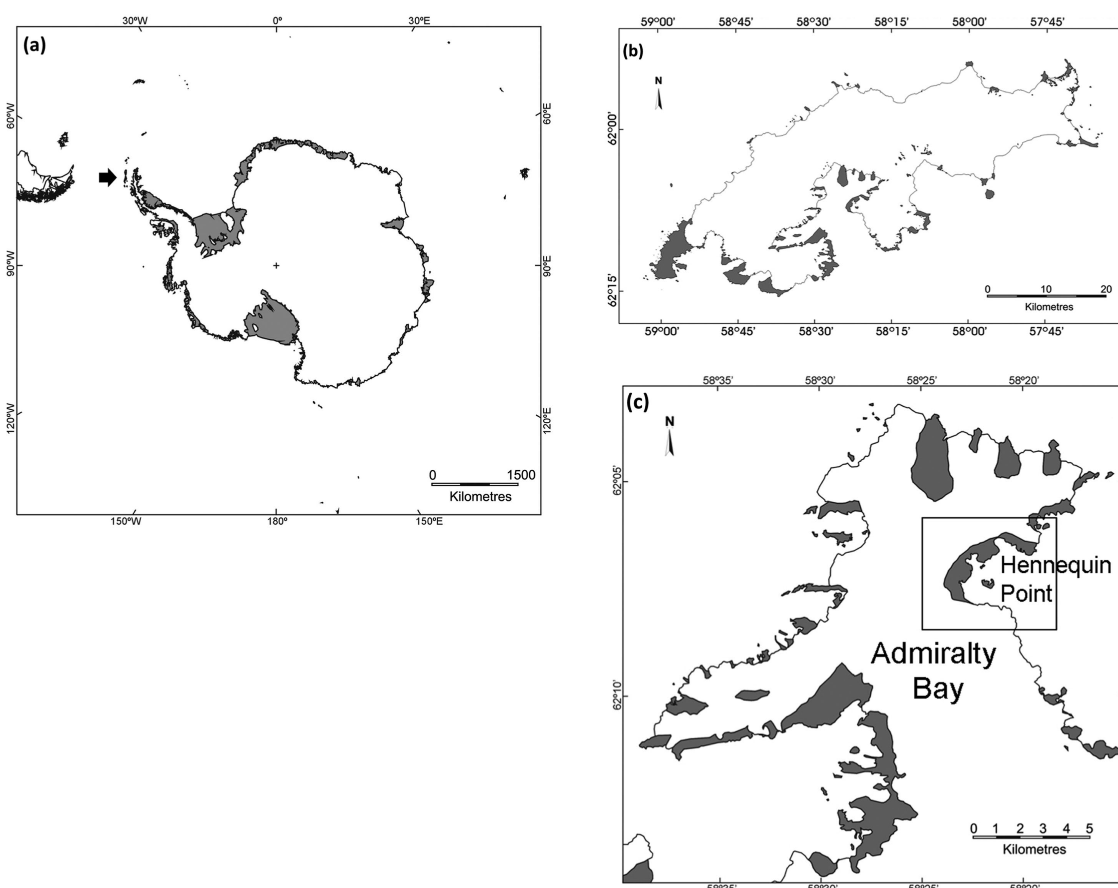

Fig. 1 Studied area. (a) Antarctica, with an arrow pointing to the location of the South Shetland Islands, (b) King George Island, with ice-free areas indicated in grey, and (c) the study area of Hennequin Point, in Admiralty Bay.

Methods

During the 2004/05 austral summer, a detailed mapping and characterization of plant communities was carried out on Hennequin Point, on the eastern coast of Admiralty Bay (Fig. 1). The area studied comprises approximately 3.06 km^2 of ice-free terrain and is composed of tholeithic basalt, andesites and volcanic tuffs, with a north-east–south-west axis of 3.6 km. The area studied is less than 1 km wide. The relief ranges from 0 to more than 300 m a.s.l.

Phytosociological surveys were undertaken using the quadrat method of Braun-Blanquet (1964), using 25 × 25 cm quadrats launched randomly (in a total of 206 quadrats sampled) for recording the frequency and coverage degree of each species identified. The selection of the sites was subjectively based on the extent of vegetation cover and its diversity, which was previously evaluated by assessing its physiognomy and location. The percentage frequency and cover were determined as proposed by Gimingham & Lewis-Smith (1970) and Lewis-Smith (1972). To assess the importance of each species identified in the surveys, an index of ecological significance (IES) was calculated (Lara & Mazimpaka 1998). Statistical analyses were applied, using the software EstimateS 8.2, to obtain the phytosociological parameters (diversity, maximum diversity and equability) for each plant formation described (Chao 2004; Colwell 2004). The Shannon index was applied to estimate diversity and its index of equability. To illustrate the importance of the species in the total sampling, the index of ecological importance was used (Lara & Mazimpaka 1998), which combines the parameters of abundance (coverage and frequency), described as $IES = F(1+C)$, where F is the relative frequency of the species in the area or habitat and is generated by the number of occurrences (x) divided by the total number of samples considered (n): $F = 100x/n$; and C is the average coverage of the species in the samples, calculated as $C = \Sigma(c_i)/x$, where c_i is the class of coverage and x is the number of sampling dots in which the species occur. These equations are similar to those used by Braun-Blanquet (1964).

Plant communities were mapped in the field using an Ashtech Promark II® DGPS (Ashtech OEM, Sunnyvale, CA, USA), which yields sub-metric precision after post-processing with the Astech Solutions® software, referenced to the active global positioning system station of Comandante Ferraz Station. This map was overlaid and adjusted with a high-resolution IKONOS satellite image, acquired in the summer of 2008, generating the final map presented here at a scale of 1:10 000.

The description and classification of the plant communities were based on Lewis-Smith & Gimingham (1976), Pereira & Putzke (1994) and Redón (1985). The identification of bryophytes was based on Ochyra et al. (2008) and the lichens on Øvstedal & Lewis-Smith (2001), Olech (1996) and Spielmann & Pereira (2012). In the cases of some *Bryum* species, there has been a change in genus allocation and the names follow the recent literature (Spence 2005, 2007). The species names were updated based on the names in databases available on the internet, such as W3Tropicos (www.tropicos.org) for mosses and Index Fungorum (www.indexfungorum.org) for lichens. All species and survey data are available at the Federal University of Pampa Herbaria, Campus São Gabriel.

The place-names presented in this work follow the official nomenclature presented by Simões (2004).

Results and discussion

The terrestrial plant communities of the maritime Antarctica can be generically divided into two basic types: (1) those comprising only cryptogams and (2) those comprising both cryptogams and phanerogams, as suggested by Longton (1967, 1979) and adopted by Victoria et al. (2004) for the area near the Polish Arctowski Station, on the western coast of Admiralty Bay. At Hennequin Point, in 206 quadrats launched we mapped six different plant communities (three cryptogamic and three mixed cryptogamic–phanerogamic) covering approximately 17.4% (0.542 km^2) of the studied ice-free area. A list of plants and lichen found in the samples is presented in Table 1. The main characteristics of the mapped communities (area, dominant species and terrain) are summarized in Table 2. Fellfield communities occur in recently deglaciated areas (Fig. 2) and these are also discussed.

The most important species ($IES > 50$) is *Sanionia uncinata*, as also reported for other ice-free areas in the Admiralty Bay region (Furmanczyk & Ochyra 1982; Ochyra 1998; Victoria et al. 2009). The most important lichens are *Usnea aurantiaco-atra*, followed by *Ochrolechia frigid*, which is associated with *Andreaea* spp., notably *Andreaea gainii*, the second most important moss species recorded in the area. Other species, with their importance values, are summarized in Table 3, while the plant formations are illustrated in Fig. 2 and their diversity status is summarized in Table 4.

Table 1 Plant and lichen species of Hennequin Point, King George Island, Antarctica. (Table continues next page.)

Bryophyta
- Amblystegiaceae
  - *Sanionia uncinata* (Hedw.) Loeske
  - *Warnstorfia sarmentosa* (Wahlenb.) Hedenas
- Andreaeaceae
  - *Andreaea depressinervis* Card.
  - *Andreaea gainii* Card.
  - *Andreaea regularis* Müll. Hal.
- Bartramiaceae
  - *Bartramia patens* Brid.
  - *Conostomum magellanicum* Sull.
- Brachytheciaceae
  - *Brachythecium austrosalebrosum* (Müll. Hall.) Paris
- Bryaceae
  - *Bryum orbiculatifolium* Card. & Broth.
  - *Pohlia cruda* (Hedw.) Lindb.
  - *Ptychostomum archangelicum* (Bruch & Schimp.) J.R. Spence
  - *Ptychostomum pallescens* (Schleich. ex Schwägr.) J.R. Spence
  - *Ptychostomum pseudotriquetrum* (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen
- Dicranaceae
  - *Chorisodontium aciphyllum* (Hook. f. & Wilson) Broth.
- Ditrichaceae
  - *Ceratodon purpureus* (Hedw.) Brid.
- Grimmiaceae
  - *Bucklandiella sudetica* (Funck) Bednarek-Ochyra & Ochyra
  - *Schistidium antarctici* (Card.) L.I. Savicz & Smirnova
- Hypnaceae
  - *Hypnum revolutum* (Mitt.) Lindb.
- Meesiaceae
  - *Meesia uliginosa* Hedw.
- Polytrichaceae
  - *Polytrichastrum alpinum* (Hedw.) G.L.
- Smith
  - *Polytrichum juniperinum* Hedw.
- Pottiaceae
  - *Hennediella antarctica* (Ångstr.) Ochyra & Matteri
  - *Hennediella heimii* (Hedw.) R.H. Zander
  - *Syntrichia filaris* (Müll. Hall *in* Neum.) R.H. Zander
  - *Syntrichia magellanica* (Mont.) R.H. Zander
  - *Syntrichia saxicola* (Card.) R.H. Zander
- Seligeraceae
  - *Dicranoweisia brevipes* (Müll. Hall.) Card.
  - *Dicranoweisia crispula* (Hedw.) Milde

Marchantiophyta
- Antheliaceae
  - *Anthelia juratzkana* (Limpr.) Trevis.
- Cephaloziaceae
  - *Cephalodia badia* (Gottesche) Steph.
- Cephaloziellaceae
  - *Cephaloziella varians* (Gottsche) Steph.
- Geocalycaceae
  - *Chiloscyphus dissitifolius* (Herzog & Grolle) Hentschel & J. Heinrichs
- Lepidoziaceae
  - *Hygrolembidium ventrosum* (Mitt.) Grolle
- Anastrophyllaceae
  - *Barbilophozia hatcheri* (A. Evans.) Loeske
- Jungermanniaceae
  - *Lophozia excisa* (Dicks.) Dumort.

Algae
- *Prasiola crispa* (Lightfoot) Kützing.

Phanerogams
- *Colobanthus quitensis* (Kunth) Bartl
- *Deschampsia antarctica* Desv.

Lichenized and lichenicolous fungi
- *Acarospora macrocyclos* Vain.
- *Amandinea petermanii* (Hue) Matzer, H. Mayrhofer & Scheid. (=*Rinodina petermanii* [Hue] Darb.)
- *Bacidia stipata* Lamb
- *Buellia anisomera* Vain.
- *Buellia russa* (Hue) Darb.
- *Caloplaca athallina* Darb.
- *Caloplaca cirrochrooides* (Vain.) Zahlbr.
- *Caloplaca citrina* (Hoffm.) Th. Fr.
- *Caloplaca regalis* (Vain.) Zahlbr.
- *Candelaria murrayi* (Dodge) Poelt
- *Cetraria aculeata* (Schreb.) Fr. (=Coelocaulon aculeatum [Schreber] Link)
- *Cladonia asahinae* J.W. Thompson
- *Cladonia borealis* S. Stenroos
- *Cladonia gracilis* (L.) Willd.
- *Cladonia squamosa* Hoffm.
- *Cystocoleus ebeneus* (Dillwyn) Thwaites
- *Haematomma erythroma* (Nyl.) Zahlbr.
- *Himantormia lugubris* (Hue) Lamb
- *Huea cerussata* (Hue) C.W. Dodge & G.E. Baker
- *Huea coralligera* (Hue) C.W. Dodge & G.E. Baker
- *Hypogymnia lugubris* (Pers.) Krog
- *Lecania brialmontii* (Vain.) Zahlbr.
- *Lecanora physciella* (Darb.) Hertel
- *Leptogium puberulum* Hue
- *Mastodia tesselata* (Hook.f. & Harv.) Hook.f. & Harvey
- *Micarea assimilata* (Nyl.) Coppins (=Lecidea assimilata Nyl.)
- *Microglaena antarctica* Lamb
- *Ochrolechia frigida* (Sw.) Lynge
- *Ochrolechia parella* (L.) A. Massal.
- *Pannaria hookeri* (Borrer ex Sm.) Nyl.
- *Parmelia saxatilis* (L.) Ach.
- *Physcia caesia* (Hoffm.) Fürnr.
- *Physcia dubia* (Hoffm.) Lettau
- *Physconia muscigena* (Ach.) Poelt
- *Placopsis contortuplicata* Lamb
- *Porpidia albocaerulescens* (Wulfen) Hertel et Knoph
- *Porpidia crustulata* (Ach.) Hertel et knoph
- *Pseudephebe pubescens* (L.) Choisy
- *Psoroma hypnorum* (Vahl) Gray
- *Ramalina terebrata* Hook et Tayl.
- *Rhizocarpon geographicum* (L.) DC.
- *Rhizocarpon polycarpon* (Hepp) Th. Fr.

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Table 1 *(continued)*

Rhizoplaca aspidophora (Vain.) Redón
Rhizoplaca melanophthalma (DC. in Lam. et DC.) Leuck. et Poelt
Sphaeorophorus globosus (Hudson) Vain.
Stereocaulon alpinum Laurer ex Funck
Stereocaulon glabrum (Müll. Arg.) Vain.
Umbilicaria decussata (Vill.) Zahlbr.
Umbilicaria propagulifera (Vain.) Llano
Umbilicaria rufidula (Hue) Filson
Usnea antarctica Du Rietz
Usnea aurantiaco-atra (Jacq.) Bory
Usnea trachycarpa (Stirt.) Mull. Arg.
Verrucaria psycrophila Lamb
Xanthoria candelaria (L.) Th. Fr.
Xanthoria elegans (Link.) Th. Fr.

Cryptogamic communities

Lichen–moss cushion formation

This mixed community occurs mainly on moraines, rocky protalus and talus deposits as well as on rock outcrops which border the several escarpments on Hennequin Point. It is composed mainly of epilithic lichens that grow on rock surfaces and are tolerant of exposure to strong winds and dry mineral soils. Twenty-seven species were found in this formation ($E = 0.69$; $H' = 0.98$). *Usnea antarctica, U. aurantiaco-atra, Rhizocarpon geographicum, Cladonia* spp. and *Sphaerophorus globosus* are abundant in this habitat. Close to skua (*Catharacta* spp.) nests, *Haematomma erythromma* and *Caloplaca* and *Xanthoria* spp. prevail. On the borders of the escarpments *Leptogium menziesii* and *Placopsis contortuplicata* are common on gravel. Moss cushions of *Schistidium antartici* and *Andreaea gainii* (often associated with epiphytic *Ochrolechia frigida*) occupy more protected and wetter microenvironments occurring between the rock fragments, possibly where late-lying snow lies.

This is the most extensive/widespread community type in the studied area, accounting for approximately 28% of the vegetated area. Protalus and talus habitats are very frequent geo-environments in the study area. As shown by Allison & Lewis-Smith (1973) and Longton (1982), epilithic lichens have an important role in mineral bioweathering through the release of organic chelates capable of chemically altering the underlying rocks.

Moss carpet formation

This community occurs on the marine terraces of Hennequin Point (Fig. 2), with stable hydromorphic cryosols. Twenty-eight species were recorded in this formation ($E = 0.63$; $H' = 0.91$), with thick moss carpets of *S. uncinata* being the predominant species. Four similar

Table 2 General characteristic of the plant communities mapped at Hennequin Point, Admiralty Bay, King George Island, Antarctica.

Community type	Common species	Geormophological characteristics	Area ha	Area %
	Cryptogamic communities			
Lichen–moss cushion formation	*Usnea antarctica* Du Rietz *Usnea aurantiaco-atra* (Jacq.) Bory Andreaea gainii Cardot *Ochrolechia frigida* (Sw.) Lynge	Rock outcrops, and coarse fragments on moraine, talus and protalus deposits	15.3	5.0
Moss carpet formation	*Sanionia uncinata* (Hedw.) Loeske *Rhizocarpon geographicum* (L.) DC.	Uplifted marine terraces	9.2	3.0
Fruticose and crustose lichen formation	*Usnea aurantiaco-atra* (Jacq.) Bory *Mastodia tessellata* (Hooker f. & Harvey) Hooker f. & Harvey *Lecania brialmontii* (Vainio) Zahlbr.	Rock outcrops on the seashore, with strong influence of seabird droppings	0.33	0.1
Fellfield communities	*Ptychostomum pseudotriquetrum* (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen *Ptychostomum. pallescens* (Schleich. ex Schwägr.) J.R. Spence *Hennediella heimii* (Hedw.) R.H. Zander	Recently deglacitated terrains such as fluvial–lacustrine plains and uplifted plateaus and cryoplanation surfaces	24.1	7.9
	Cryptogamic–phanerogamic communities			
Grass and cushion chamaephyte Formation	*Deschampsia antarctica* Desv. *Colobanthus quitensis* (Kunth.) Bartl. *Sanionia uncinata* (Hedw.) Loeske *Hennediella heimii* (Hedw.) R.H. Zander	Shallow soil developed on the surface of basalt dyke; strongly influenced by *Larus dominicanus*. colonies.	1.8	0.6
Deschampsia antarctica–moss–fruticose lichens subformation	*Deschampsia antarctica* Desv. *Usnea* spp. *Syntrichia magellanica* (Mont.) R.H. Zander	Stable protalus and talus deposits with pockets of organic-rich soil.	3.5	1.1

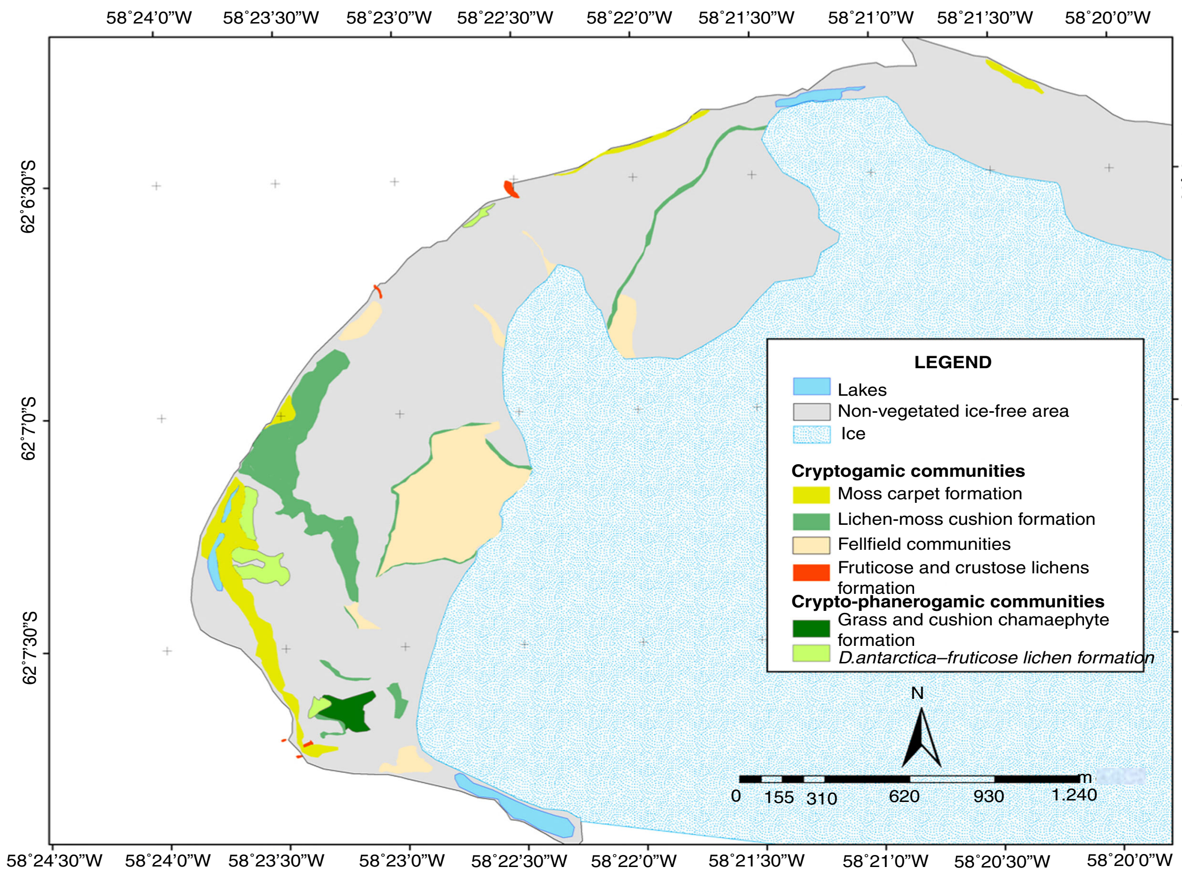

Fig. 2 Spatial distribution of plant communities at Hennequin Point, King George Island.

Table 3 Most important species found in the phytosociological survey at Hennequin Point.

Species	Number of quadrats[a]	F^b (%)	IES[c]
Sanionia uncinata (Hedw.) Loeske	148	71.84	211.7
Usnea aurantiac-oatra (Jacq.) Bory	53	25.7	34.91
Andreaea gainii Card.	51	24.75	32.57
Ochrolechia frígida (Sw.) Lynge	36	17.47	21.38
Usnea antarctica Du Rietz	34	16.5	22.2
Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen	30	14.5	16.97
Ptychostomum pallescens (Schleich. ex Schwägr.) J.R. Spence	27	13.1	15.00
Polytrichastrum alpinum (Hedw.) G. L. Sm.	22	10.68	11.97
Deschampsia antarctica Desv.	19	9.22	10.05
Polytrichum juniperinum Hedw.	18	8.73	9.56
Lecania brialmontii (Vainio) Zahlbr.	16	7.76	8.37
Bryum orbiculatifolium Cardot & Broth.	15	7.28	8.07
Buellia russa (Hue) Darb.	14	6.80	7.42
Hennediella heimii (Hedw.) R.H. Zander	11	5.33	5.62
Mastodia tesselata (Hooker f. & Harvey) Hooker f. & Harvey	11	5.33	5.62
Synchitria magellanica (Mont.) R.H. Zander	10	4.85	5.02
Leptogium menziesii Mont.	9	4.36	4.59
Rhizocarpon geographicum (L.) DC.	8	3.88	4.05

[a]Number of quadrats in which the species was recorded.
[b]Species frequency in 206 quadrats.
[c]Index of ecological significance (IES) in the total sampling.

Table 4 Number of species (R), equability (E), specific diversity observed (H') and the expected species diversity (H_{max}) for the plant formations found at Hennequin Point.

Formation	R	E	H	H_{max}
Lichen–moss cushion formation	27	0.69	0.98	1.43
Moss carpet formation	28	0.63	0.91	1.44
Fruticose and crustose lichen formation	28	0.55	0.80	1.44
Grass and cushion chameophyte formation	23	0.77	1.05	1.36
Deschampsia Antarctica–moss carpet subformation	11	0.47	0.48	1.04

areas, amounting to approximately 17% of the vegetated area, were mapped.

In the northernmost part of the ice-free area, there are two elongated raised beaches in the early stage of colonization by moss carpets. The stands are discontinuous and the dominant moss rather sparse (Fig. 2). These narrow marine terraces undergo a continuous sedimentation process due to the proximity of upland scree slope deposits. Hence, solifluction is high and widespread and inhibits the establishment of a continuous carpet of moss, and the cryoturbic action separates the graded material into stone and soil polygons or circles. However, larger marine terraces, close to the Ecuador Refuge, possess the largest and best developed stands of this plant community, forming extensive continuous carpets composed of *S. uncinata* often in association with hydric species, such as *Brachythecium austrosalebrosum* and *Warnstorfia sarmentosa*. Soil stability and greater isolation from the downward movement of mineral debris appears to be a determining factor for the development of these closed stands.

As observed in other areas of Admiralty Bay (Fumarzcky & Ochyra 1982; Ochyra 1998; Victoria et al. 2004), the establishment of these communities is strongly related to water supply. There are numerous small meltwater ponds and several larger lakes (Fig. 2). The chemical composition of the species found in these formations is strongly correlated with meltwater chemistry (Simas et al. 2008), suggesting that they may be potential indicators of melting water and ecosystems in future monitoring.

Fellfields communities

Although this is the largest community mapped, occupying approximately 44% of the vegetated area, the vegetation is not continuous, and these plant communities represent a successional stage of development that precedes the establishment of more developed and complex communities. These communities occur on recently deglaciated areas and on low-lying terraces as well as on the higher plateau. The more stable surface conditions and abundant water supply along meltwater channels allow relatively rapid plant colonization. Mats of cyanobacteria (i.e., *Nostoc commune*, *Phormidium* spp.) and algae *Prasiola crispa* are frequent in waterlogged areas, with occasional *Ptychostomum pseudotriquetrum* and *Ptychostomum pallescens,* as well as *Hennediella heimii* in wet areas, frequently forming vegetation stripes along the meltwater channels. *Andreaea gainii* and some crustose lichens grow in drier, slightly higher ground.

The soils are very similar to those found in other recent ice-free areas of Admiralty Bay, having a high salt concentration due to sea spray input and, to a lesser extent, mineral weathering (Simas et al. 2008). Despite this salt precipitation on the plants in these communities, their growth is, apparently, not affected. It is most likely that the rain or snowfall melt ameliorates the effect of the higher mineral concentrations (Kennedy 1995), such as salt ions and others injuries on the lichen species also (Cooper et al. 2001).

Fruticose and crustose lichen formation

This community occurs on small coastal rock outcrops strongly influenced by sea birds. The diversity status of this formation is similar to those for the moss carpet formation ($E = 0.55$; $H' = 0.80$), but there are fewer species in the present formation (Table 4). Numerous lichens are abundant, notably *Usnea aurantiaco-atra, Caloplaca* spp., *Xanthoria elegans*, *Xanthoria candelaria*, *Physcia caesia*, *Haematomma erythromma*, *Ramalina terebrata*, *Mastodia tessellata*, *Lecania brialmontii* and *Buellia* spp. It represents approximately 0.1% of the vegetated area.

Cryptogamic–phanerogamic communities

Grass and cushion chamaephyte formation

This community represents about 3% of the vegetated area and is associated mainly with kelp gull (*Larus dominicanus*) and skua (*Catharacta* spp.) colonies close to the sea. The vegetation occurs on basaltic dykes that interrupt the gravelly beaches and marine terraces. This formation shows the highest diversity status ($E = 0.77$; $H' = 1.05$), probably because of the higher coverage found in this formation (Fig. 2). These areas are characterized by the conspicuous presence of *Deschampsia antarctica* and *Colobanthus quitensis* associated with ornithocoprophilous lichens, such as *Caloplaca* spp., *Carbonea* sp., *Ramalina terebrata, Xanthoria elegans, Parmelia saxatilis* and *Umbilicaria antarctica* (less frequent). The grass is established on soil that is 20–30 cm deep and enriched with nutrients from guano deposition, while the lichens are mostly crustose species, growing on the exposed bare rock and subjected to N and P-rich leachates.

In areas of fresh guano deposition, the soil is colonized initially by the foliose green alga *Prasiola crispa*. Similar communities, too small to be mapped, also occur around skua nests, on marine terraces, associated with *Sanionia uncinata* carpets. *Hennediella antarctica* and *Polytrichum juniperinum* occur in some sites within these communities, indicating a high tolerance of ornithogenic nutrient input, which is not shown by other *Pottiaceae* and *Polytrichaceae* in the maritime Antarctic region. The influence of bird activity on the development of the terrestrial ecosystems of Admiralty Bay and similar regions in the maritime Antarctica has been reported by several authors (Gimingham & Lewis-Smith 1970; Longton 1982; Pereira & Putzke 1994; Ochyra 1998; Putzke & Pereira 2001; Simas et al. 2007). The high nutrient input from guano deposition, especially N and P, create specific soil conditions which can enhance vegetation development, but also inhibit some nitrophobic plants (Simas et al. 2007), such as *Hennediella heimii*.

Despite their rather localized occurrence, these communities are an important potential carbon sink due to the presence of the lignin-bearing phanerogams, *D. antarctica* and *C. quitensis*. In contrast to the areas occupied by fellfield communities, the soils supporting these plants are more acidic and have much higher C, P and total N concentrations (Michel et al. 2006; Simas et al. 2007).

Deschampsia antarctica–moss–fruticose lichen subformation

This community is similar to the lichen–moss cushion cryptogamic community, but with the addition of *Deschampsia antarctica*, and comprises only 11 species ($E = 0.47$; $H' = 0.48$). It occurs mainly on stable rocky protalus and talus deposits as well as on rock outcrops (where the grass occurs in rock crevices and on ledges), and represents 6.5% of the vegetated area. It is composed mainly of lichens which grow on rock surfaces and which tolerate very exposed and dry conditions. *Usnea antarctica* and *U. aurantiaco-atra* are the most common fruticose lichens. *Rhizocarpon geographicum, Parmelia saxatilis* and *Physconia muscigena* also occur. At the margins, *Leptogium menziesii* and cushions of *Syntrichia magellanica* and *Andreaea gainii* are observed, growing in more protected and wetter microenvironments amongst the rock fragments. There are often small *Sanionia uncinata* carpets and *Polytrichastrum alpinum* colony shoots adjacent to skua nests in the proximity of the Ecuador Refuge.

Conclusions

Overall, the plant communities of Hennequin Point are smaller in area than those mapped by Victoria (2005) on the western coast of Admiralty Bay. This may be due to the absence of penguin colonies, because the impact of penguin rookeries is regarded as a major factor linked to the occurrence and distribution of many plant and lichen species growing in maritime Antarctica (Longton 1982).

Floristically, the eastern and western shores of Admiralty Bay are similar, with several species present in both regions, but the abundance and frequency of species differs. On the western coast, *Sanionia uncinata* and *Polytrichastrum alpinum* are the most abundant moss species while on the eastern coast, although *S. uncinata* is very abundant. Polytrichaceae (*P. alpinum* and *P. juniperinum*) are not as abundant as observed at the western coast. Bryaceae and often Pottiaceae are prevalent, especially in waterlogged areas. As in other areas of Admiralty Bay, *Ptychostomum pseudotriquetrum* and *Hennediella heimii* are widely distributed on marine terraces, reinforcing their preference for non-ornithogenic, alkaline, salt-rich substrates (Furmanczyk & Ochyra 1982; Ochyra 1998). However, *Syntrichia magellanica* is more abundant in coastal sites around gull and skua nests and colonies.

The species of Grimmiaceae which, on the western coast, are restricted mostly to higher areas, are frequently present in lowland sites of the eastern coast. The native grass species occur in most plant communities, being most frequent in the grass and cushion chamaephyte formation, but are also present in other communities, especially those on marine terraces (*Deschampsia*–moss–fruticose lichen subformation).

The accuracy obtained from this survey will allow the monitoring of plant communities in ice-free areas from Hennequin Point. It may be possible to verify the increase or regression of the vegetation patches by overlaying the map generated in this study with further surveys.

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