Vegetation Map of Potter Peninsula, Maritime Antarctica

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Abstract. This paper aims to map the vegetation communities at the ice-free areas of Potter Peninsula at Maritime Antarctica using satellite image classification. We used a recent Quickbird image for digital classification. The image was georreferenced with orthorectification using terrain control points obtained in the field with a Leica DGPS, coupled with a digital elevation model. We used the NDVI (Normalized Difference Vegetation Index) for help in the vegetation class discrimination. In the image classification, we adopted the Maxver classifier (maximum verossimilarity), in which the training samples were demarcated based on field observations and intensive plant collection between February and March 2008. The vegetation communities were adapted from Longton (1967), based on local variations. The NDVI offers a clear distinction between the surfaces according to the spectral response difference of the infrared and red bands. The vegetation communities occupy approximately 23% of the ice free area. Lichens and mosses sub-formation covered the largest exposed areas. Mosses sub-formation occupation was restricted to wet areas, and grasses had a preference for rich ornithogenic soils. Vegetation coverage mapping gives an important basis for future environmental monitoring work in these areas and can help determine rates of expansion of vegetation coverage, and impacts caused by changes in local weather.

Keywords: Remote Sensing, high resolution satellite image, vegetation communities, Maritime Antarctic.

1. Introduction

The ice-free areas in maritime Antarctica have a peculiar flora, dominated by Cryptogams as Bryophytes, including mosses and Liverworts, two species of taluses algae, *Prasiola crispa* and *P. Cladophylla*, 360 known species of lichens and only two native phanerogams (Antarctica hairgrass *Deschampsia antarctica* Desv., and Antarctica pearlwort, *Colombathus quitensis* (Kunth) Bartl. (Øvstedal and Smith, 2001). They are adapted to cold climate, low solar radiation and snow coverage in winter.

When assessing the extent of plant community coverage it is important to analyse their temporal dynamics with ecological relationships and site attributes such as soil parent material, slope, and climate (Schaefer et al, 2004). Understanding the factors affecting the distribution of vegetation in the ice-free areas is an excellent tool for future studies on climate change, such as changes in landscape and plant communities. Longton (1967) based in previous works, adapted a vegetation classification system to maritime Antarctica, where the grouping of the different species is based on growing form and habitats. The formations are based on the criteria of the habitats and by the growth form of the most abundant species. The Tundra. Sub-formation units are based on growth form and the predominant association refers to the floristic similarity between the components (Smith & Gimingham, 1976, and Smith, 1972).

Most previous studies have focused on field floristic surveys helped with GPS, (Kim et al, 2007; Pereira et al, 2007), and identification of aerial photograph mosaics (Michel 2005; Santana, 2006; Francelino et al, 2004), resulting in vegetation maps of large scales in small ice-free areas. At extensive and inaccessible areas with heterogeneous distribution of vegetation, such as maritime Antarctica, the traditional vegetation mapping is more difficult at large scales.

However, satellite images with high resolution are excellent alternatives for these works. The satellite images through Remote Sensing can help the climate changes monitoring impacts in ice-free areas with efficient and more precise scales.

The objectives of the present work are to map the vegetation communities with satellite image classification in ice-free areas at Potter Peninsula at Maritime Antarctica.

2. Material and Methods

Potter peninsula is located in King George island, part of South Shetland archipelago, Maritime Antarctica (figure 1), in the flowing coordinates: 62˚13,5' and 62˚16’ S, 58˚42’ and 58˚33’ W. Potter peninsula stretches over a 6 km long east-west extension, and 3.5 km long north-south axis, with a total area of approximately 72.00 km^2 that is largely ice-free during the summer. There is located the Argentinean Base of Jubany. The climate of King George Island according Köppen classification is ET regime, polar tundra (Setzer, 2004), annual mean temperatures –2,8ºC, in summers -1,3 to 2,7ºC and winter -15,5 to -1,0ºC (Ferron et al, 2004). Potter peninsula belongs to Warszawa block formation, volcanic rock formed in Ypresuan period 50.6to 49.1 Ma (Kraus & del Valle, 2008). Potter Peninsula also hosts the Antarctic Specially Protected Area (ASPA) nº 132, in a marginal track along the south coast of the peninsula. This is an area with a concentration of Antarctica fauna such as extense penguin rookeries (*Pygocelis sp)* and mammals such as sea-lions *(Otaria flavescens)*, wedell-seals *(Leptonychotes weddellii)* and elephant-seals *(Mirounga leonina)*. In elevated areas skuas (*Catharacta* sp.) and giant-petrels (*Macronectes giganteus*) occur. The birds are responsible for deposit of nutrients in these areas, by the accumulation of remains of food and excrement.

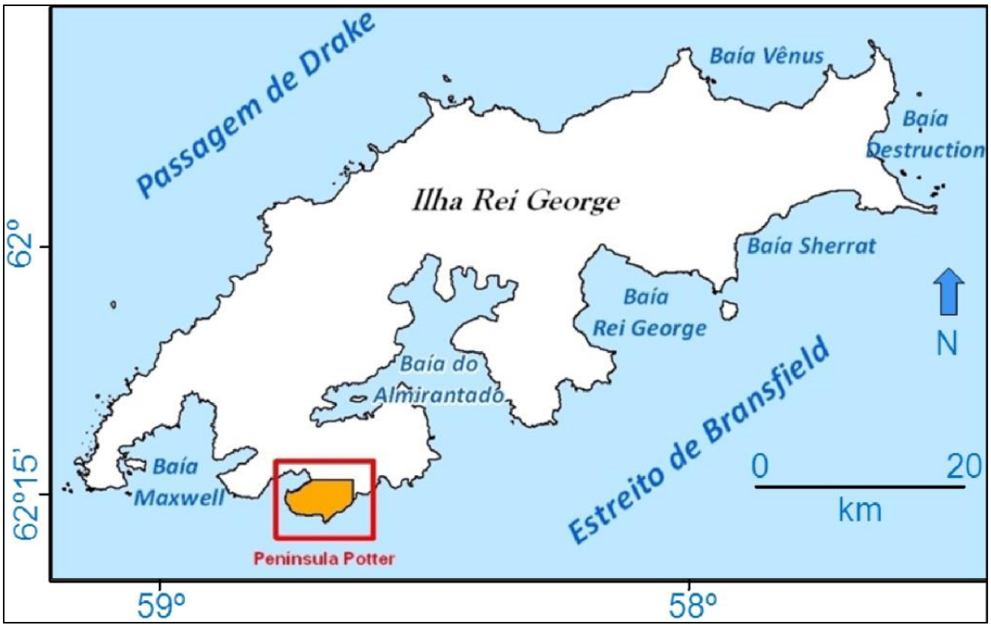

Figure 1: Study site location map

For the vegetation mapping, we used a recent Quickbird image (date January 6 2007), with four separate multispectral bands and a spatial resolution of 2.4 m. We used the NDVI (Normalized Difference Vegetation Index) for help in the vegetation class discrimination, such the following equation:

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

Where: NDVI is the Normalized Difference Vegetation Index; NIR is the Near Infrared Band; VIS is the Visible Red Band.

The image was georeferenciated and orthorectified using control points obtained in the field by a Leica DGPS, coupled with a digital elevation model (Lusky et al, 2001), following ArcGIS 9.3 routine procedures.

In the image classification, we adopted the Maxver classifier (maximum verossimilarity) using Idrisi Andes software, in which the training samples were demarcated based on field observations and intensive plant collection between February and March 2008, with precise GPS location. The vegetation communities were adapted from Longton (1967), based on local variations, and the thematic classes are presented in Table 1. The vegetation communities description were adapted from Longton (1967), based on local variations, and the thematic classes are presented in Table 1.

Table 1: Vegetation communities classification of Potter Peninsula.

Thematic classes	Description	Principal Specie
Mosses Sub-Formation	Mosses in wetted areas (associates with cyanobacteries)	*Usnea aurantico-atra, Usnea antarctica, Ochrolechia cf. frigida, Crustose sp, Usnea sp*
Mosses and Grass Sub-Formation	Bryophites and *D. antarctica* terraces well drained in ornithogenic soils	*Sanionia uncinata, Deschampsia antarctica, Polytrichastrum alpinum*
Lichens Sub-Formation	Homogeneous lichens fields in well drained rocky soils	*Sanionia uncinata, Andreaea* e *Nostoc spp, Phormidium spp*
Lichens and Mosses Sub-Formation	Mosses and lichens in ornithogenic soils in marine terraces	*Polytrichum sp, Usnea sp, Sanionia uncinata,*
Algae Taluses Sub-Formation	*Prasiola crispa* closed to penguin's rookeries and giant-petrels excesses of ammonia (fresh guano).	*P. crispa*
Rookeries	Active rookeries	(*Prasiola crispa*)
Exposed soil	Beach and moraines with incipient vegetation	
Water	Lake and sea Water	
Snow cover	Snow cover remains	
Shadow	Shadow	

3. Results

The infra-red band (0,76 a 0,90 mm) allowed a clear contrast between vegetated areas (due to different photosynthetic activities) compared with other surfaces, such as snow, exposed bare soil, and water bodies. The NDVI offers a clear distinction between the surfaces according to the spectral response difference of the infrared and red bands (Figure 2). Where, values close 0 (yellow in the map) correspond to exposed soil surface. In red, with values bellow -0.7 refer to water surfaces. have highest , the positive values refer to vegetation coverage due the clorofile compounds of plants in Infrared band. The highest values correspond to mosses and grasses communities (green values in the map).

Figure 3 shows the supervised classified map, which produced a very satisfactory kappa index (0.98). However, although we used a high resolution image, a more reliable automated classification of the vegetation was constrained by local microhabitats and the high heterogeneity of Antarctic plant communities.

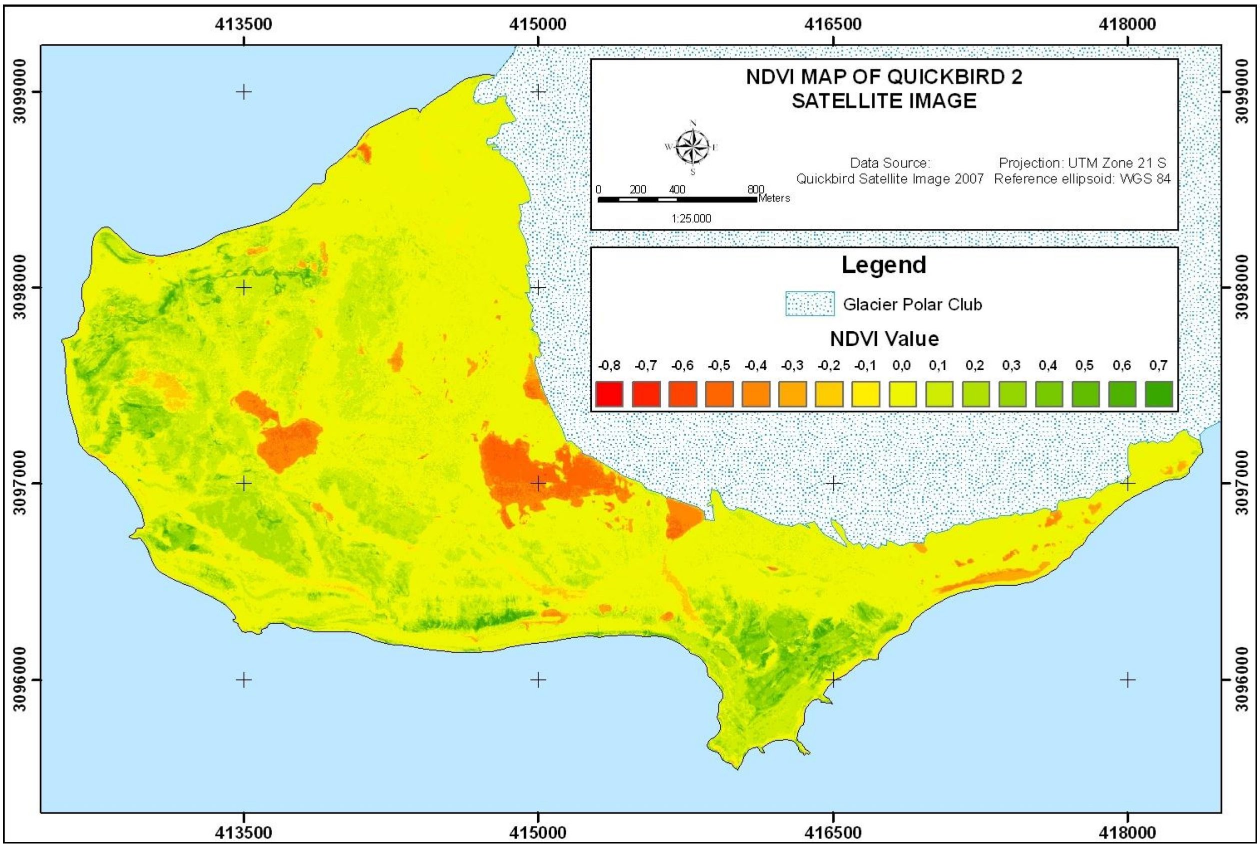

Figure 2: NDVI map of Quickbird 2 satellite image.

The oldest part of the peninsula has several distinct vegetation types. These areas are occupied with dense coverage of bryophytes and *D. antarctica* tuff replacing old areas of mosses, showing more advanced stages of vegetative succession. Poorly drained fields covered by mosses and *Prasiola* sp, and in most areas with shallow soil and rocky fields of Usnea sp, are typical at the most recent young moraine. According to recent studies of increasing temperature trend (Ferron et al, 2004), areas previously covered by snow and ice will be exposed to weathering and for expansion of plant communities through plant succession ecology.

Table 2: Thematic classes of plant communities areas in Potter Peninsula.

Thematic class	Areas (ha)	%
Mosses Sub-Formation	9.46	1.31
Mosses and Grass Sub-Formation	9.23	1.28
Lichens Sub-Formation	52.11	7.24
Lichens and Mosses Sub-Formation	81.26	11.29
Algae Taluses Sub-Formation	12.17	1.69
Rookeries	4.40	0.61
Soil expose	461.57	64.11
Water	43.94	6.10
Snow cover	39.05	5.42
Shadow	6.77	0.94
Total	719.96	100.00

At Potter peninsula, about 23% of ice-free areas were occupied with vegetation (Table 2). They are distributed in different parts of the landscape, where the oldest places with ice-free areas started at the beginning of the Holocene and ornithogenic areas have the most diverse vegetation cover. Lichens and some mosses species have greater distribution in the landscape, with 18.53% of coverage. They begin occupation in areas of stabilized moraine and rocky surfaces. Mosses and Gramineaes preferentially occupy areas with some influence from the birds in places with better drainage and very stable. Climate and soil stability are undoubtedly the dominating factors controlling both the establishment of vegetation and development of the soils (Allen et al, 1967).

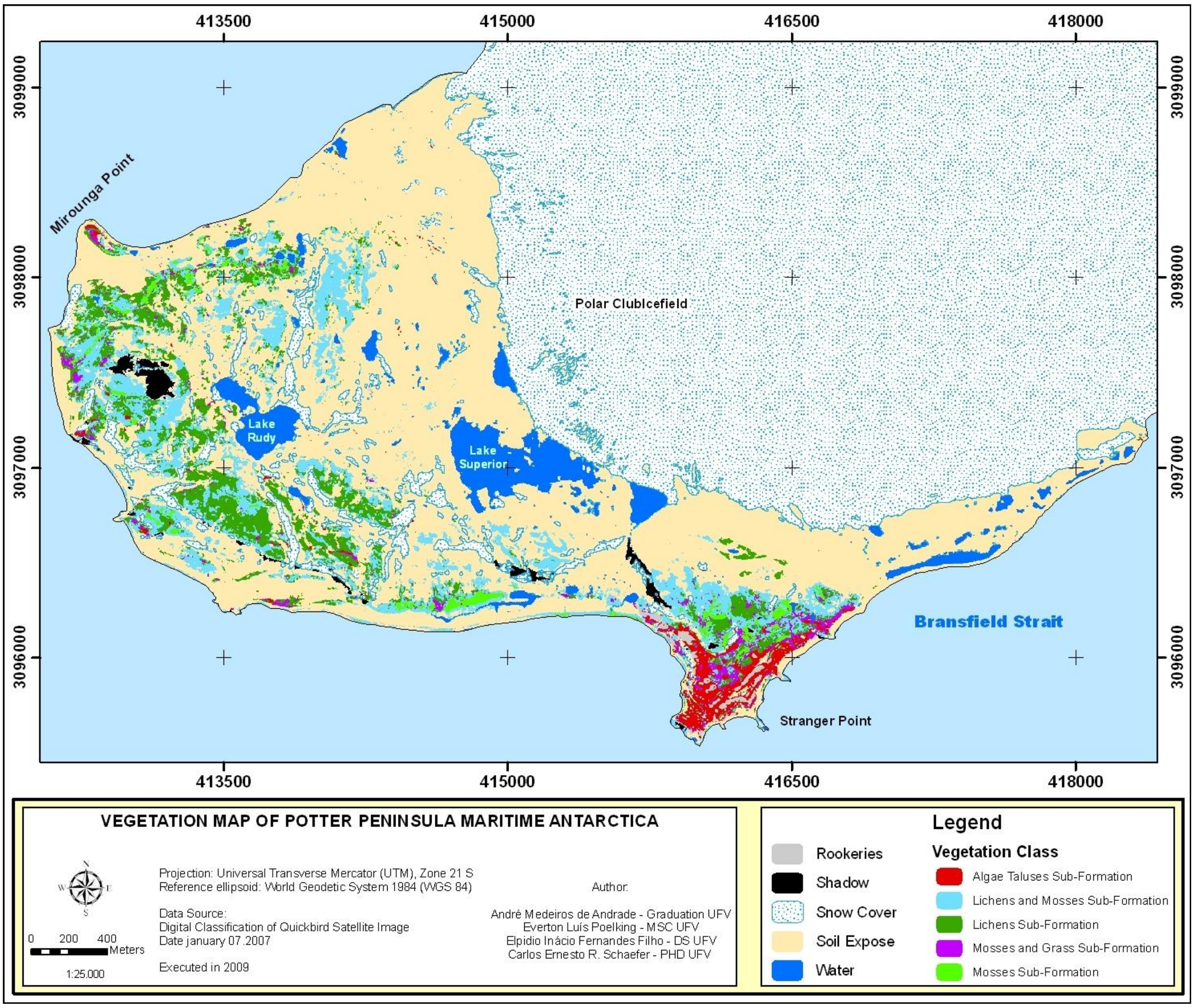

Figure 3: Vegetation coverage map of Potter Peninsula, Maritime Antarctica.

4. Conclusion

The vegetation communities occupied approximately 23% of ice free areas at Potter Peninsula. Lichens and mosses sub-formation covered largest exposed areas. Mosses sub-formation occupied restricted to wet areas, and grasses have preference to rich ornithogenic soils. Vegetation coverage mapping is an important basis for future work with environmental monitoring in these areas. Thus, it can be integrated with future surveys with the various components of the landscape, find evidence of environmental change in ice-free areas and determine rates of expansion of this coverage, impacts caused by changes in local weather.

5. Acknowledgments

The authors thank the National Council for Scientific and Technological Development (CNPq), Foundation for Research Support of Minas Gerais (FAPEMIG) and the Brazilian Antarctic Program (PROANTAR).

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