1 Antarctic Coastal Landscapes: Characteristics, Ecology and Research

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1.1 Antarctic Environments and Ecosystems

The Antarctic region is divisible ecologically into three circumpolar zonal subregions (Fig. 1.1, Table 1.1), each offering limited opportunities for settlement to plants and animals. The innermost high-latitude zone includes the polar continent, an ice-covered dome rising to over 4250 m, which imposes the most rigorous living conditions. The maritime zone, widest and most clearly defined in the sector containing the Antarctic Peninsula, features winters chilled by the presence of sea ice, and longer, markedly warmer summers. The periantarctic zone, including scattered island groups in a wide expanse of ocean, is far enough north to be free of pack ice in winter, and is correspondingly warmer throughout the year.

Polar terrestrial environments generally impose special demands on indigenous plant and animal communities (Table 1.2), which constrain the extent and biotic diversity and abundance of particular habitats. In the Antarctic region the most rigorous challenge is the presence of land ice. In the form of ice caps, glaciers, ice streams and ice shelves, this presents a virtually sterile substrate covering over 98 % of the continent, and between 60 and 80 % of land in the maritime zone. It is present on all but one of the periantarctic island groups: only the small and relatively low-lying Macdonald Islands are ice-free. Land ice supports only a limited flora of bacteria and cryophilic snow algae, in particular areas close to sea level.

Where the ice has retreated, conditions for living remain harsh, but bare rock and the finer materials resulting from weathering, followed by early stages of soil formation, provide a range of opportunities for plant and animal communities to develop. Ice-free areas are common both on continental Antarctica and in the maritime and periantarctic zones, mostly, but not exclusively, close to sea level. Papers in this volume are concerned especially with three areas, two on the continental coast and one in the maritime zone (Table 1.3), that are associated with long-term research stations.

Why have we chosen these three comparatively small ice-free exposures from such a vast area? The three associated stations have long records of bio-

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Table 1.1. Zonation of climate and vegetation within the circumpolar Antarctic region. (After Stonehouse 1982, 1989)

Region	Subregion	Subdivisions	Characteristics	Boundary
Antarctic	Continental Antarctica	East and West Antarctica, Alexander Land, Charcot Land, islands close to the continent. Three ecological zones: high plateau, inland slopes, coast	Mostly ice-covered; mean temperatures of warmest month below 0 °C. Annual precipitation <20 cm; clear skies inland. Soils ahumic, Protoranker, Ranker. Vegetation algae, lichens, mosses. Limited soil fauna of nematodes, mites, collemboles etc.	Extends to South Pole
	Maritime Antarctica	Antarctic Peninsula south to 69° S on west coast, 64° S on east coast, and neighbouring islands: South Orkney, South Shetland and Sandwich Is., Peter I Øy also (probably) Scott I. and Balleny Is.	Mostly ice-covered; mean temperatures of warmest months –10 to +2 °C, winter means rarely below-15 °C. Annual precipitation 20–100 cm; cloudy. Soils ahumic, Protoranker, Ranker. Vegetation: algae, lichens, mosses, 2 spp. of angiosperms; limited soil fauna of nematodes, mites, collemboles etc.	0 °C July isotherm
	Periantarctic islands	South Georgia, Bouvetøya, Heard I., Macdonald Is.	Glaciated uplands (not Macdonald Is.); mean temperature of warmest months 0 to +6 °C, winter means rarely below –2 °C. Soils mostly brown. Vegetation mosses, ferns, many angiosperm species; soil fauna includes earthworms, beetles Northern limit of pack ice	Antarctic Convergence

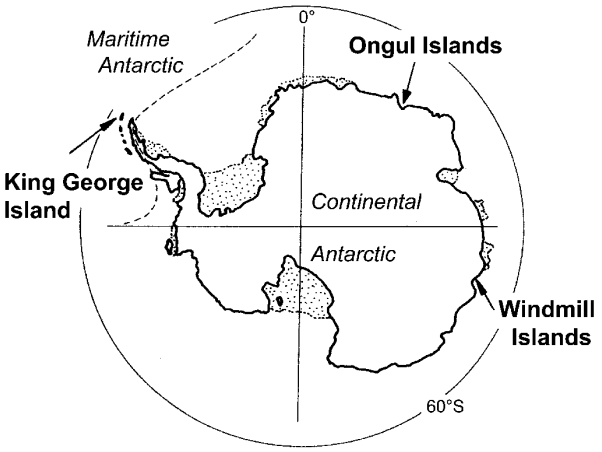

Fig. 1.1. Map of the Antarctic region 60°S, showing the locations of the three places which are the special focus of this book (cf. Chaps. 3–5). The boundary between the Maritime and the Continental Antarctic is marked by a *dashed line*. (After Seppelt 1986)

Table 1.2. Factors restricting plant settlement and growth in Antarctic ecosystems

Climatic factors	Soil factors	Recruitment factors
Low mean monthly temperatures	Prevalence of ice and bare rock	Isolation from other continents
Short growing season	Immature Lithosols	Few sources of propagules
Wide daily temperature ranges	Lack of available water	Inhospitable substrates
Frequent freeze-thaw cycles	Immature drainage systems	
Strong winds	Lack of nutrients in Lithosols	
Low precipitation	High nutrients in ornithogenic soils	
	High permafrost, thin active layer	

Table 1.3. Coastal areas and associated research stations (see Chaps. 3–5)

Landscape area	Admiralty Bay	Windmill Is.	Ongul Is.
Research station	Henryk Arctowski	Casey	Syowa
Co-ordinates	62°10' S, 58°28' W	66°17' S, 110°31' E	69°00' S, 39°35' E
Locality	King George Is., South Shetland Is.	Budd Coast, Wilkes Land	Kronprins Olav Kyst, Dronning Maud Land
Antarctic zone	Maritime	Continental	Continental
Altitude	10 m	20 m	15 m
Air temp. – annual mean	–2.7 °C	–9.1 °C	–13.4 °C
Precipitation – annual mean	510 mm	195 mm	146–192 mm

logical and other scientific research, including synoptic meteorological records. Collaborative research projects, especially since 1992, have resulted in directly comparable data sets for soils, vegetation, plants and microbes. Climatologically, Syowa Station is more like Casey than Arctowski, but its vegetation contains maritime elements that link it more closely to Arctowski than to Casey. Soils, although often poorly understood in their ecological role, have been studied at all three stations, creating a sound basis for all other aspects of terrestrial research.

1.2 Characteristics of Antarctic Coastal Landscapes

1.2.1 The Former Use of 'Oasis' as a Synonym for Ice-Free Landscapes

The term 'oasis' basically originated in Egypt to describe fertile areas of the Libyan desert. A literary note worth reading on the term 'oasis' is given by J. Pickard in his introductory chapter 'Antarctic Oases, Davis Station and the Vestfold Hills' (in: Pickard J (ed) Antarctic Oases. Academic Press, Sydney, 1986, pp. 1–19): *It gained common usage for desert areas where, because of the anomalous presence of groundwater, vegetation grew and persisted in surroundings of aridity and near-sterility*. Antarctic surveyors (e.g. Stephenson 1938, Klebelsberg 1942, Byrd 1947, quoted in Pickard (1986) misappropriated the term to describe areas of continental Antarctica where local paucity of precipitation, sometimes combined with anomalous topography, results in the local starvation of ice sheets and the consequent appearance of bedrock, gravel and soil.

Early users of the term in an Antarctic context referred simply to anomalous ice-free areas on the continent. Shumskiy (1957), reviewing contemporary discoveries along the continental coast of Antarctica, defined oases as substantial ice-free areas separated from neighbouring ice sheets by an ablation zone, and kept free from snow by ablation due to low albedo and radiation. In a much later review and catalogue of Antarctic oases, Pickard (1986a) suggested that a minimal area of at least 10 km^2 was needed to distinguish oases from smaller ice-free areas, for example nunataks, beaches and moraines. He catalogued one very large 'mountain oasis' (the Victoria Land Dry Valleys system) and six 'low coastal oases' (Bunger Hills, Vestfold Hills, Windmill Islands, Schirmacher Oasis, Sôya Coast and Thala Hills). With colleagues (Pickard 1986), he summarised aspects of the Vestfold Hills Oasis, providing a general introduction to continental coastal oases so defined.

Used in this sense, the term 'oasis' expressed the curious fact that a substantially ice-covered continent displays small, discrete ice-free areas. It bore no implications of that most striking feature of hot desert oases – abundant

vegetation. Antarctic oases as originally defined are so arid as to be conspicuously lacking in plant life.

In its original Antarctic context, and in Pickard's review, 'Antarctic oasis' was restricted to continental localities and did not include the many extensive ice-free areas of the maritime Antarctic, i.e. the western flank of Antarctic Peninsula and the southern islands of the Scotia Arc. The term appeared to be broadened to include ice-free areas throughout more, possibly all, of the Antarctic region. The extension may be confusing, although expressing some truth common to all, its use is not quite correct and cannot be applied to the comparatively well-vegetated coasts of periantarctic islands. Svoboda and Freedman (1994) used the term in a similar sense for ice-free areas of Ellesmere Island in the Canadian Arctic.

Ice-free areas throughout the region have emerged relatively recently (i.e. probably within the past few thousand years) from under receding land ice, to be subject to colonisation by plants, animals and man. Ice-free areas of the maritime region, like those of the continent, are bounded at least in part by edges of the ice sheet from which they have emerged. Several differ from their continental counterparts by having substrates of thin organic soils and patches of continuous vegetation (see below). However, these do not invalidate comparison: they indicate either longer periods of exposure, or more favourable conditions for soil formation, plant recruitment and growth, or possibly both.

Glaciers currently bound several coastal areas of South Georgia and Heard Island, while periglacial evidence suggests that ice sheets previously covered most or all of the islands, down to and including the coasts. Again, the mature soils and wider diversity of vegetation on these islands contrast with those of more southerly regions. Again, these are likely to indicate only longer histories of exposure and colonisation under comparatively mild climatic conditions, in particular the absence of sea ice that ensures warmer and shorter winters.

1.3 Characteristics of Antarctic Coastal Landscapes

Ice sheets covering Antarctica and its neighbouring islands persist where solid precipitation, usually of snow or ice spicules, exceeds melting and ablation, either locally or in nearby catchment areas from which the ice has travelled. Their transient and mobile surfaces are biologically inhospitable, colonised only by a limited microflora of bacteria and snow algae. For different reasons they are inhospitable to man. Research stations built on the relatively dry interior plateau sink slowly into the ice. Those built on coastal ice shelves, where precipitation is higher, tend first to disappear under snow, then to move seaward with the general flow and be lost when the ice shelf calves.