The Plants of Macquarie Island: The Development of a Subantarctic Plant House

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This paper reviews some of the information available on the ecological and physical influences on Macquarie Island's complex range of plant communities. The plants that have managed to reach the island and successfully colonise it exhibit a range of strategies for dissemination, reproduction, and colonisation. The conjunction of climatic factors and inherent soil instability creates a shifting mosaic of colonisation and succession. We believe an understanding of these processes will contribute to the successful cultivation and management of the plants in the new Subantarctic Plant House at the Royal Tasmanian Botanical Gardens. Germination trials and field observations of these plants by researchers from the University of Queensland and Royal Tasmanian Botanical Gardens staff has and will continue to provide additional information.

BACKGROUND

Subantarctic Macquarie Island lies at latitude 54°30' S in the Southern Ocean, approximately 1000 km south-southeast of Tasmania. It is a relatively young landmass, emerging from great depth as oceanic crust between 300,000 and 80,000 years ago (Selkirk et al., 1990). The island now lies in isolation on the eastern edge of the Australian tectonic plate and is shaped like a narrow rectangle, measuring 34 km in length with a maximum width of 5.5 km. The highest point is 433 m above sea level (asl) with the mean elevation of the plateau above 200 m asl, although a number of areas exceed 300 m asl.

CLIMATE

The island lies on the outer edge of an important oceanic boundary, the Antarctic Convergence, where cold waters from the south meet warm waters from the north. The circumpolar currents and a belt of low atmospheric pressure surrounding Antarctica at between 35° and 60°S have a major effect on the island's weather, resulting in only a moderate variation in the diurnal temperature. Overall, the mean maximum temperature is 6.3°C and the minimum 2.9°C, giving an annual mean temperature of 4.8°C.

Precipitation falls as rain, mist, sleet and snow but snow cover is erratic over the year and is neither regular nor persistent over winter (Bergstrom et al., 1997). Mean annual precipitation is not high at 895 mm but because of its constant nature and the low degree of evaporation, the soil remains continually moist. The "Furious Fifties" exert a commanding influence on the climate of Macquarie Island which lies directly in the path of these winds, and mean wind flow over the island is in a northwest to westerly direction (Streten, 1988). The severity of the winds is greater on the exposed plateaus where soil and air temperatures are also lower, and precipitation higher than for the rest of the island.

Cloud cover averages seven-eighths in all months making the island one of the cloudiest places on earth (Streten, 1988). Despite prolonged summer daylength, overall light intensity is low but the island's plants are able to use light efficiently at prevailing temperatures. These temperatures are not low enough to limit metabolic activity and plant productivity is high (Selkirk et al., 1990). These climatic factors have a strong influence on the geomorphic processes and vegetation distribution on Macquarie Island (Selkirk et al., 1990).

SOIL DYNAMICS

The interaction of several of the physical and, to a lesser extent, the chemical forces which prevail in this climate result in bare soil becoming available for colonisation by plants. Frost, wind, and water combine with the force of gravity to produce a varied and shifting pattern of erosion, complicated at a more local level by the activity of marine birds and mammals. The common factor underlying the soil structure on much of Macquarie Island is that of instability. This leads to mass movement of soil, root damage, loss of plant communities and their replacement by others, often in a recognizable cycle. This sequence is well illustrated in the freeze-thaw cycles which disrupt the feldmark communities of the higher regions (Heilbronn and Walton, 1984).

VEGETATION

Macquarie Island has never been connected to an adjacent land mass (Selkirk et al., 1990) so all flora and fauna must have reached it by long-distance oceanic dispersal. The flora shows taxonomic linkage to other subantarctic islands, the continents to the west and the islands to the south of New Zealand. Current established plant species could thus be considered as obligate colonisers, and 45 vascular plants, 80 mosses, 50 liverworts, and 100 lichens have been successful (Selkirk et al., 1990). Three plants, *Azorella macquariensis, Puccinellia macquariensis* [syn. *Triodia macquariensis*] (George et al., 1993), and *Corybas dienemus* (Jones, 1998) are considered endemic to Macquarie Island, with naturalised aliens including *Poa annua, Stellaria media*, and *Cerastium fontanum.*

Zoning of plant communities on Macquarie Island is basically a function of their proximity to the sea and their altitude. The structure of the near-shore plant communities and those of the coastal terraces are strongly influenced by the sea itself, the substrate, and faunal impact. The almost exclusive communities of *Poa foliosa* and *Stilbocarpa polaris* on the coastal slopes give way to the short tussock grasslands and herb fields of the upland plateaux. The latter are recovering from the heavy grazing inflicted by the rabbit population, which is now in decline. At the highest level, on the exposed plateau the communities are moss-dominated, with the combination of wind and frost proving too hostile for most vascular plants (Selkirk et al., 1990).

Within the broader topographical context of floral communities there exist further subgroups based on the dominant species. Several of these groups may coexist side by side in the same geographic area. These groupings can be broadly categorised into: tall tussock grassland, short tussock grassland, fern brake, mire, herb field, and feldmark. Within these broad groupings, there exists a range of alliances, associations, and sub-associations that make up a complex matrix of plant mosaics (Selkirk et al., 1990).

Bergstrom et al. (1997) have identified four basic growth patterns displayed by Macquarie Island plants and related them to their colonising ability. Firstly, small herbs and grasses with vegetative growth potential, rapid flowering, and seed set with high germinability, all of which enable them to colonise bare ground. Secondly, medium herbs and medium to large grasses, the major contributors to biomass on the island, with the capacity for juvenile vegetative expansion and high seed germinability. The third group, typified by large herbs have extensive storage tissue and vegetative growth, attributes which enable them to function as perennial stayers. Lastly there is a group of plants which have no vegetative reproduction, very slow flowering and seed production levels but which can tolerate and colonise difficult sites. Species which demonstrate some of the preceding growth patterns will form a significant part of the display in the Subantarctic Plant House.

ROYAL TASMANIAN BOTANICAL GARDENS (RTBG) SUBANTARCTIC PLANT HOUSE

The Subantarctic Plant House is a teardrop-shaped, solid-walled, clear-roofed display facility which measures 14 m on its long axis, is 6 m wide, and stands 4 m high; it has high curving walls to maximise the opportunities for visual display combined with a separate steel framed external structure. This building is a unique response to the problems of creating a cool climate house. Internally the structure will be cooled by piped cold water at ground level; air conditioning and misting systems will cool the atmosphere. The steel frame will support a shading system and external watering.

CLIMATE AND CULTIVATION

Given the practical and financial constraints it has been impossible to replicate the extremes of the Macquarie Island climate. The temperature variation within the house will be several degrees above the equivalent on the island. The island's constant high winds and minimum temperature are difficult to duplicate. Air movement in the building will be provided by fan-driven chiller units, and though this will supply ample air flow it will not provide the extremes experienced on the island. Trial cultivation has indicated that a high level of air flow is an important requirement for the successful growth of these plants.

The island's constant high humidity will be maintained in the new structure by chiller units and a fogging system. Macquarie Island House will have solid sides and a clear double-skinned polycarbonate roof, protected by a 75% shade cloth. Given the plants ability to thrive in low light conditions this will provide adequate light levels for cultivation. Some variation occurs within the house, with areas closest to the north wall in constant shade while the base of the southern wall receives direct sunlight in summer. The feldmark cushion plant, *Azorella macquariensis*, requires higher light levels and will be grown at the base of this wall. An unknown factor is how plants from the exposed plateau will adapt to the new conditions, *A. macquariensis* tends to produce larger leaves and has a more open habit in cultivation. Experience to date, growing the plants in refrigerated containers under artificial light, indicates that environmental conditions in the house will be suitable for successful growth.

PLANT COMMUNITIES IN CULTIVATION

Scale and dimensions within the house do not permit enough variation in the environmental conditions, therefore our approach will be a horticultural one. The composition of community plantings will be defined from the outset and maintained by weeding out unwanted species. Communities dominated by single species will be planted as such, but others, for example short tussock grasslands, mire, and coastal vegetation will be composed of representative species. Small-scale replication of some of the more complex plant combinations will be trialled but several plants will not be considered due to their weed potential. Mosses and hepatics will be added as named provenanced collections become available.

SOIL STRUCTURE

The complex and unstable nature of the island's substrate cannot be reproduced although this has significant influence in the make-up of the community structure on the island. Over the past 3 years of trial cultivation the Gardens have developed a generic soil mix for all Macquarie Island plants. This replicates many of the characteristics of the island's soil in that it has good structure and high water-holding capacity. The base mix contains composted pine bark, sand, and Tasmanian peat (2 : 1 : 1, by volume). Low nutrient levels will be supplemented by regular application of liquid fertiliser. Initial plantings will use the one standard mix rather than attempting to vary them to suit individual plants.

PROPAGATION

The material at the Gardens has been mainly collected by staff members and researchers from the University of Queensland over the past six years. Most material was collected from the north of Macquarie Island. Grasses, rushes, and sedges have been successfully propagated by division using tillers. Smaller herbs like *Callitriche, Montia, Colobanthus, Acaena,* and *Leptinella* have been easily divided into rooted sections although the feldmark cushion *Azorella* has been difficult to propagate by division. The important large herbs *Pleurophyllum* and *Stilbocarpa* have been cultivated only from direct transplants from the wild. Successful long-term cultivation of *Pleurophyllum* has only been achieved by transplanting wild collected seedlings at the second to third true leaf stage and a process of regular repotting. *Stilbocarpa* can be successfully transplanted using large sections of rhizome provided a reasonable root system has developed. Small cuttings of adventitious growth excised from the rhizome will be trialled as another potential method of propagation. Germination experiments using seed from the island and cultivated plants will continue.

SUMMARY

There is a wealth of information about the plants of Macquarie Island and their ecophysiological requirements which we have used to define the environmental conditions within the Subantarctic House. With limited physical and financial resources, we have had to develop a more moderate set of environmental parameters than those which prevail on the island. An assessment of the cultural requirements for each species has been based on a knowledge of their habitats and associations in the wild, coupled with a practical approach to their horticultural needs. The result will be representative selection of plant communities which should grow successfully in the environment of the plant house to give a realistic representation of Macquarie Island's vegetation.

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Armillaria Control at the Royal Tasmanian Botanical Gardens

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In recent years the Royal Tasmanian Botanical Gardens has suffered from a massive infection of *Armillaria* that threatened the survival of a large proportion of the Gardens. The background situation and containment including the eradication and prevention processes either considered, trialled, or used to attack the disease, are described. The success of the work is attributed to proactive fundraising and the courage to take drastic action.

INTRODUCTION

Fungal root rot disease caused by members of the genus *Armillaria* is a phenomenon that has a global distribution (Shaw and Kile, 1991). *Armillaria luteobubalina,* a species endemic to Australia, has been a major problem in the Royal Tasmanian Botanical Gardens (RTBG). Some background to the situation and the methods to treat the disease are covered below.

The fungus can be either saprophytic or pathogenic. It commonly exists in dead wood but in appropriate conditions can also infect living plants. The saprophytic phase, typically in a buried tree stump, can last several decades (Kile, 1981; Summerell, pers.comm.), or even centuries (Anderson et al., 1979) which makes its control problematic. The species does not produce rhizomorphs. Spread of infection can take place in one of two ways: either by windblown spore dispersal or by subterranean contact, usually across root systems. Local spread by root contact is believed to be the most common.