South Georgia Non-Native Plant Management Strategy 2016 - 2020

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Cover image: Introduced grasses along a river bank at Grytviken Whaling station. The non-native *Agrostis capillaris* is a dark green against the native *Festuca* grassland. (Bradley Myer, March 2015)

Executive summary

- The small and fragile vegetated ecosystems of South Georgia cover approximately 30,000 hectares (8% of the total area of the island).
- There are 25 species of native vascular plants on South Georgia and 41 non-native plant species which have been introduced through human activities.
- Non-native plant species were first introduced by sealers and shore-based whaling operations.
- There has been tremendous progress in restoring South Georgia's natural habitats in recent years, including major projects to eradicate invasive rodents and reindeer.
- After reindeer had been removed, non-native plant species were released from grazing pressure and, as a consequence, have been able to grow, flower and set seed unhindered.
- A key element of the holistic, ecosystem based management approach adopted by the Government of South Georgia & the South Sandwich Islands (GSGSSI) was to ensure that resources were in place to establish a non-native plant management programme to dove-tail with the completion of the reindeer eradication project.
- This document provides details of the strategic tools and tactics required to manage non-native plants on South Georgia.
- It is estimated that 33 non-native plant species can be managed to zero density or eradicated by 2020 given adequate resourcing.
- Four non-native plant species require sustained control and a further three require localised site-led control only.
- Long-term, it is feasible to aim for the eradication of 75% or more of the non-native plant species that are currently found on South Georgia
- The eradication of these species is a realistic objective due to the island's location and biosecurity measures in place.
- Continued implementation of biosecurity measures is vital to prevent the introduction, establishment and further spread of non-native plant species.
- The work proposed in this strategy has been subject to an Environmental Impact Assessment.

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1. Introduction

South Georgia is part of the United Kingdom Overseas Territory of South Georgia & the South Sandwich Islands (SGSSI). Located in the South Atlantic approximately 1,450 south-east of the Falkland Islands, the island is home to an abundance of wildlife including five million seals of four different species and 65 million breeding birds of 30 different species

The landscape of South Georgia is mountainous and glaciated. Only the coastal fringes, which are snow free in the summer months, can support vegetation. As a result only 8% of the land mass provides a suitable habitat for plants. Of that, only 3% is fully vegetated, with the remaining 5% either partially or sparsely vegetated. There are 25 indigenous vascular plants species and with the exception of the hybrid *Acaena magellanica x tenera*, no endemic higher plants are known, although there are a few endemic bryophytes and lichens (McIntosh and Walton 2000).

With the harsh climate characterised by low temperatures and winter snow cover at sea level, the vegetated ecosystems are small and fragile. Despite the lack of endemic vascular plant species, the structure of the communities is unique and valuable. Non-native species have the potential to impact many aspects of ecosystem function, including nutrient cycling and trophic interactions (Chown and Block 1997). If they become wide spread the may also change the character of communities (Figure 1) and reduce wilderness values.

Figure 1: Non-native Deschampsia cespitosa *overtopping native* Festuca contracta

Many plant species were introduced by sealers and those involved in shore-based whaling activities through the importation of building materials, livestock and fodder (Greene 1964). Although whaling ceased in the 1960s, one of the legacies of the whaling era is the spread of these non-native plants from the stations and other sites of human activity into the surrounding native vegetation.

Reindeer were also introduced to South Georgia during the whaling era and as well as damaging native vegetation through grazing and antler rubbing, they contributed to the spread of non-native plants. Following the GSGSSI reindeer eradication project (GSGSSI 2013, 2014) the scale of this assisted dispersal is becoming apparent as vegetation recovers and populations of non-native plants become more visible.

Eradication of non-native species is a stated management priority for the Government of South Georgia & the South Sandwich Islands (GSGSSI). As part of its commitment to the sustainable management of the environment and to the protection of South Georgia's indigenous biodiversity, GSGSSI is committed to restoring habitats and managing the threats posed by non-native species. Key strategy documents including the South Georgia Strategy 2016-2020 and the National Biodiversity Action Plan 2016-2020 clearly outline the need for non-native plant species management.

Local management of selected non-native plant species on South Georgia has been undertaken since 2004 when the first efforts to control *Cardamine glacialis* were initiated. This species is thought to have been introduced in the 1980's during the construction of the research station at King Edward Point and as a result, its distribution is still restricted. Herbicides and physical removal were trialled with varying success. In spring 2010 the introduction of new herbicides and the development of a prototype South Georgia Non-Native Plants Database enabled a more methodical approach to be implemented for the control of non-native plants. This database records historical non-native plant populations by area, allowing these locations to be searched and control measures implemented.

In 2014 GSGSSI were successful in applying for funding from the UK Government funded Darwin Plus initiative (www.darwininitiative.org.uk) for a project entitled 'Strategic Management of Invasive Alien Plants on South Georgia'. This funding has enabled a more strategic approach to island wide non-native plant control. As well as on-going control of low incidence species the funding allowed the completion of comprehensive surveys, and the distribution and extent of non-native plant species on the island to be mapped (Figure 2). This data complemented an earlier non-native plant survey undertaken by the Royal Botanic Gardens at Kew in 2009 (Osborne et al. 2009) and has enabled the production of this document. The South Georgia Non-Native Plants Database was further developed and now provides a comprehensive tool for non-native plant management on South Georgia.

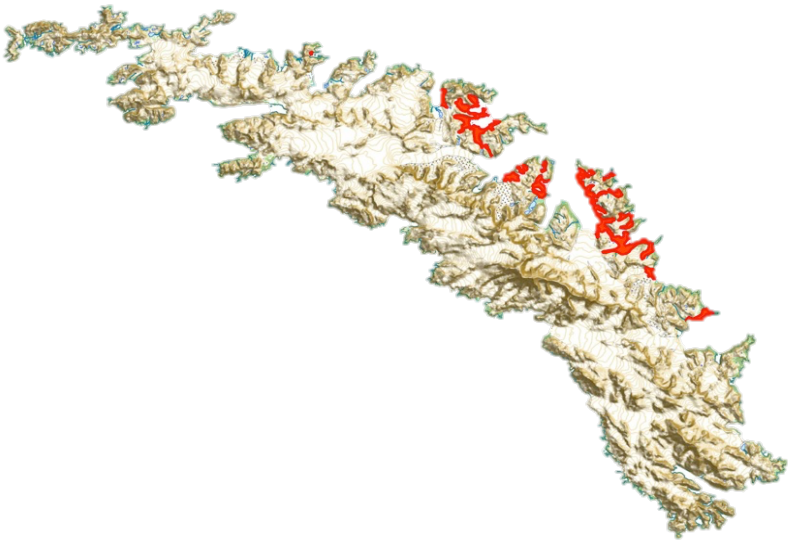


Figure 2: Areas surveyed in 2015 season shown in red total more than 6000 ha.

The purpose of this document is to build on the tools already available by setting out the rationale for and a framework under which non-native plants on South Georgia can be managed for the period 2016-2020. Implementation of this strategy should directly reduce the populations of non-native plant species, decrease competition for native plant species and help restore South Georgia to a more natural state.

1.1 Current Situation

The distribution of the majority of non-native plant species is restricted to the central north coast of the island (Figure 3). However, increasing visitor numbers and glacial retreat mean that there is a risk of non-native plants spreading to other areas. Some non-native species such as *Poa annua* have already spread beyond the point of control. Without strategic management, others, which still have a restricted distribution, could spread to the point where control is no longer achievable.

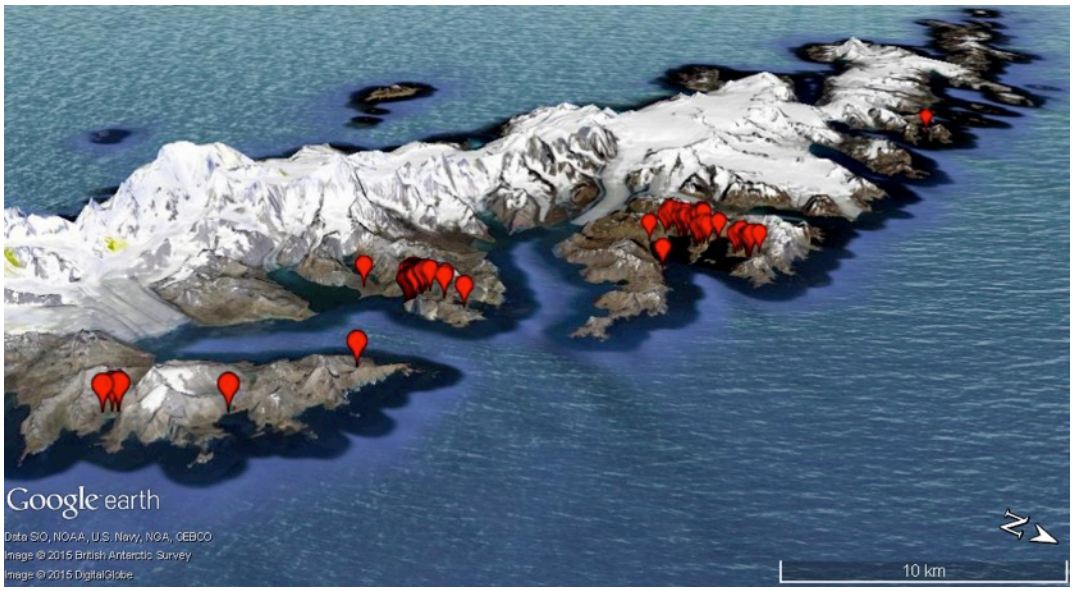


Figure 3: South Georgia sites of high priority non-native plant sites (February 2015)

The eradication of many non-native plant species is a realistic objective as most are in relatively small populations, associated with areas of human disturbance; only a few are widely distributed across the island. Those species that are widespread due to dispersal by wind or reindeer will be more of a challenge. However, containment is still a realistic aspiration and will reduce their impact on native biodiversity

There are 158 sites where non-native plants are subject to control measures that are currently recorded in the South Georgia Non-native Plants Database. Follow-up work and monitoring will be required at these sites because sizable seed banks, which can take a number of year to deplete, can be contained within the soil. Continued resourcing will allow follow up work at low-incidence species sites, which it is hoped will lead to the eventual eradication of many of the non-native plant species. The remaining, more widespread non-native plants species will be managed on a site-by-site basis.

Implementation of this strategy, continuing to implement rigorous biosecurity measures and building capacity to react rapidly if new species are detected will have profound benefits for South Georgia ecosystems.

2. Legislative and Planning Context

The regulatory and strategic framework outlined below provides the context in which this strategy operates.

2.1 Domestic legislation – Wildlife and Protected Areas Ordinance 2011

The Wildlife and Protected Areas Ordinance gives comprehensive protection to the flora and fauna of South Georgia. Amongst other things the legislation includes:

- Protection for wild birds and mammals, native invertebrates, native plants and the habitats in which they live;
- Prohibition of introducing non-native species.

In the context of non-native plant management, it is a requirement that a permit is obtained from the Commissioner in order to undertake herbicide control, since the process of control may cause damage to native species. In order for a permit to be granted, an Environmental Assessment must be undertaken and all practical means used to minimise disturbance to native biota should be in place (see Myer 2016). The Wildlife and Protected Areas Ordinance 2011 also enshrines in law GSGSSI's commitment to biosecurity.

2.2 International Agreements – Convention on Biological Diversity

In 2015, at the request of GSGSSI, the UK government extended its ratification of the Convention on Biological Diversity to SGSSI. The objectives of the Convention are:

- the conservation of biological diversity;
- the sustainable use of its components; and
- the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

The ratification of the Convention to include SGSSI is an endorsement of its principles and a commitment to meet its Aichi Targets, including Target 9 which states "*By 2020, invasive non-native species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment*".

2.3 Planning and Strategy

The South Georgia Strategy 2016-2020 is an overarching framework agreed by GSGSSI and the Foreign and Commonwealth Office (FCO), with the principal objective of "*World-class environmental management underpinned by the highest standards of governance*". The overarching strategic environmental objective is "*To conserve the Territory's environment, minimise human impacts and, where practicable, restore native biodiversity and habitats"*. Under this objective, GSGSSI further commits to "*Effectively manage invasive alien species and work along the entire biosecurity continuum to implement best practice biosecurity protocols, post-border monitoring and emergency response measures"*. (GSGSSI 2016a).

3. Non-native Plant Management

3.1 The Principles

The following principles will guide GSGSSI in the planning and execution of non-native plant management on South Georgia:

- Managing non-native plant species is a key part of habitat restoration and is an essential process for protecting the biodiversity and landscape character of the island.

- A precautionary approach will be adopted, but lack of information about the potential impact or habitat of a non-native species should not lead to postponement of remedial action against that species once it is confirmed as being non-native.

- Effective biosecurity and surveillance will be used to prevent non-native plants from being introduced and becoming established.

- Control measures which cause the least disturbance will be used to minimise damage to native plants and reduce opportunities for the re-establishment of non-native species.

- Any kind of physical disturbance of soils or vegetation will be minimised in order to reduce opportunities for colonisation by non-native species.

- Persistence of action is vital to successful control. Depending on environmental, conditions, the seed banks of some species can remain productive for extended periods. This persistent management will continue until the seed bank is exhausted. Eradication is only achieved when the seed bank is no longer viable.

- Accurate records on sites, control history and methodologies will be maintained in order to ensure the successful management of the control programme. and to limit the effects of control measures on non-target species.

- Workplans and appropriate logistical support will be put in place and regularly reviewed to ensure that actions are undertaken at periods best suited to the successful control or detection of non-native plant species .

3.2 Processes and concepts

3.2.1 Biosecurity

Although eradication of many of South Georgia's non-native plant species is feasible due to the island's remoteness from potential sources of non-native species, the long term success of any operation may be compromised unless effective biosecurity measures are in place to prevent re-establishment or new introductions.

GSGSSI operates along the entire biosecurity continuum to reduce the risk of non-native species entering and becoming established in SGSSI (GSGSSI 2016a). Procedures are in place that govern cargo and personnel movements to and around South Georgia. These include:

- mandatory checks and cleaning of personal clothing and equipment;
- packing guidelines for cargo;
- a ban on high risk items;
- procedures for checking cargo on arrival on South Georgia and for containment of any non-native propagules should they arrive.

A complete overview of biosecurity policies in effect in SGSSI can be found in the 'Biosecurity Handbook' (GSGSSI 2016b)

Any activities undertaken as part of this strategy will aim to ensure that plant propagules are not inadvertently spread during work. Standard biosecurity procedures will be followed at all times: field staff will wash their boots either in the sea or puddles when moving between sites; rucksacks and jacket pockets will be cleaned out regularly. Seed heads collected in the field will be stored in a sealed plastic bag before being incinerated.

Two discrete areas at South Georgia have been designated as zones of prohibited access due to the presence of *Cardamine glacialis* (see Figure 4). Government Officers brief all personnel and visitors of the restrictions on arrival at King Edward Point and the restrictions are strictly enforced.

Figure 4: Prohibited access areas at King Edward Cove due to the presence of Cardamine glacialis.

An annual environmental assessment will be carried out in respect of infrastructure and facilities maintenance at Grytviken and King Edward Point, especially in respect of moving soil and gravel between sites.

3.2.2 The Restoration Framework

Ecosystems are inherently complex as component elements are related through both direct and indirect pathways. The Restoration Framework allows for accountability and transparency in a clear and coherent process designed for non-native plant control. It is a flexible process which can be used to provide a timetable for actions and it allows for measurable outcomes that can be easily monitored. Sites or populations typically progress from the Initial Control Phase, to the Follow Up Control Phase, to having the seed bank managed (Seed bank Control Phase), to a Surveillance Phase where further incursions from external sources such as neighbouring or upstream seed sources. The process can take several years to reach Surveillance status (Figure 5) depending on the seed viability of the non-native plant species.

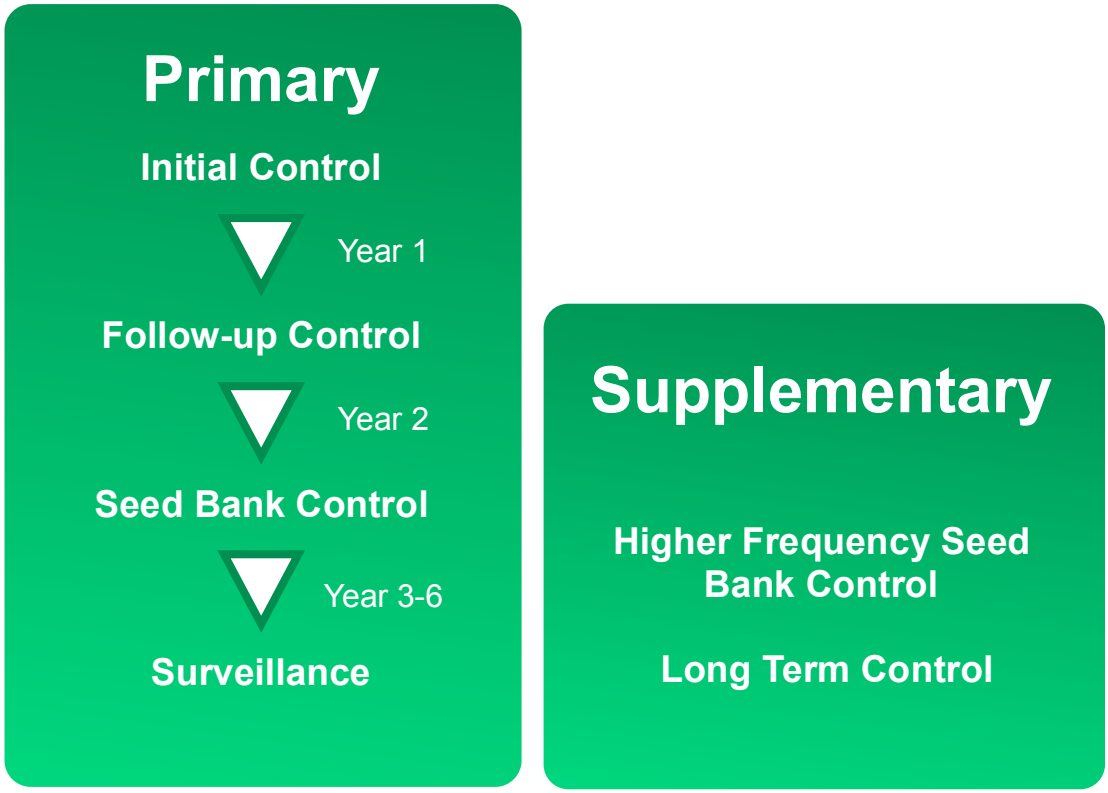


Figure 5: The Restoration Framework Phases Overview

The primary restoration framework phases are defined in Table 1. Two supplementary phases, which account for scenarios where the primary framework is not suitable, are set out in Table 2.

Some sites may not be suitable for total removal of non-native plant species due to the risk of erosion, their contribution to an otherwise absent habitat structure or characteristics of certain non-native plant species. In these circumstances planned, slow removal is needed. The long-term control phase covers this situation.

Due to the cryptic nature of some plants such as the *Cardamine glacialis* a higher frequency of visits can be required; this situation is covered under the Higher Frequency Seed bank Control phase.

Table 1: Primary Restoration Phase Definitions

RESTORATION PHASE	DEFINITION	METHODOLOGY	PHASE DURATION	KEY PERFORMANCE INDICATORS
Initial Control	Mature non-native plant species that transform the function of the ecosystem are present within the designated area.	Control of all adult plants provides immediate positive effects on the ecosystem.	Dependent on resources. Ideally completed in Year One but often a total area is worked through in stages.	All mature non-native plants dead.
Follow Up Control	Non-native plants that transform the function of the ecosystem requiring foliar spraying are present within the designated area.	Continued control to ensure all original plants are dead.	One year after initial control.	All original non-native plants dead.
Seed bank Control	All original non-native plants that transform the function of the ecosystem are dead. Seed banks remain in the soil resulting in germination events within the designated area.	Foliar spraying or hand pulling of all plants that have germinated from the seed bank. Best implemented in summer once seeds have germinated and before they reach maturity.	Generally three to four years, depending on seed viability of the species concerned.	No non-native plants reaching maturity.
Surveillance	All non-native plants eliminated and the seed bank exhausted. Non-native plants may still re-enter the designated area from neighbouring locations.	The emphasis from this point is ongoing monitoring and the management of any incursions from external sources. The design of themonitoring programme is dependent on site specific variables.	Ongoing	New individual incursions only, no communities of non-native plants evident. No non-native plants reaching maturity.

Table 2: Supplementary Restoration Phase Definitions

RESTORATION PHASE	DEFINITION	METHODOLOGY	PHASE DURATION	KEY PERFORMANCE INDICATORS
Long Term Control	The planned gradual removal of non-native plants where complete removal would promote adverse environmental conditions e.g. erosion, removal of all structural habitat.	Undetermined due to unique site values and issues.	Undetermined due to unique site values and issues.	Progressive decrease of the infestation.
Higher Frequency Seed bank	Management of some species such as *Cardamine glacialis* requires greater search effort and visit frequency.	Sustained search and control visits over the growing season.	Ongoing	Progressive decrease of the infestation.

3.2.3 Species-led Control

A species-led approach aims to target specified non-native plant species across their entire known range on South Georgia (Williams 1997).

3.2.4 Site-led Control

A site-led approach aims to protect the natural values of sites from existing or potential impacts of widespread non-native plants through sustained control (Williams 1997).

To support the Restoration Framework, South Georgia has been divided into management units (Figure 6). They were determined bydividing the island into eight eco-geographic zones, defined primarily by climate, vegetation and the historic presence of introduced mammals (Martin et al. 2006). The zones were then further divided into smaller units based on the level of historic human disturbance, presence of non-native plants, geographical features and ease of logistical access (see Annex 1).

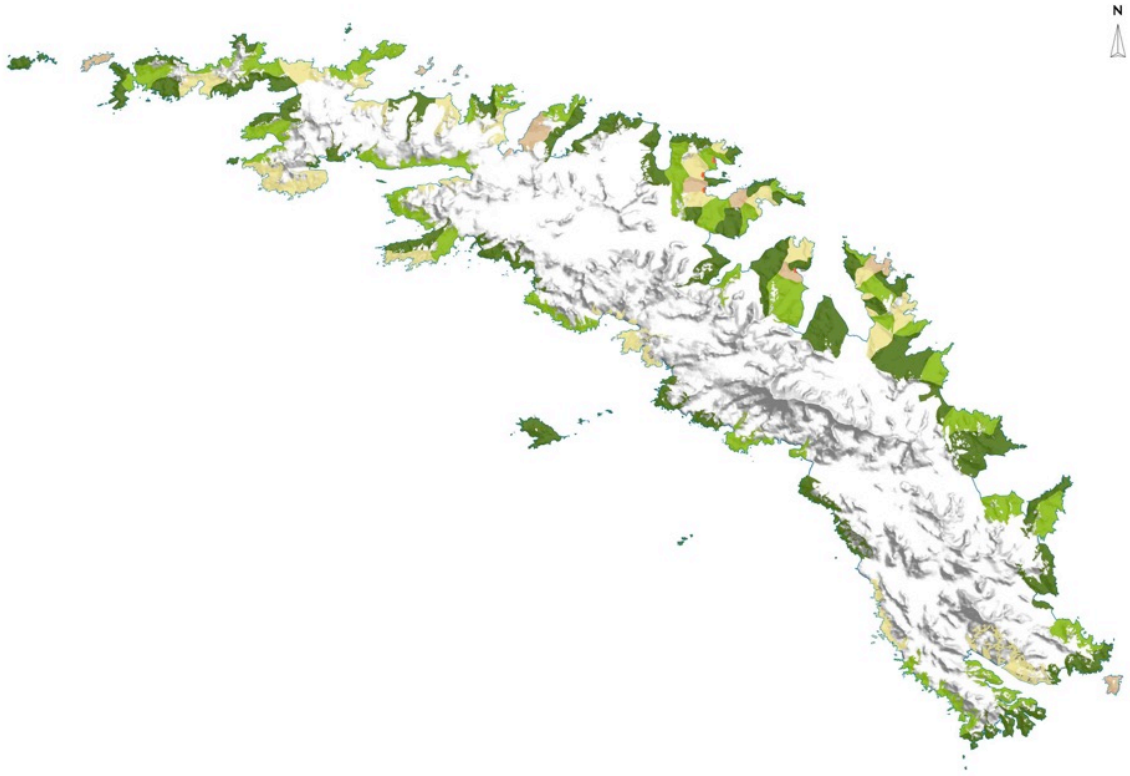


Figure 6: South Georgia management units (detailed maps are contained in Appendix A)

The management priority given to each unit will reflect the non-native plant infestations it contains. Higher priority will be given to those units with relatively small populations that could potentially threaten large areas. Ease of logistical access will also be taken into account and units that can be easily accessed may be visited before more frequently than remote units.

3.2.5 Persistence, Timeliness and Accuracy

There are three cornerstone requirements of a successful non-native plant management programme:

Persistence - needed to ensure that every last plant is treated and the seed bank is fully diminished. This could take many years.

Timeliness - vital for ensuring that populations do not spread beyond the point of control before control operations are taken.

Accuracy - needed to ensure that control measures are effective against target species and to minimise effects on non-target species.

Without all three cornerstones, a control programme is likely to fail. The South Georgia Non-native Plants Database is an important tool to help ensure that management information is consistent and accurate. This information will be used for annual database reporting to ensure timeliness of visits at regular intervals. Persistence can only be achieved if there is long-term commitment to providing the necessary resources. This includes using highly motivated and dedicated people (Brown et al. 2015, Buddenhagen et al. 2015).

3.2.6 Control Techniques

Native species adapted to South Georgia's cold climate typically exhibit slow growth rates and slow rates of colonisation on disturbed ground. For this reason, it is particularly important to minimise damage to native species when undertaking control work. As well as being unsightly, bare ground may also provide favourable conditions for colonisation by non-native plants.

All operations outlined in this strategy aim to minimise impacts on native plant communities, and, in particular, will avoid causing any reduction in ground cover. Maintaining vegetative cover inhibits the ability of seeds to germinate and reduces non-native plant growth through competition. Small scale manual control may be appropriate at times, but generally hand pulling or digging up plants creates large volumes of material that needs to be disposed of and often creates perfect conditions for non-native plant re-establishment or colonisation.

Application of herbicide is the preferred method of non-native plant control for minimising disturbance and reducing the time required to treat each site, although manual control may be viable at some small sites. Selective herbicides, specific to the target species, used at a dilution rate appropriate to the species, will be used to minimise impacts on native species even during site-led control operations. The South Georgia Non-native Plants Database will list the herbicides to be used and the lowest effective rate, determined through herbicide trials, for all control targets. Those rates should be continually reviewed and adjusted based on results achieved.

3.2.7 Surveillance

Regular monitoring is essential in order to locate potential introductions of new non-native plants. Many parts of South Georgia are rarely visited because the majority of visits being restricted to designated landing sites. Therefore plant surveys will be carried out at every opportunity by personnel visiting remote sites around the island, particularly at sites with a history of human disturbance or occupation.

Data on any species found will be collected and recorded in order to enable entry in the South Georgia Non-native Plants Database. Visit records for each management unit will be maintained in the database.

3.3 Using Physical Removal Methodologies only

The use of physical removal methodologies was recommended in a report presenting the results of a botanical survey in 2009 (Osborne et al. 2009). It was recommended in order to avoid potential hazards associated with the use of herbicides. Physical removal is an effective and immediate way of dealing with unwanted plants. However, it is labour intensive and generally only considered to be appropriate for small scale management projects or as part of strategic weed management programmes when the target reaches very low population density.

The major issue with physical removal of plants is the risk of disturbance to the immediate environment. Invasive species often have evolutionary adaptations that enable them to quickly colonise disturbed ground. In addition, mature target individuals are likely to have reproduced, therefore the soil may have a high seed load. Physical removal may result in increased germination and seedling survival.

Physical removal also poses a biosecurity risk associated with safe disposal of removed plant material which may contain seeds. Removed vegetation would need to be immediately contained and transferred to a disposal facility for burial or burning. Physical removal on South Georgia would present significant logistical challenges, especially if attempted on a landscape scale.

The plan for *Cardamine glacialis* control at King Edward Point provides an example of how physical removal can be integrated into a strategic management programme. This method is under consideration as a feasible control option when population density has declined to the point where herbicide control is no longer the most efficient method. Physical removal becomes the best option at a point when it is impractical to mix less than 1 litre of herbicide at the recommended rate for control. The plants are, by their nature, small and tender, negating any issues with disturbance, containment and disposal. The use of this methodology will also depend on whether the target has set seed or not. If it has set seed, the best option will still be to spray a 500 mm radius around the plant in order to apply a pre-emergent herbicide such as Flexidor, in the expectation that seedlings will perish as they emerge.

In summary, physical removal has its strengths and weaknesses as a methodology for the management of non-native invasive plants. It may be the optimal approach under a narrow range of circumstances, however, it is not suitable as a stand-alone methodology for non-native invasive plant management on South Georgia.

Other alternative approaches including biological control were considered and are included in the Environmental Impact Assessment (Myer 2016). However, none were considered to be feasible for use on South Georgia.

3.4 The Cost of Doing Nothing

After introduction, plants can go through a lag phase, which is the time before the species becomes naturalised and spread exponentially. While South Georgia's cold climate and short growing season may extend the lag phase, this does not mean that, once established, non-native plants will not have a profound impact. For example, some introduced species such as *Agrostis capillaris* are capable of forming exclusive colonies that out-compete and exclude other species (Figure 7). Most of the indigenous vegetation is of low stature and therefore has no ability to shade out plant species that have been introduced by human activity. Without management of the non-native plant species the island's entire vegetated area will be at risk from invasion by introduced plants.

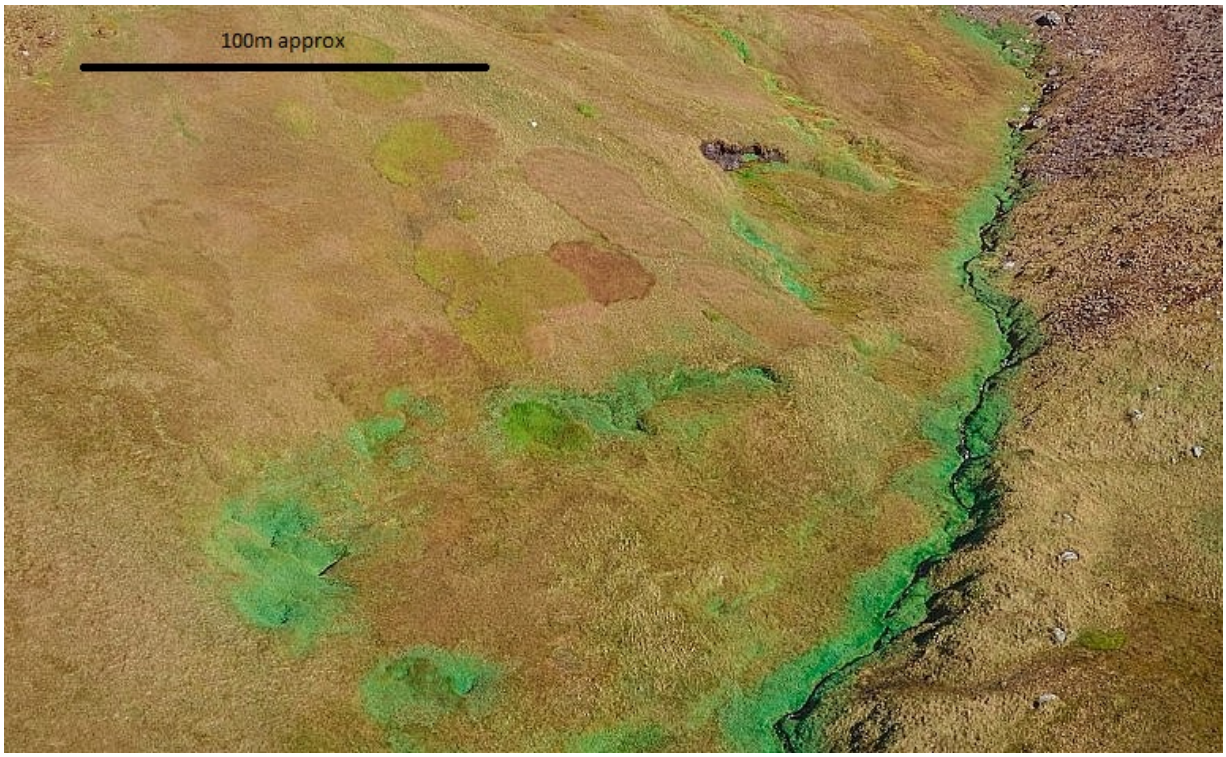


Figure 7: Agrostis capillaris *(circular patches) and* Poa pratensis *(lime green) invading native Festuca grassland behind Grytviken Whaling Station (March 2015)*

The recent removal of reindeer and rodents is expected to result in sudden changes to inter-specific competitive plant dynamics on South Georgia. Grazing pressure has the effect of suppressing the growth of palatable indigenous and non-native species, and of spreading the propagules of both. Removal of grazing pressure means that native and non-native species are able to grow unhindered. However, introduced species often have much more vigorous growth and are able to out-compete native species for light, nutrients and space. Furthermore, species that are currently at low population density could become common if there is no management in place. Naturalised species such as *Agrostis capillaris* and *Trisetum spicatum* that have a moderate population density could dominate the vegetated landscape. At the very least, this would change the character of the landscape, and thereby compromise GSGSSI's commitment to its objective of preserving indigenous ecosystems.

One advantage of sudden vigorous growth resulting from removal of grazing pressure is that non-native species become more conspicuous and are easier to survey, allowing their extent to be quantified and facilitating effective application of herbicide by field workers. Many of the areas previously inhabited by reindeer were surveyed during 2015. Since this period which closely followed the reindeer eradication, it was an ideal time for survey and control of non-native plants.

Olsen Valley, formerly grazed by reindeer, is unique in being the largest vegetated low altitude valley on South Georgia. While relatively free of non-native plants, reindeer have spread non-native plant outliers throughout the catchment (see Figure 8). Without control, this area will become a mosaic of indigenous species and non-native grasses and biodiversity values will be compromised.

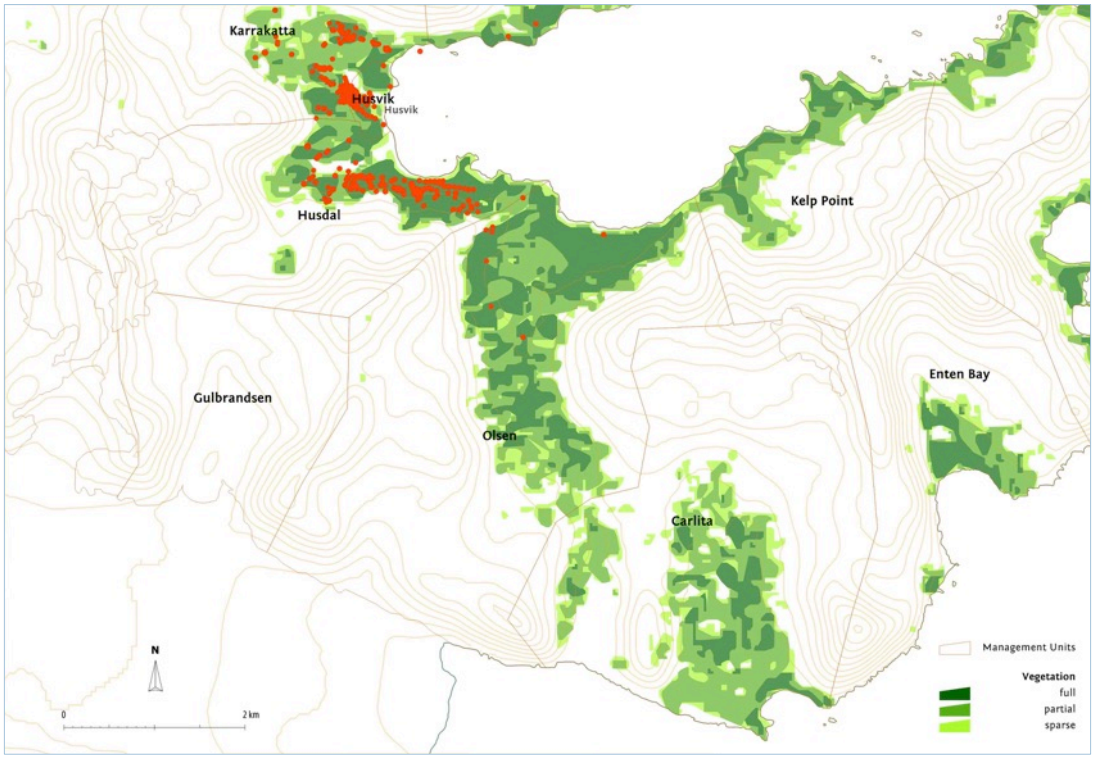


Figure 8: Olsen Valley with surveyed non-native plants in 2015 (red points) and associated management units.

The climate on South Georgia is changing rapidly, with some glaciers retreating at up to 1 metre each day (Cook et al. 2010) opening up new areas for plants to colonise. In the absence of management, non-native plants are likely to provide an alternative, more competitive set of successional processes to those of native plants. Even with management, early colonising communities are likely to include *Poa annua* and *Cerastium fontanum* along with indigenous species.

In summary, it is probable that doing nothing to manage non-native plants will lead to an alternative landscape character dominated by non-native plants with associated changes in biodiversity.

3.5 Environmental Risk

Herbicides can be hazardous and their misuse can potentially cause adverse effects to the environment and human health. The most effective way to minimise or avoid such effects is to employ trained, skilled operators to handle and use herbicides.

The herbicides selected for use on South Georgia have been chosen on the basis that careful use will provide an acceptable degree of safety to the user, efficacy on the target and protection of non-target species. The products themselves have been rigorously tested under a wide range of conditions in South Georgia and New Zealand (Kelvin Floyd and Bradley Myer pers. comm.).

Data on appropriate herbicide mixes, application methods, timing and data management are specied specific. That data is stored within the South Georgia Non-native Plants Database (Figure 9). New staff will receive training in the correct use of herbicides. The Environmental Impact Assessment (Myer 2016) contains more detailed information regarding the potential risks to the environment.

The non-native plants on South Georgia range from being managed at zero population density through to being widespread to the point where herbicide control is not feasible. Herbicides will be applied at the lowest level needed to kill the target species while minimising disturbance and damage to non-target species. The overall environmental risk will thereofore be minimal.

Where practical, selective herbicides will be used i.e. herbicides that will kill certain types of plants, but not others. For example, Grazon is a triclopyr based herbicide designed to control broadleaved plants and brush weeds and will not affect grasses. Careful use of selective herbicides can eliminate the target without necessarily disturbing the indigenous vegetative cover. This is usually advantageous since the remaining vegetative cover helps to suppress the target seed bank, resulting in reduced follow-up requirements. However, careful application is still required as non-target species of the same type will be affected.

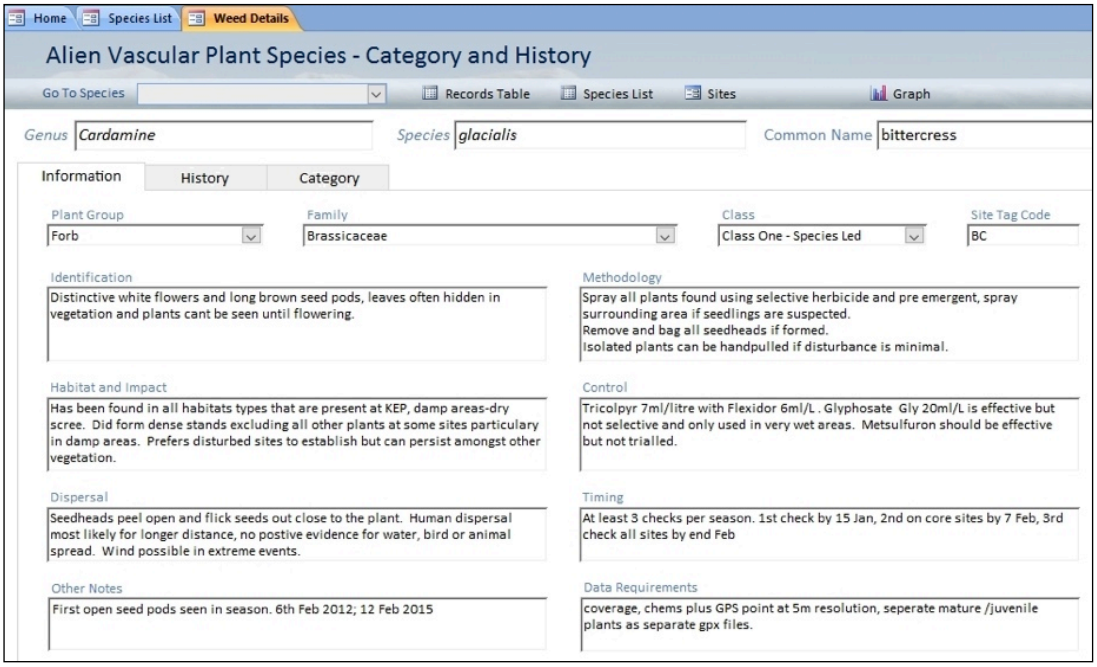


Figure 9: Species information

4. Goal

The goal of the South Georgia non-native plant management strategy is as follows:

By 2020, the unique vegetated landscapes and biodiversity of South Georgia will be conserved through the eradication of the majority of non-native plant species. Measures will be in place to manage remaining species and to prevent the introduction and establishment of new non-native plant species.

4.1 Targets

It is anticipated that the following targets can be achieved by 2020:

- All Class 1 species will be at zero population density (see Section 5 for a full account of classes of non-native plant species).
- At least 75% of Class 1 species will be eradicated.
- Class 2 populations will be surveyed and mapped
- 10,000 square metres (1 Hectare) of land containing Class 2 species will be controlled annually.
- Class 2 non-native plant populations will be reduced in abundance and distribution annually.
- Class 2 non-native plants will be maintained at zero density in high visitor traffic areas at King Edward Point and Grytviken..
- More detailed information will be gathered on the distribution of Class 3 species to inform control decisions at outlying sites.
- Issues relating to the origin and source of non-native species will be resolved within 12 months of them being added to the Research Class.

These targets act as key performance measures and progress will be reported on annually.

Section 5 for a full account of classes of non-native plant species.

5. Non-native Plants on South Georgia

A total of 76 non-native vascular plant species have been recorded on South Georgia. It is considered that 41 of these species are still present. Although it is possible that some non-native plant species may not naturalise, all species should be considered potentially invasive, given that their lag phase is unknown. Non-native plant species have been classified according to their distribution, population size, feasibility and time-scale under which eradication or control could be achieved (Williams 1997).

5.1 Non-native Plants Classification

5.1.1 Class One – species-led

Plants in Class One have been selected either due to the limited size of their population, the ease of control and/or follow up, or a combination of these factors which indicate that control is feasible using the minimum resources recommended under this strategy. Species in this Class will be maintained through a species-led approach, whereby all plants on the island will be controlled annually before they are able to produce viable seed.

The control objective for this class is eradication. This will be achieved by maintaining zero population density annually. The eradication time frame will differ for each species depending on its propagule life, but may take many years.

Table 3: Class One Species – 33 species

Latin Name	Common Name
Achillea millefolium L.	Yarrow
Achillea ptarmica L.	Sneezewort
Agrostis vinealis Schreber	Brown bent
Allium schoenoprasum L.	Chives
Anthoxanthum odoratum L.	Sweet vernal grass
Anthriscus sylvestris (L.) Hoffm	Cow parsley
Capsella bursa-pastoris (L.) Medik.	Shepherd's purse
Cardamine glacialis DC.	Bittercress
Carex aquatilis Wahlenb.	Water sedge
Carex nigra (L.) Reichard	Common sedge
Carex sp.	sedge unknown (not flowering)
Dactylis glomerata (L.)	Cocksfoot
Deschampsia cespitosa (L.) P.Beauv.	Tufted hair-grass
Deschampsia flexuosa (L.) Trin.	Wavy hair-grass
Elytrigia repens (L.) Gould	Couch grass
Empetrum rubrum Vahl ex Willd.	Diddle-dee

Latin Name	Common Name
Festuca rubra L.	Red fescue
Juncus filiformis L.	Thread rush
Leontodon autumnalis L.	Autumn hawkbit
Leptinella scariosa Cass.	Feathery buttonweed
Luzula muliflora var *congesta* (Ehrh.) Lej.	Heath wood-rush
Nardus stricta L.	Mat grass
Lobelia pratiana Gaudich. ex Lammers	Berry-lobelia
Ranunculus acris L.	Meadow buttercup
Ranunculus repens L.	Creeping buttercup
Rumex acetosella L.	Sheep's sorrel
Rumex crispus L.	Curled dock
Sagina procumbens L.	Pearlwort (Procumbent)
Stellaria media (L.) Vill.	Common chickweed
Trifolium repens L.	White clover
Tripleurospermum inodorum (L.) Sch.Bip.	Scentless mayweed
Vaccinium vitis-idaea L. 1753	Cowberry
Veronica serpyllifolia L.	Thyme-leaved speedwell

5.1.2 Class Two – Site-led

These are species that have the potential to drastically alter the landscape and reduce biodiversity values on South Georgia, but due to their widespread distribution will require a longer term approach than Class One species. Species in Class Two require ongoing control through a site-led approach that reduces distribution, dispersal and population size. Priority sites are those with low populations and those around high visitor use areas.

The control objective for this class is to contain and reduce the population distribution. This will be achieved by sustained ongoing control under the restoration framework. The amount of control undertaken annually will be dependent on resources available each season and weather conditions at the time.

Table 4: Class Two Species – 4 species

Latin Name	Common Name
Agrostis capillaris L.	Common bent
Deschampsia cf parvula.	Punkgrass
Poa pratensis L.	Smooth meadow grass
Trisetum spicatum (L.) K.Richt.	Spike trisetum

5.1.3 Research Class

This class is for plant species that require taxonomic identification or where the feasibility or control is not yet fully understood. Assessment of species in the Reseach Class will be done through consultation with Royal Botanic Gardens Kew and other relevant agencies.

Table 5: Research Class – 1 species

Latin Name	Common Name
Carex sp.	Small rush

5.1.4 Class Three – Widespread site-led species

These non-native plants are widespread across some parts of South Georgia. Due to their dispersal mechanisms and distribution, large scale control is not currently considered to be feasible. However, from a biosecurity perspective, small scale control around buildings at King Edward Point and Grytviken will minimise the risk of human assisted spread to un-invaded sites elsewhere around the South Georgia and also reduce potential habitat for other introduced taxa such as invertebrates which may initially colonise around station buildings.

Targeted methods will reduce these Class Three populations at chosen sites and promote their replacement with native vegetation.

Table 6: Class Three – 3 species

Latin Name	Common Name
Cerastium fontanum Baumg.	Common mouse-ear
Poa annua L.	Annual meadow grass
Taraxacum officinale F.H. Wigg.	Dandelion

5.1.5 Historic Class

These are species that have been previously recorded on South Georgia. The majority have not been seen for ten years or more, but historic locations will be monitored for any reappearance. They will be considered to be no longer extant on the the island if no plants are seen following continued monitoring beyond the expected life of the seedbank.

Table 7: Historic Class – 35 species

Latin Name	Common Name
Aegilops sp.	Goat grass
Alchemilla monticola Opiz	Velvet lady's mantle
Alopecurus geniculayus L. 1753 not Lindh. ex Scheele 1849 nor Sibth. ex Steudel 1840	Marsh foxtail
Artemisia sp.	Mugwort
Avena fatua L.	Wild-oat
Brassica cf. *napus*	Rape
Carum carvi L.	Caraway
Centella sp.	Centella
Cerastium arvense L.	Field mouse-ear
Daucus carota L.	Carrot
Festuca ovina L.	Sheep's fescue
Hypericum tetrapterum Fries	Square-stemmed St John's-wort
Lactuca sp.	Wild Lettuce
Lamium purpureum L.	Red dead-nettle
Lolium multiflorum Lam.	Italian rye grass
Lolium temulentum L.	Darnel ryegrass
Lotus corniculatus L.	Bird's foot trefoil
Lupinus sp.	Lupin
Matricaria discoidea DC.	Pineapple weed
Phleum pratense L.	Timothy grass
Pisum sativum L.	Pea
Plantago sp.	Hoary plantain
Poa trivialis L.	Rough meadow grass
Raphanus sp.	Radish
Rorippa islandica (Oeder) Borbas	Northern yellow-cress
Rumex alpinus L.	Alpine dock
Senecio vulgaris L.	Common groundsel
Sinapis arvensis L.	Charlock
Solanum tuberosum L.	Potato
Sonchus sp.	Sow thistle
Stellaria graminea L.	Grass leaf starwort
Thlaspi arvense L.	Field penny-cress
Trifolium hybridum L.	Alsike clover
Urtica dioica L.	Common nettle
Urtica urens L.	Annual nettle

5.2 Process for Changing Classification

When a new plant species is found, it must first be established whether, on the balance of probabilities, it is a non-native species or is a species which naturaly occurs in South Georgia (see discussion in Hughes and Convey 2010). Once it has decided that a plant is non-native, it should be considered a Research Class species pending taxonomic verification. It should remain in the Research Class until further surveys and research have determined its classification as Class One, Two, or Three. Once population size has been established, species with a limited distribution with known extents that can feasibly controlled using existing resources should be added to Class One. Species with a large population size or that are wide spread, but where it is determined site-led control is still possible, should be added to Class Two. If site-led control is not possible, the species should be added to Class Three. A re-sighting of any Historic Class species will promote that species to Class One (Figure 10).

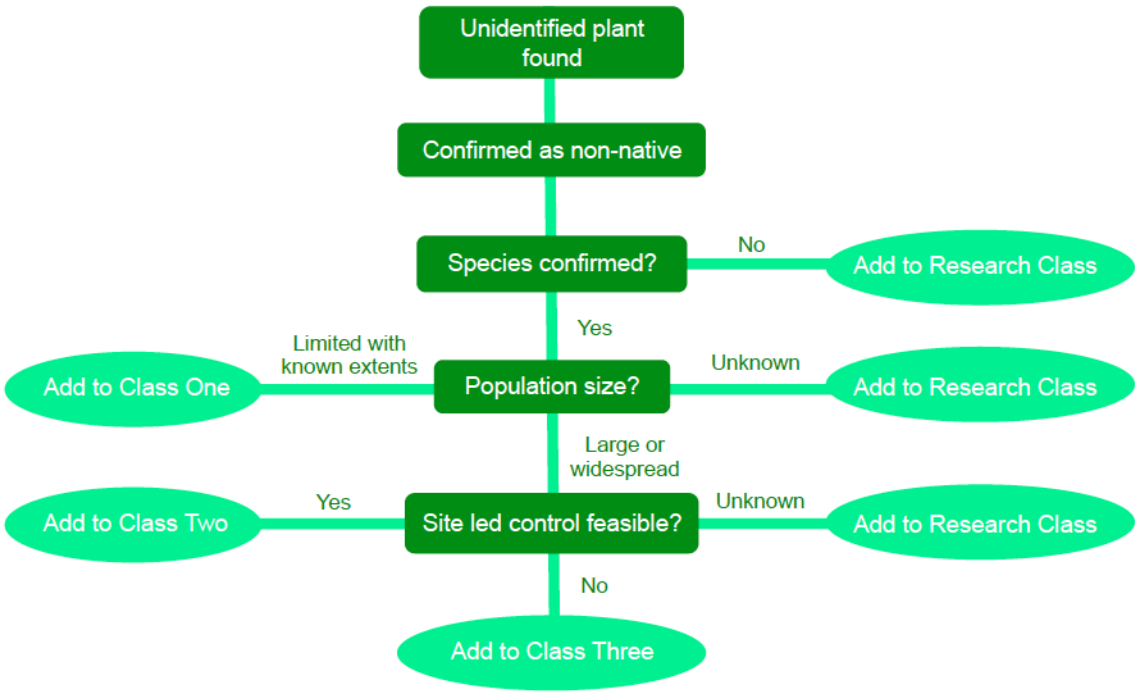


Figure 10: Decision tree for when an unidentified plant is found.

A species will be considered eradicated once all known sites are clear of all re-growth or seedlings for three consecutive seasons. To ensure eradication, sites will continue to be monitored regularly for seedling growth for a minimum of three further years in case of a remaining seed bank. Some species may require a longer period of monitoring if evidence exists of a longer seed bank life in the South Georgia environment.

6. Resources

To achieve the goal of this strategy, dedicated, trained staff will be required for surveillance and control operations. The optimum time for carrying out plant control work is during South Georgia's short growing season between early January and mid-March. Ideally, plant control visits should be scheduled to coincide with peak growth when species are easily visible and have key identifiable features such as flower heads, but before the plants set seed.

Staff will be required on South Georgia for nine weeks from early January until mid-March to enable the control priorities to be completed. Continued surveillance and control is required at King Edward Cove throughout this period, particularly for *Cardamine glacialis*.

Due to safety and logistical issues, teams of at least two people will be required when working in areas outside King Edward Cove. The surveillance and control recommended for the Stromness Bay area will require a team at least two people to be based at Husvik for four weeks from early February to early March. Additional days will be required for other remote site visits, notably to Prince Olav Harbour and on the Barff Peninsula where there are considerable populations of some Class Two species.

Staffing levels will be managed for maximum efficiency in the field within the timeframe available each summer. An example of how control targets could be achieved would be to have one person for nine weeks and at least three other people for six weeks (see Table 8). This would allow one person to manage non-native plants at King Edward Point in January and a two person team to be based at Husvik from Febuary onwards. A second staff member in Febuary would join the person who was based at King Edward Point in the early season to undertake control work at sites on the Barff Peninsula and further afield.

With additional staff, control of widespread species would be more effective, and the timeframe required to contain those species would be considerably reduced.

Without sufficient resourcing, the principles of this strategy will be compromised, especially the persistence and timeliness required to manage the seed banks. If resources for effective control are not made available, population growth and maturing plants will place at risk any current gains made in non-native plant control and increase the timeframe required for control.

Table 8: Estimated minimum number staff days required by class for 2016-2020.

	January	February	March	Total staff days by class
Class One -Species-led	1 x 15 days	4 x 10 days		**55**
Class Two -Site-led	1 x 2 days	4 x 14 days	4 x 15 days	**114**
Class Three – Site-led	1 x 3 days	4 x 2 days		**11**
Unit Surveillance		4 x 2 days		**8**
Total staff days by month	**20**	**108**	**60**	**Total 188**
Note: The days required for Class One - Species-led are expected to decline over this period, however this time should be invested into the populations of Class Two - Site-led to increase the number of management units controlled.				

Effective species-led control results in declining resources required, with the timeframe dependent on the persistence of the species. With continued control, typical resources required are shown below in Figure 11.

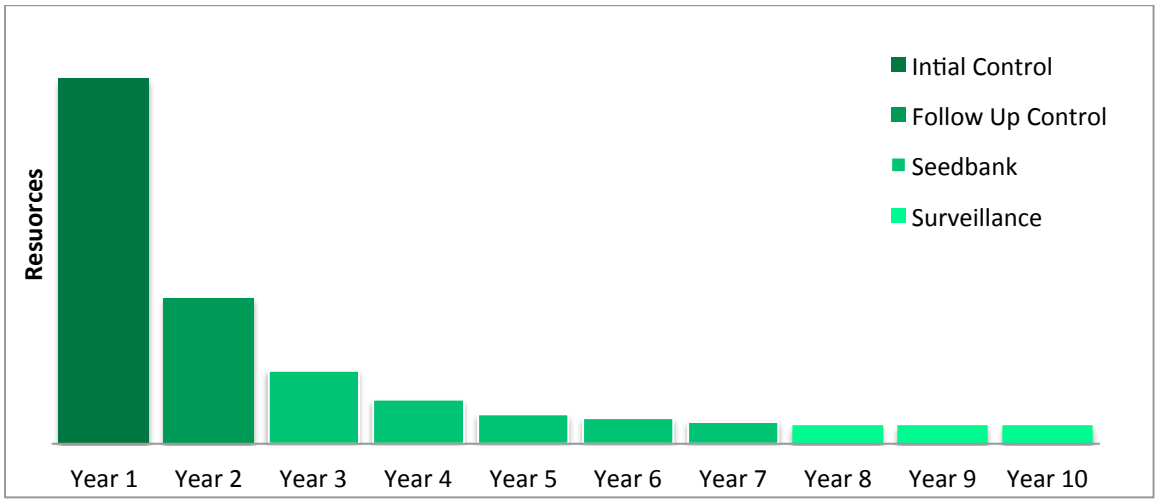


Figure 11: Species-led control; Typical resources required by year.

Site-led control resource requirements will be dependent on the species present in each management unit. Effective control will allow more units to be brought into the control programme (Figure 12). The priority of each management unit is embedded within the Non-native Plants Database and is a function of the incidence of invasive plants, its accessibility and when it was last visited.

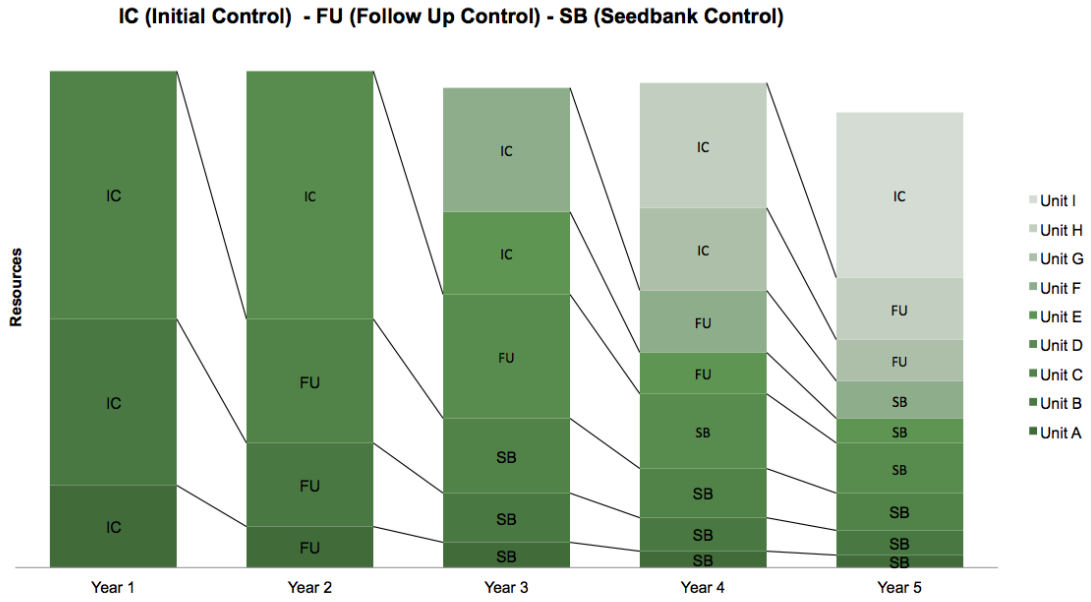


Figure 12: Example of site-led control; typical resources allocated per year to ensure restoration framework outcomes. Management units are added each year as phase progression reduces resource requirements in units controlled

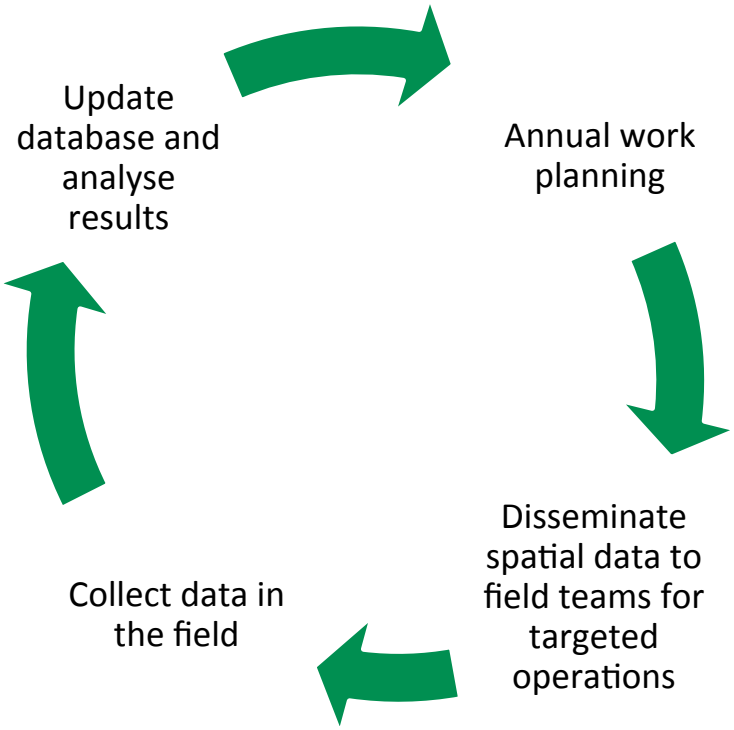
Data Management and Work Planning

Recording spatial data is essential as it provides:

- Evidence of control efforts – locations, targets and herbicides used.
- Measure of success – quantitative records of herbicide use and plant coverage provide measurable indicators of success.
- Opportunity for analysis – the data provide evidence of changes at control sites that can be compared over time which allows feedback for strategic decision making and planning.
- Record keeping – to ensure that remnant seed banks and populations are not forgotten.
- Management – pertinent spatial data to save time and energy when a targeted approach is needed in the management of a particular population.

6.1 Data Management Loop

The South Georgia Non-native Plants Database enables data recording and reporting on activities. This information also provides the ability to analyse data, make decisions about future operations based on the analysis and then disseminate information to field teams to enable extremely targeted field operations.



6.2 Species Information

All non-native plant species recorded on South Georgia will be entered into the South Georgia Non-native Plants Database. This will contain identification notes, control methodology, and other relevant information on the plant site, including spatial data recorded in the field.

Historic plant records will also be maintained for each species to enable targeted searches at particular sites to see if the plants have reappeared. This will be particularly important in areas that are no longer grazed by reindeer.

6.3 Species-led control records

All species-led control will be spatially recorded. Each site will have unique code for each distinct non-native plant group, with all control visits entered for the site. Information recorded at each site will allow analysis over time and a measure of success of control efforts at each site and across all species.

The South Georgia Non-native Plants Database contains timings, control methodologies and other relevant information for each species, and will be used to query previous visits for planning control visits.

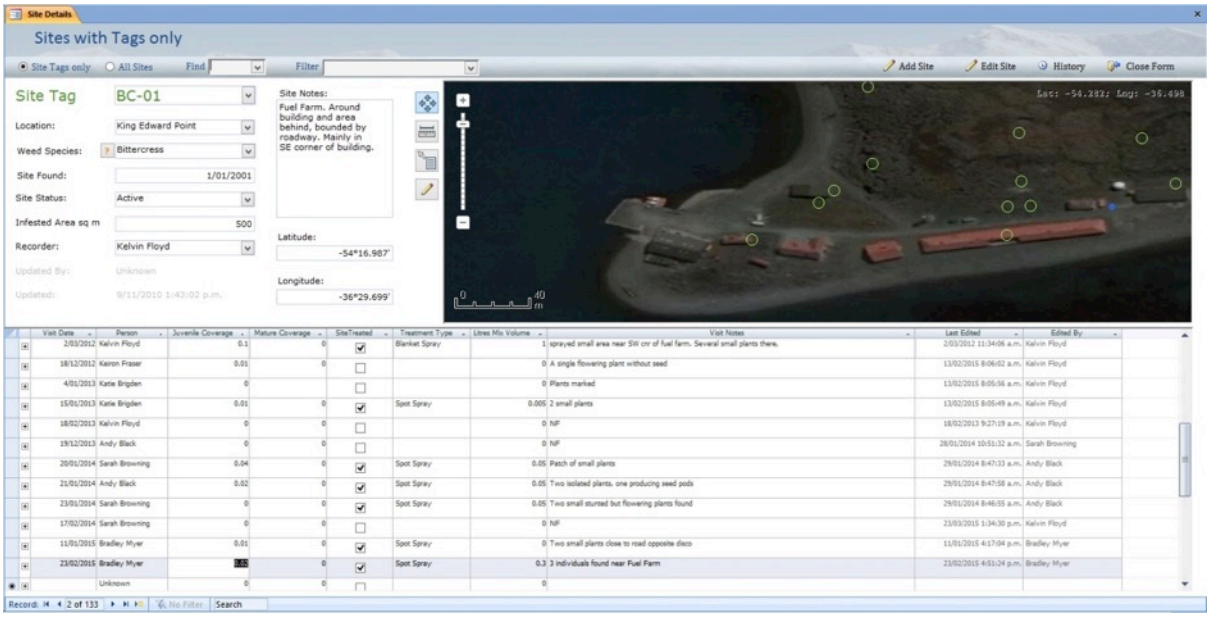


Figure 13: Database Species-led Record

Each species-led site will have a status that directly relates to the planning of visits.

Species-led Sites Status:

- *Active Status – control has been undertaken*
- *Surveillance Status - control appears successful, follow up checks still required at least at two year intervals*
- *Retired Status – no plants seen for a period that reflects viability of the seed bank.*

6.4 Site-led control and surveillance records

All site-led controls will have a spatial record of control efforts to allow tracking of herbicide use by location and species. Records of control or survey visits to each site (or weed management unit) will be entered in the South Georgia Non-native Plants Database to ensure that long term histories of activities in each management unit are maintained.

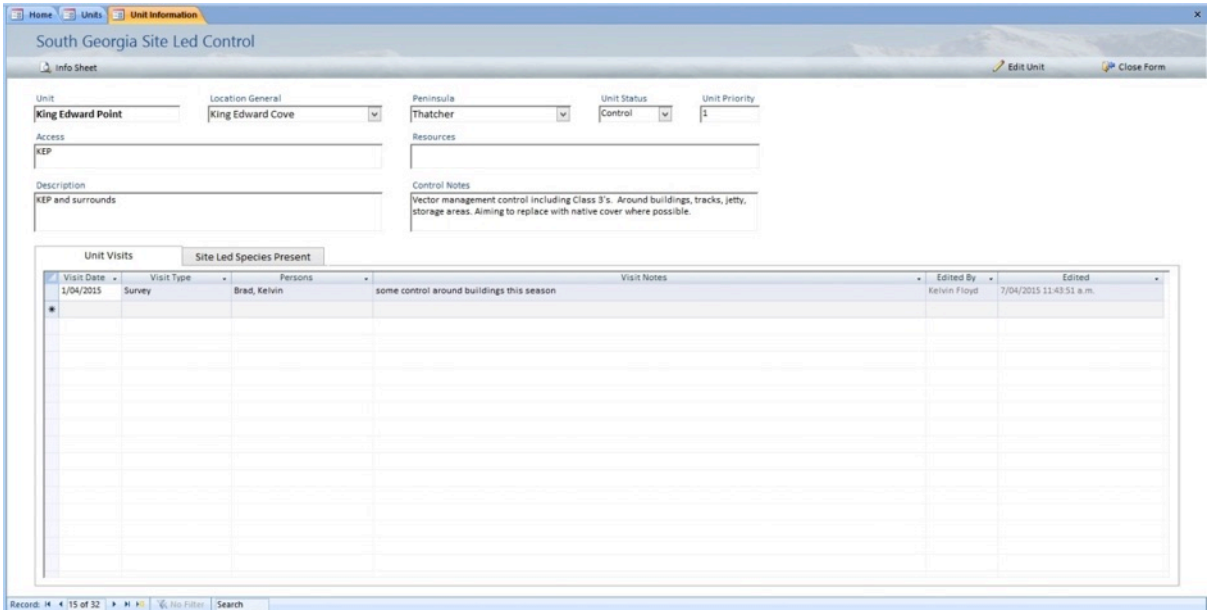


Figure 14: Database Site-led Record

Records will be maintained of all plant classes present in each management unit and data added for each visit. This will enable an island wide picture of non-native plant distribution to be maintained. These data can be queried when planning future control and surveillance visits.

Each unit will have a status which will directly relate to the planning of visits.

Management Unit Status:

- *Control Status – the management unit has species present with a control objective and visits to the unit are required, follow up and seed bank control should be undertaken very two years after initial control is undertaken.*

- *Surveillance Status – the management unit has no species that require control, monitoring visits only are required.*

7. Management Considerations

This programme of works will require a commitment from the parties involved to achieve the strategy goal. There is no doubt that the challenges of non-native plant control on South Georgia are significant, but with perseverance, accuracy and timeliness, effective control and, in the majotity of cases, eradication, can be achieved.

Information sharing and reporting, combined with a five year review period is an essential part of the programme, as it will enable adjustments to be made to management in response to changing circumstances. A major focus of the review will be the control objectives assigned to each species. Eradication should be possible for some of those species currently classified as zero population density. The 5-year review will be an opportunity to reflect on the successes and failures of the programme and amend it accordingly.

7.1 Organisational Structure

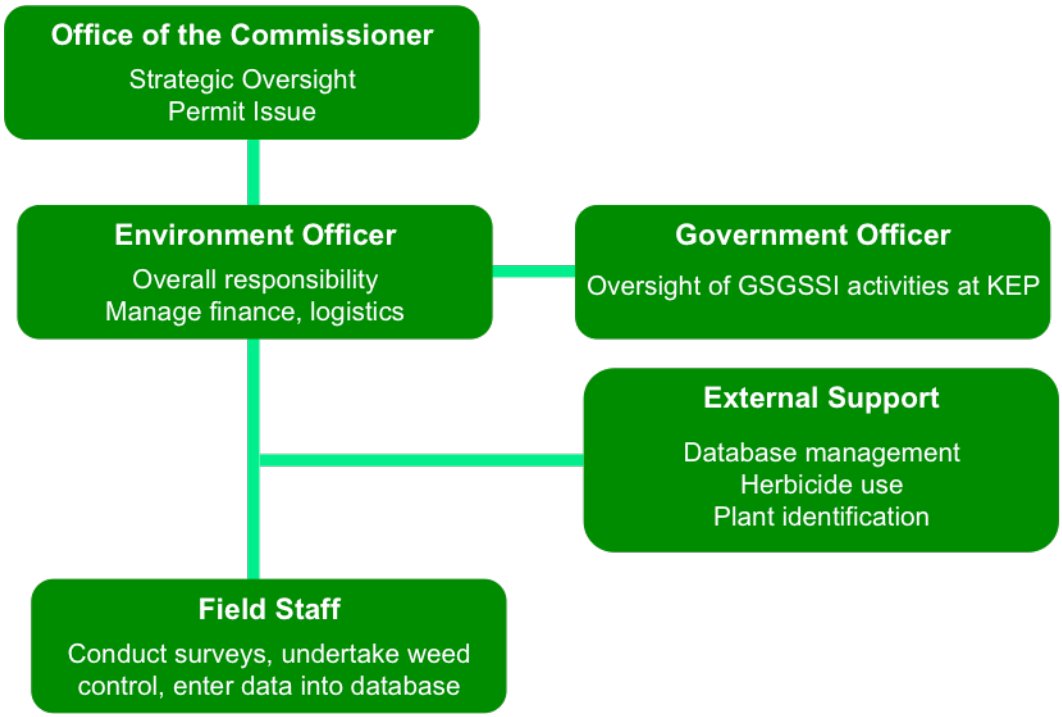


Figure 15: Organisational structure

7.2 Reporting

During the field seasom, a designated member of field staff will prepare a weekly operational report that will capture and summarise the various actions undertaken during the preceding seven days. The following will be included in the weekly report:

- spatial data;
- agrichemical usage;
- weather;
- health and safety incidents;
- notable interactions with visitors;
- results.

An end of season report will also be produced. It will detail overall progress towards deliverables by measuring success against the targets described in Section 4.1.

Conclusions and recommendations will be considered by GSGSSI and, as necessary, stakeholders for assimilation into subsequent work programmes.

7.3 Review Periods

Progress on the implementation of this strategy and the sucees in achieving the stated goal and targets will be reviewed every five years to fit in with the GSGSSI planning framework. A written report will be produced. It will evaluate the strategy as a whole, its implementation and successes and failures, along with an analysis of species and site management, and surveillance reports. Its conclusions and recommendations will provide the opportunity for GSGSSI and stakeholders to consider the shape of the strategy for the subsequent five year period

8. Acknowledgements

This document was prepared by Kelvin Floyd, Bradley Myer and Jennifer Lee. Thanks to the the UK Government Darwin Plus initiative for contirbuting the funding necessary to produce this strategy. Kerry Brown, Peter Williams and Colin Clubbe provided valuble comments on draft documentation. Control of non-native plants has only been possible thanks to the hard work of many field workers and those who support them. Particular thanks go to Ken Passfield and Sally Poncet.

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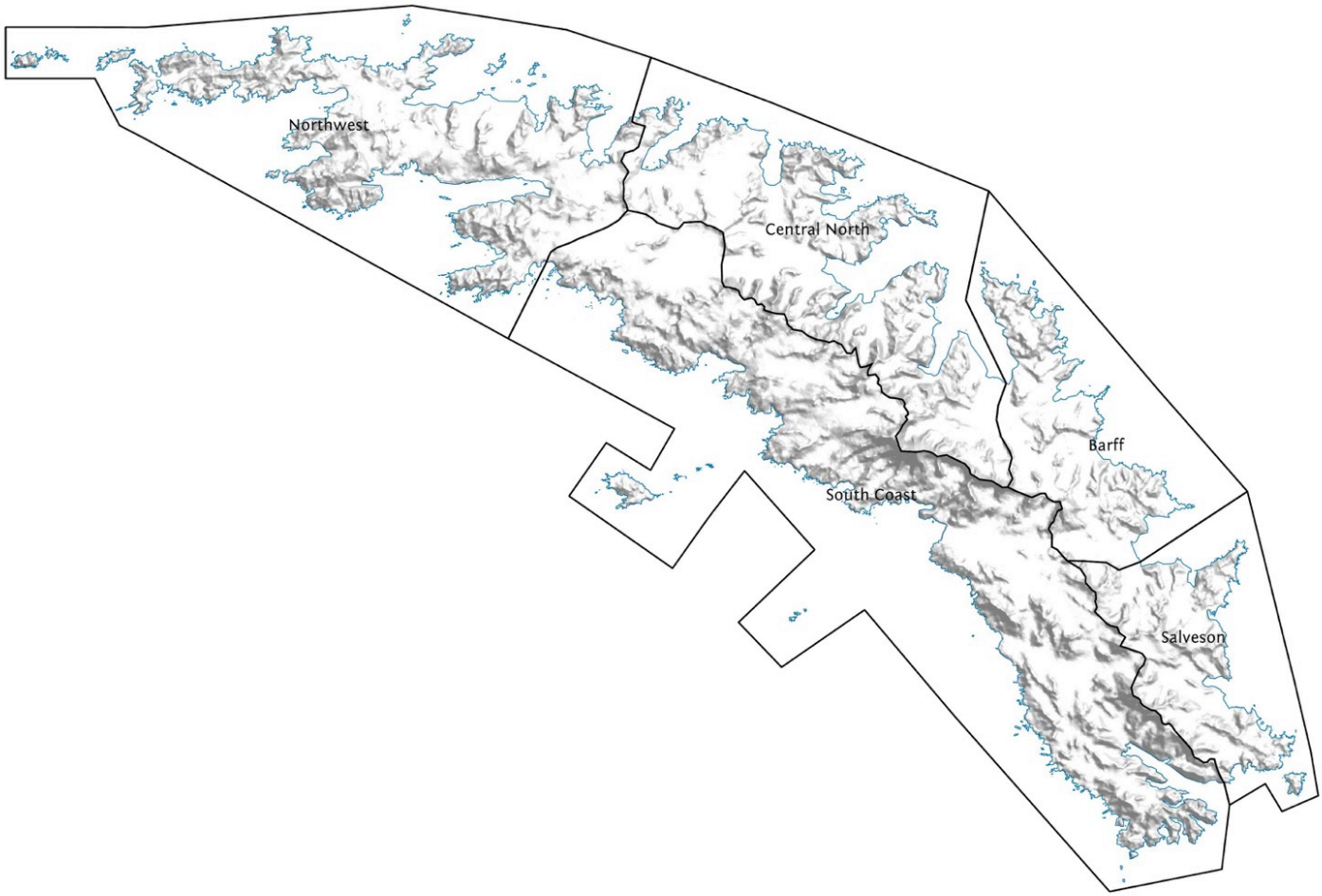
Appendices

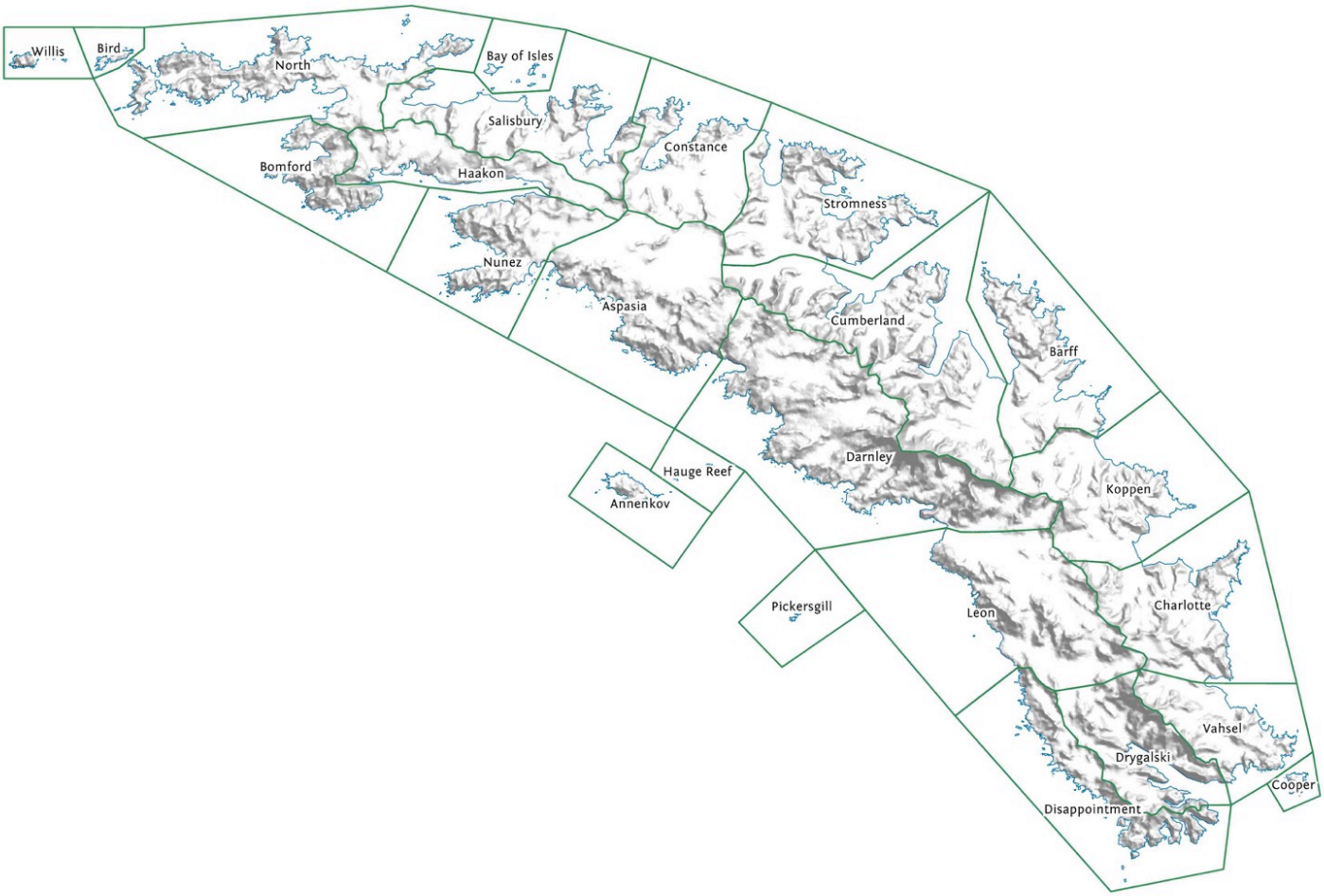
Appendix A – South Georgia Biozones, Ecological Regions and Management Units

South Georgia Biozones



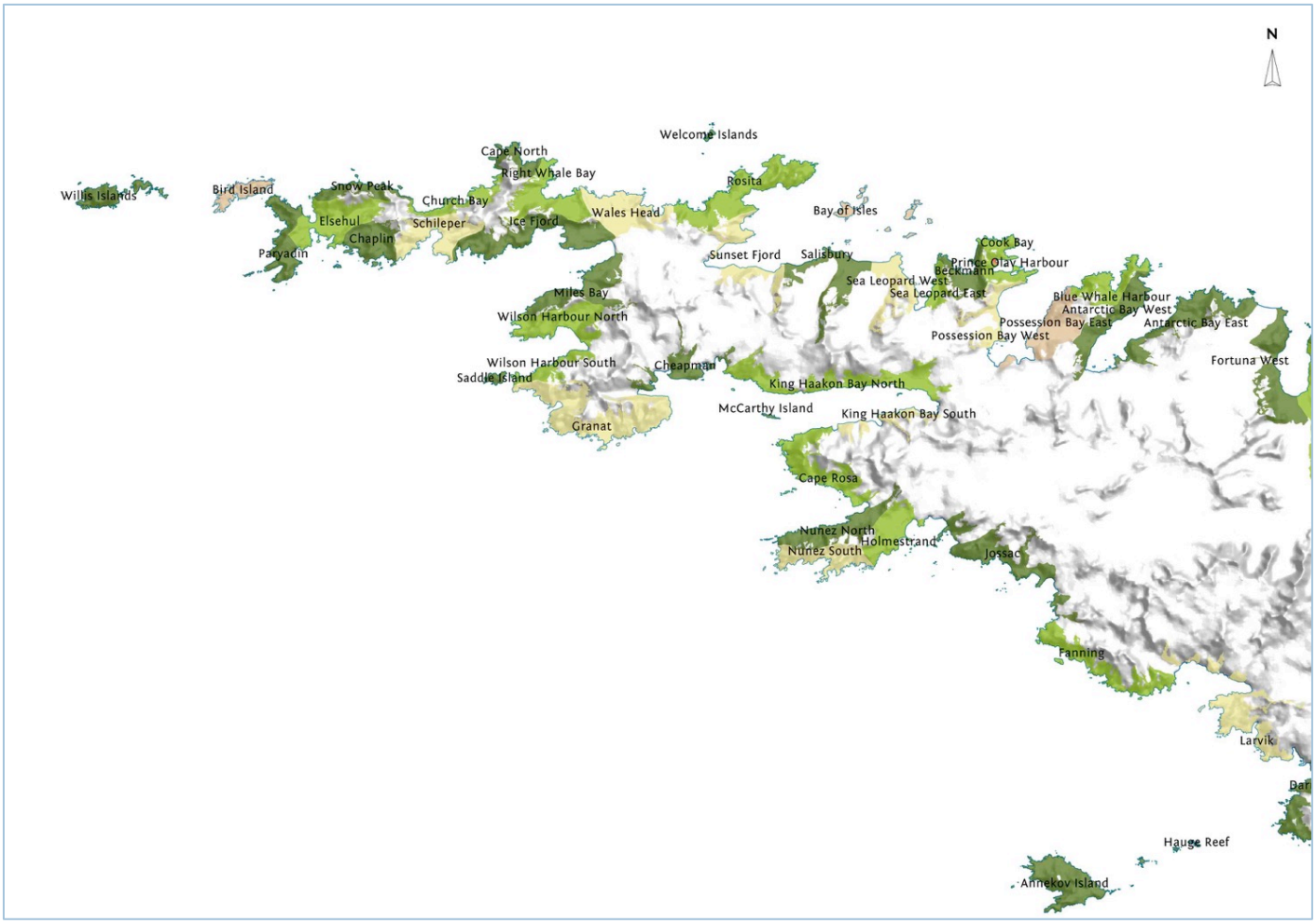
Appendix A

South Georgia Regions



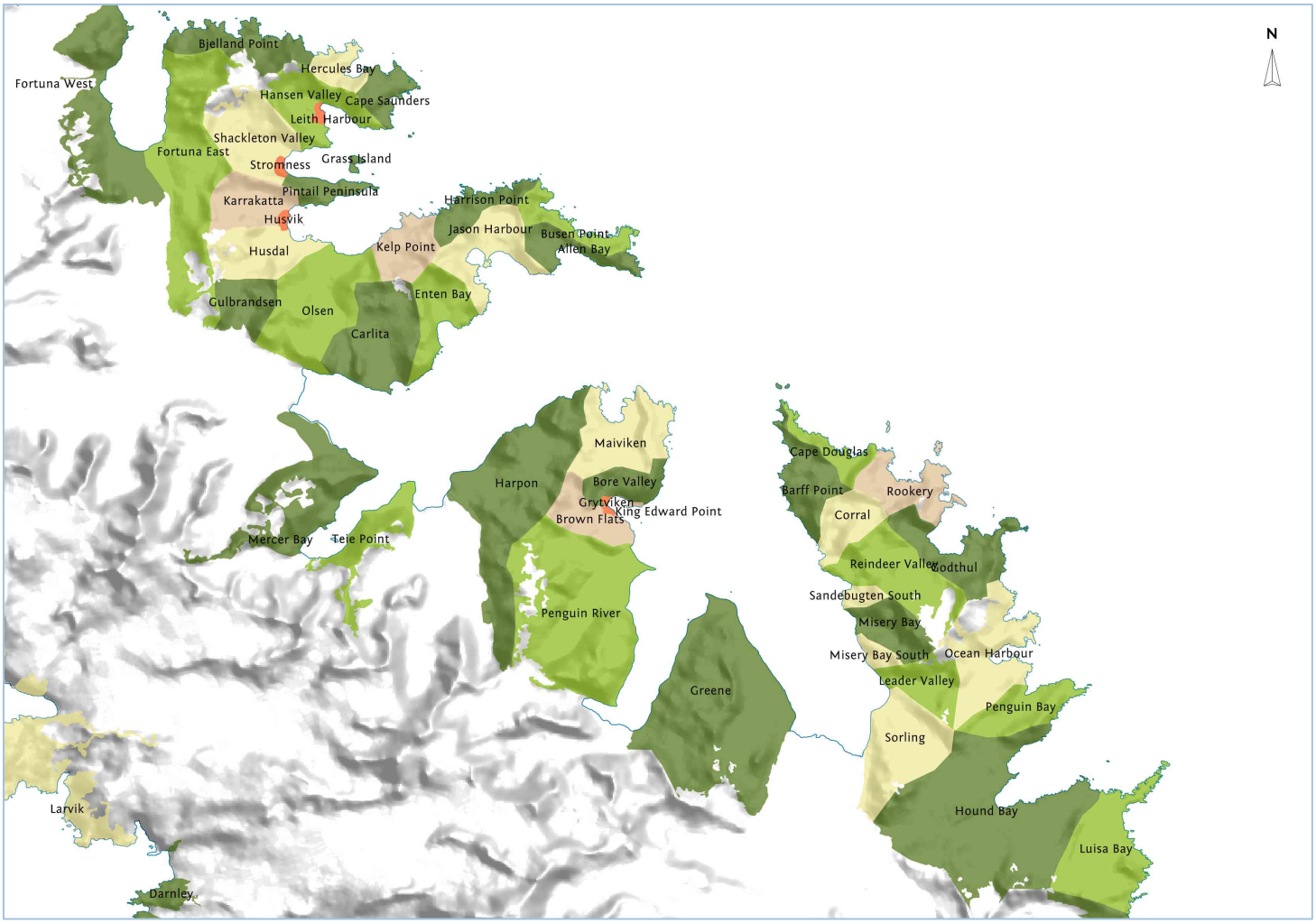
Appendix A

North West South Georgia Management Units



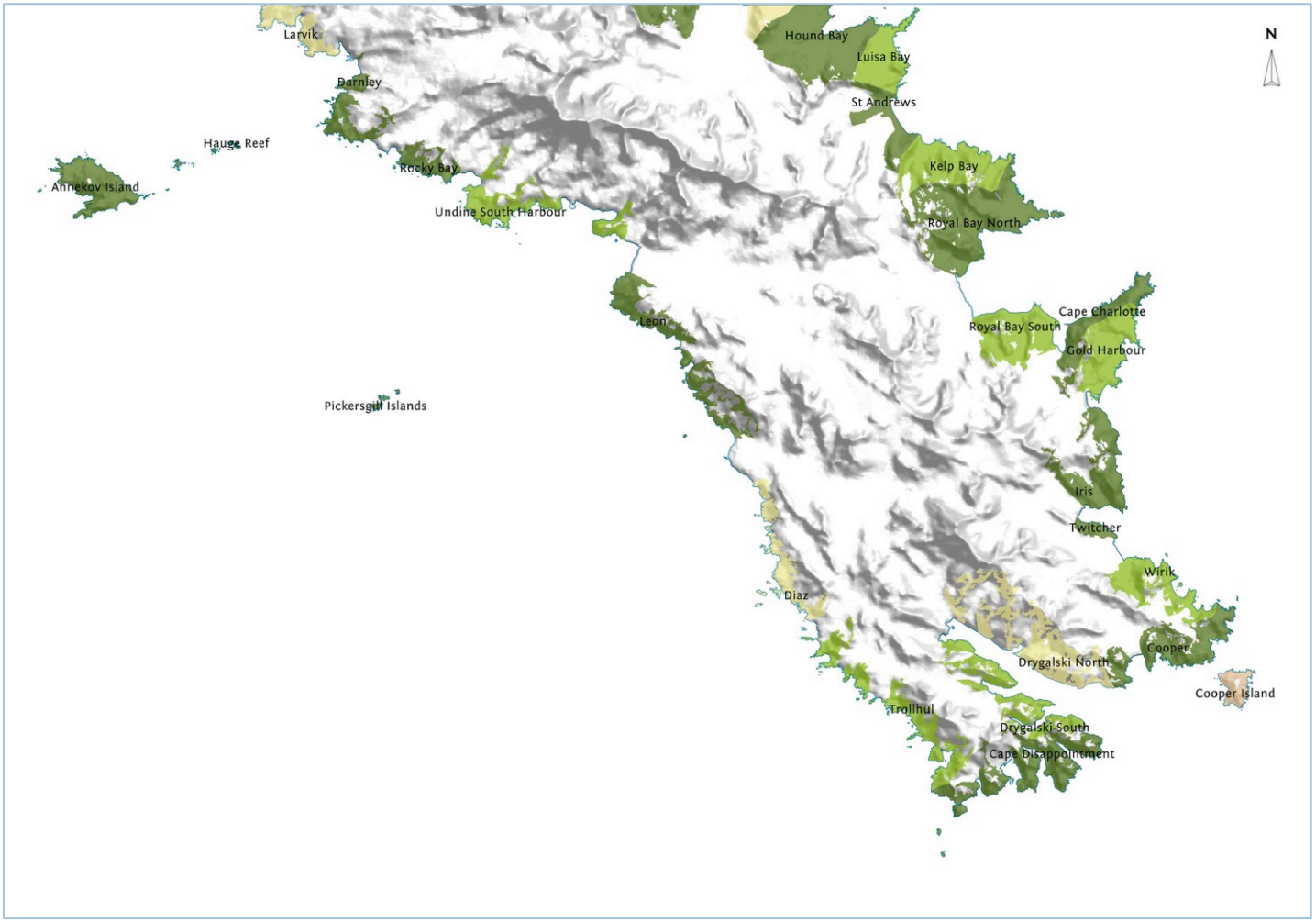
Appendix A

Central South Georgia Management Units



Appendix A

South East South Georgia Management Units



Appendix A