Alien plants and their impact on Tristan da Cunha

Part 1: General account

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Soft Rush (Juncus effusus; left) and Monterey Pine (Pinus radiata; right) invading grazed vegetation and native Phylica bush vegetation near Sandy Point.

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Summary

With the vast increase in transport of people and goods across the globe, many plant and animal species have been dispersed to areas outside their natural distribution. In the new areas they colonize, alien species are a major threat to many of the local ecosystems. They also can have serious adverse economical impacts, for instance by reducing agricultural yields and greatly increasing the cost of weed management.

Alien species are species of plants or animals that have arrived in an area where they do not occur naturally, by means of transport provided by people. Some species are brought in on purpose, for instance to grow them as food for humans or fodder for animals, or as ornamental garden plants. Others have arrived by accident, without the people bringing them in probably being aware of it. Examples of these are weed seeds that were brought in as impurities in vegetable or flower seeds, seeds that were present in hay that was imported from elsewhere, or seeds or plant fragments in soil in which plants were imported, or attached to containers or to imported cars.

The basic objective of the management of the island is the maintenance in a sustainable way of the resources that maintain life on the island. The main resources of Tristan are 1) the fisheries (Tristan rock lobster and fish), which form the basis of the economy of the island; 2) the land, soils, hydrology, and ecosystems of the island, which make local food production possible, as well as providing a place to live, providing a good quality water supply, etc. , and 3) the natural biodiversity of the island, including a large number of endemic plants and animals, i.e. species that do not occur anywhere in the world outside the Tristan group. For instance, nearly half of the native flowering plants and ferns are endemic. The first two of these resources (fisheries and land with associated ecosystems as a place to live) are primarily of local importance. They provide the local community with an economic basis and a place to live. The third resource (natural biodiversity), however, has a global importance. From this global importance obligations arise for the maintenance of this biodiversity. One of the local reasons for conservation of this unique biodiversity is that it is a potential source of attracting outside funds for its safeguarding and management, as well as through ecotourism.

This report provides the results of an alien plant survey of Tristan, during the summer of 2007/2008.

In total we found some 137 species of alien vascular plants. One third of these were found only in small numbers, while two thirds were widely dispersed. Several of the presently restricted species are expected to become much more abundant and widespread. Of 131 alien species previously reported, 32 were not found by us. We have searched the sites for which these species were listed, and believe that most of these have disappeared. Conversely we found 38 species not previously recorded on Tristan. Of these a number have been on the island already for quite long (several decades, presumably) but have not been identified, or for some reason were never noticed. But about half of the newly listed species are probably recent arrivals. There is a steady increase in the number of alien species over time. Our results show clearly that invasions by alien plant species are a continuing process

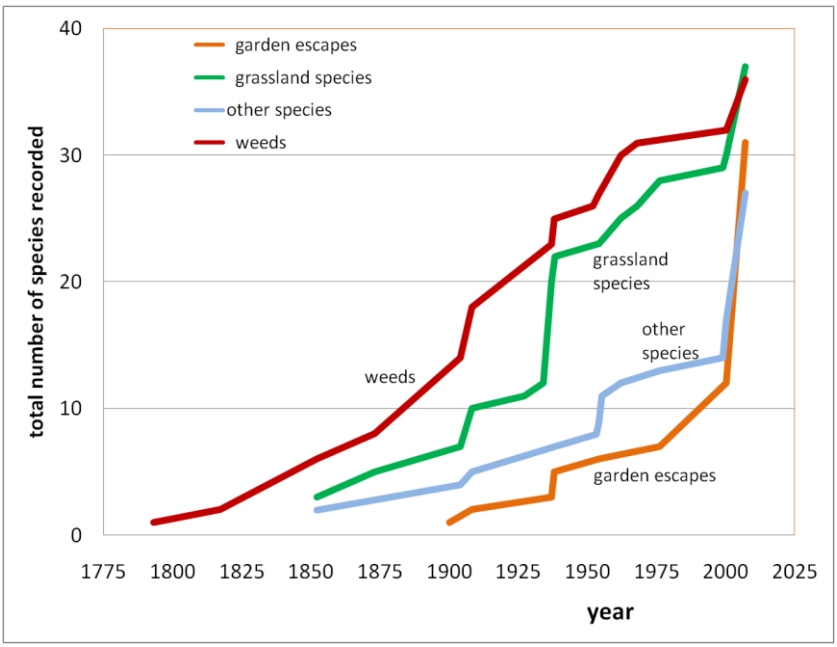

FIGURE A.1. *The increase of the number of alien plant species of different ecological groups on Tristan da Cunha over time. Weeds are species most commonly found as weeds in gardens and the Patches; grassland species are grasses and other species most commonly found in grasslands; garden escapes are species imported as garden plants (ornamentals, vegetables, etc.), which have escaped; and the remainder (other species) do not fit in the first three categories, and are mostly ruderal species. Only species observed during the 2007/08 survey are included in this figure.*

(Figure A.1.), with on average one successful alien plant invasion every 1.5 years. Measures to stop or at least greatly reduce this influx are of vital importance.

For each alien species we collected information on its distribution, its reproduction and dispersal, and its impact on agriculture and natural biodiversity.

Of the alien species that were found in the Patches some 35 are weeds, and at least 10 of these regularly reach cover values of more than 50% in some fields. Thus alien plant have a serious impact on crop production, by reducing crop yield as well as by requiring much resources (time, herbicides) for weed management.

In grasslands, more than half of the species that are most commonly found in pasture areas have no value as forage plants. Looking at the forage quality value of the species and the height of the plants, one can see that all low-growing species, except for White Clover (*Trifolium repens*), are of very little value. Several of these, e.g. Silvery Hair-grass (*Aira caryophyllea*), Squirrel-tail Fescue (*Vulpia bromoides*), and Procumbent Pearlwort (*Sagina procumbens*), occur in large numbers, adversely affecting the forage production of the pastures. Species occurring in the pastures that have no value for livestock reduce the carrying capacity of the pastures, by using resources (space, nutrients) without any useful return.

Many alien species invade natural habitats, and several of them are becoming dominant, locally completely replacing the original native vegetation. This results in a significant reduction of native biodiversity, and may ultimately lead to extinction of native species.

Alien species have also an impact on various other ecosystem services, like atmospheric regulation, erosion control, water supply, nutrient cycling. The impact of alien plants on such ecosystem goods and services on Tristan is hard to quantify, and we have restricted ourselves in our report to general remarks. These impacts, however, should not be ignored just because we cannot quantify them at present.

The distribution and impact of the alien plant species are summarized in Table A.1.

To reduce the negative impact of alien species control measures are desirable. For some species, however, control does not appear to be feasible. This is the case for species that are widespread, occur in large numbers, produce large amounts of seeds, and disperse easily. Control is also very difficult for species that are hard to find or to distinguish from other species. For a number of species, however, control is quite feasible, and we strongly suggest that measures are taken to control, and preferably eradicate, these species.

The most important suggestions for control are the following:

Monterey Pine (*Pinus radiata*)

Monterey Pines form an extensive forest in the Sandy Point area, spreading by seed away from the area where they were originally planted, steadily extending the forested area. Although at present hardly any use is made of the wood of these trees, potentially they are a useful resource for timber for building and for fence poles on the island. At this moment all wood for these purposes is imported from South Africa. A practical problem is that any wood harvested from the Sandy Point forest has to be transported by barge from Sandy Point to the Settlement, or to wherever it is going to be used.

The number of native species in these dense pine forests seems to be smaller than in non-forested areas, but more quantitative data need to be collected on this subject. Conversion of native vegetation to forest reduces the availability of nesting areas for birds. In addition it will drastically change the quality of plant litter in the soil, as well as the microclimate at soil level, which is expected to have a large impact on invertebrate species. We strongly suggest to remove Monterey Pines (*Pinus radiata*) outside the Sandy Point forest area, and also prevent the spread of trees towards the higher reaches of the island, by cutting the trees up there before they start to produce seed. Alternatively one could kill the trees by ringbarking them. The other Pine species on the island, the Cluster Pine (*Pinus pinaster*) spreads very slowly at this moment, but in future probably will become a problem. We suggest also to remove all trees of this species, at least where the occur outside the Settlement.

New Zealand Christmas Tree (*Metrosideros excelsa*)

The New Zealand Christmas Tree, *Metrosideros excelsa*, is abundant in the area covered by lava from the 1961 eruption. A few trees were found outside this area. Several of these presumably have been planted. Thus this species has a considerable impact on the new lava areas, but given that most of the areas where it is found have hardly any native vegetation yet (except for some mosses, ferns and lichens), it is not clear how to judge this impact at present. Obviously, in the long run, instead of the

expected vegetation of mosses, lichens, ferns, grasslike plants, and Island Berry (*Empetrum rubrum*) we now can expect a dense forest of New Zealand Christmas Trees to develop. At this moment we do not think that *Metrosideros* is likely to spread much outside the 1961 lava area. However, once large numbers of trees start producing seed in this area, this species may well start spreading rapidly into other areas, becoming a serious threat to native biodiversity. It would be important to develop a control program for this species, before the numerous trees in the new lava area start to produce seed.

Loganberry (*Rubus loganobaccus*)

Loganberry (*Rubus loganobaccus*) occurs at the Settlement, both in and locally outside gardens, but is most abundant at Sandy Point. Here over a large area the ground-layer of the forest, as well as some slopes outside the forest, is completely overgrown by Loganberry. Apart from transforming the structure of the vegetation it is not clear what the impact is on the botanical biodiversity of the invaded areas. But it is clear that invasion by loganberry has displaced several albatrosses from their nesting sites. An eradication program of this species at Sandy Point is presently underway and we suggest to continue the eradication of the Loganberry in all areas outside the settlement.

Australian Myrtle (*Leptospermum laevigatum*)

Australian Myrtle or Australian Tea tree (*Leptospermum laevigatum*) forms a big, dense patch of many small plants (about 50 cm high) with a few clearly older and much larger shrub on the old coastal road through the 1961 lava area, with some plants in other sites. In dense Australian Myrtle stands few native species occur. Australian Myrtle is clearly spreading, and it is quite possible that in the long run this species will disperse into other areas and other habitats. In Australia this is a coastal species, but it is not known how far from the coast it can grow on Tristan. At present eradication of this species appears quite feasible, and should be done as soon as possible.

Amaranth (*Amaranthus spec.*),

Fat Hen (*Chenopodium album*),

Nettle-leaved Goosefoot (*Chenopodium murale*), and

Common Nettle (*Urtica dioca*)

These are presently found at a few sites only, and are known as very serious agricultural pests elsewhere. The first three species may have been imported with chicken feed, or as seed impuroties. To prevent new introductions, some years ago chicken feed containing weed seeds has been replaced by another type, with less risk of importing unwanted weeds. It is important to eradicate these weeds as soon as possible, before they reach the Patches, and become serious weeds.

Soft Rush (*Juncus effusus*)

This species is restricted in its distribution (presently only found at Sandy Point), and is expected over time to invade the pastures in this area, as well as damp natural habitats, both in this area and eventually all over the island. It may form very dense colonies, which are unpalatable for livestock, and strongly reduce the number of useful pasture species in grasslands, and native plants in invaded natural areas.

Garden escapes

For most garden escapes no control measures seem necessary. From a nature conservation viewpoint it will be useful to keep an eye on the dispersal of New Zealand Flax, and remove any plants in areas away from the Settlement.

Ruderals and other species

For three of those (Jointed Rush, *Juncus articulatus*, Wavy Hair Grass, *Avenella flexuosa*, and Pink Evening Primrose, *Oenothera rosea*) we suggest to try and eradicate them, as they have at present a very restricted distribution, and are not spreading rapidly.

Shoddy Ragwort / African Daisy (*Senecio pterophorus*)

This shrubby herb is widely spread in the 1961 lava area, producing seed in abundance. A few plants occur in the Pigbite area. It is likely that over time it will spread all over the island, strongly modifying many natural plant communities. Therefore it would be important to try and eradicate this species, before it is too late. This will require a lot of effort, but from a biodiversity conservation viewpoint, is of vital importance.

American Wintercress (*Barbarea verna*)

This species was found only in a road verge in the settlement, and at one site in the 1961 lava area. This species is know as a weed in some parts of the world. Because it has at present a very restricted distribution, it would be easy to remove this species, and we suggest to do this as soon as possible.

Other weeds

The control and ultimate eradication of a number of weeds that are presently showing a limited distribution in the Patches can also be considered. In the short term eradication of alien weed species will require an investment of resources (mostly labour). However in the long run, this can be expected to reduce the effort needed for weed control in the Patches and gardens. Of the weeds that reach high cover values, Field Woundwort (*Stachys arvensis*), Scrambling Fumitory (*Fumaria muralis*) and Green Field Speedwell (*Veronica agrestis*) are possible candidates for an eradication program. Both species have long-lived seeds, and eradication requires a prolonged commitment, but would ultimately reduce the effort required for weed control in the patches. Another species for which eradication (at least locally in the Patches) could be considered is Hedge Bindweed (*Calystegia sepium*). At present several fields in the Patches are not used for growing crops as a result of heavy infestations with this species, or, when attempts are made to grow potatoes on infested plots, these seem often to be abandoned in the course of the season. Hedge Bindweed does not seem to spread much, if at all, by seed. It spreads by long rhizomes, but also by stems that can form roots from parts that get covered by soil. Getting rid of this species requires a sustained effort of several years, combining chemical and mechanical control. The alternative to eradication this species would be to abandon the infested fields, and to prevent dispersal to uninfested patches.

We strongly suggest to start an eradication program for at least Amaranth (*Amaranthus* spec.), Fat Hen (*Chenopodium album*), and Nettle-leaved Goosefoot (*Chenopodium murale*) immediately. For other species eradication programs should be developed as soon as possible.

TABLE A.1. (following pages). *List of alien vascular plant species recorded on Tristan da Cunha, with the date of the first substantiated record for each species, present distribution and impact on agriculture and biodiversity conservation. The impact classes used are defined at the end of the table.*

Impact on natural biodiversity was quantified in the following classes:

0 = impact is so small as to be negligible (the species occurs only in a tiny area, in very low numbers, with no risk of a significant increase in numbers or area, and not found in undisturbed habitats)

\- = low impact (the species occurs in a small area only, with little risk of spreading into undisturbed habitats; species with poor dispersal capabilities)

\- - = between the previous and the next class

\- - - = moderate impact (the species is moderately abundant in disturbed as well as in undisturbed habitats, but does not reach high cover values. The species is widely dispersed.

\- - - - = between the previous and the next class

\- - - - - = very large impact (the species is, or has the potential to become widely dispersed, and replaces natural vegetation in large areas (or can be expected to do so in future); the species has good dispersal capabilities).

For the **impact on agriculture** we have used a similar set of classes, where 0 = not or very rarely found in agricultural land; - = only found in small numbers in gardens and agricultural fields; to - - - - - = a very abundant weed, often reaching high cover values.

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Agapanthus praecox Willd.	African Lily	2007	Found at a number of places in the settlement and on the new volcano; distributed with garden waste, and surviving, but apparently not spreading independently to new sites.	Also planted in gardens	**0**	**0**	
Agrostis castellana Boiss. & Reut.	Highland Bent	1908	Observed in grassland at Hottentot Gulch, ca 150 m asl, but presumably overlooked elsewhere and possibly much more widespread.	Distribution incompletely known	**+ ?**	**-**	
Agrostis gigantea Roth	Black Bent / Red Top	1937	Found in a garden and in grassland near the settlement and at Cave Point; but possibly overlooked elsewhere.	Distribution incompletely known	**-**	**-**	
Agrostis stolonifera L.	Creeping Bent	1938	Widespread all over the island, in many different habitats. An important constituent of pastures and other grasslands, but also common and locally dominant elsewhere.		**+ + +**	**- - - - -**	
Agrostis tenuis Sibth.	Common Bent / Brown Top	1927	Widespread all over the island, in many different habitats. An important constituent of pastures and other grasslands, but also common and locally dominant elsewhere.		**+ + +**	**- - - -**	
Aira caryophyllea L.	Silvery Hair-grass	1937	Widespread all over the island, and in all habitats. Mostly colonizing small or large bare patches of soil within these habitats.		**- -**	**- -**	
Amaranthus hybridus ? L.	Green Amaranth	2007	Found in a vegetable plot near the Settlement, and next to the chicken coop in the garden of the Administrator's residence.		**- (- - - -)**	**(- -)**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Anagallis arvensis L.	Scarlet Pimpernel	1873	A frequent species in the settlement, at the Patches and in the 1961 lava area. Locally reaching high cover in arable land.		**- -**	**- -**	
Anthoxanthum odoratum L.	Sweet Vernal-grass	1934	Abundant in lowland pastures between Settlement and Patches		**+ + +**	**- - -**	
Avenella flexuosa (L.) Parl.	Wavy Hair Grass	2001	A single large patch on the Base near Second Gulch		**- (- - -)**	**0**	
Barbarea verna (Mill.) Asch.	American Wintercress	2007	Found at a site in the settlement, as well as at one site in the 1961 lava area. At the latter site it may have arrived with garden waste from the settlement.		**- (- -)**	**(- -)**	
Bellis perennis L.	Daisy	1937	Found in lowland pastures in the settlement and between Settlement and Patches.		**-**	**-**	
Brassica juncea (L.) Czern.	Mustard	1938	not found (but Anchorstock Bay, where it was collected previously, was not visited).		**?**	**?**	
Bromus willdenowii Kunth	Rescue Grass	1852	Locally abundant in gardens and arable land in the settlement and at the Patches, locally reaching very high cover values. Also a few plants in the 1961 lava area.		**- - -**	**- -**	
Calystegia sepium (L.) R. Br. subsp. americana (Sims) Brummit	Hedge Bindweed	1908	In large numbers at a few sites in Tristan: locally in the Patches, at Sandy Point and at Stony Hill. At all sites associated with human activity (agriculture, and tree planting). Locally dominant.		**- - - - -**	**- -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Canna indica L.	Canna; African arrowroot	2000	Locally some plants in the settlement and the 1961 lava area, apparently dispersed with garden waste.	Also planted in gardens	**0**	**-**	
Centella asiatica (L.) Urban	Asiatic Pennywort	1904	Widespread in many habitats all around the island.		**- -**	**- - -**	
Centranthus ruber (L.) DC.	Red Valerian	2000	Locally abundant in the settlement, mainly along the coast, and in the 1961 lava area.	Also planted in gardens	**0**	**- -**	
Cerastium fontanum Baumg. ssp. vulgare (Hartm.) Greuter & Burdet	Common Mouse-ear	1852	Common all over the island.		**-**	**- -**	
Cerastium glomeratum Thuill.	Sticky Mouse-ear	2000	Common in the settlement plain, mostly in open ground.		**-**	**- -**	
Chenopodium album L.	Fat Hen	1793	Found in two gardens at the settlement. At one site it seems to have sprung up from chicken feed.		**- (- - - -)**	**0(- - -)**	
Chenopodium murale L.	Nettle- leaved Goosefoot	1908	Found on disturbed ground in a single garden in the Settlement.		**- (- -)**	**0(- -)**	
Chlorophytum comosum (Thunb.) Jacques	Spider plant	2007	Found at settlement and new volcano; presumably not spreading independently, but spread with garden waste	Also planted in gardens	**0**	**-**	
Conyza sumatrensis (Retz.) E.Walker	Guernsey Fleabane	1938	Commonly found in all habitats all around the island.		**- - -**	**- - -**	
Coronopus didymus (L.) Sm.	Lesser Swinecress	1954	Common in gardens and at the Patches, locally reaching very high cover values; also found on open ground in other habitats in the settlement plain.		**- - - -**	**-**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Cotula australis (Sieber ex Spreng.) J.D. Hook.	Australian brass buttons	1852	Found in pastures, between the Patches and Burntwood. Locally abundant, but only found at a few places.		**- -**	**0**	
Crassula pellucida L.	Stonecrop	1954	Occurring at probably the same site as the 1954 record, but now also found at one site in the 1961 lava area.		**0**	**-**	
Crepis capillaris (L.) Wallr.	Smooth Hawksbeard	1962	Abundant in arable land and in pastures and other habitats in the settlement plain; much less common at Cave Point and Sandy Point. Often reaching high cover values in the Patches.		**- - - - -**	**- -**	
Crocosmia x crocosmiiflora (Lemoine) N.E.Br.	Montbretia	2007	Escaping from gardens in the settlement and also found at a number of places in the new volcano; distributed with garden waste, and spreading vegetatively from there; also along walls in The Patches, presumably planted, but slowly spreading. Forming small, but very dense stands.	Also planted in gardens	**0**	**-**	
Cynodon dactylon (L.) Pers.	Bermuda Grass	1937	In open ground in nearly all habitats all around the island; locally dominant.		**-**	**- - -**	
Cynoglossum spec.	Hound's-tongue	2007	Several plants, forming seed, in the hospital garden.		**-**	**0 (-)**	
Cyperus esculentus L.	New Bull Grass; Nutgrass	1968	Abundant, and locally reaching high cover values in arable land and gardens; rarely found in other habitats.		**- - - - -**	**- -**	
Cyperus tenellus L.f.	Tiny Flat- sedge	1904	Frequently found on open ground in many different habitats in the lowlands all around the island.		**- - - -**	**- -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Dactylis glomerata L.	Cocksfoot	1954	Found in the settlement and in the Patches. Generally growing in small clumps, but sometimes dense stands of several m2.		**- - -**	**-**	
Eschscholzia californica Cham.	Californian Poppy	2007	Some plants outside gardens in the Settlement, as well as in the 1961 lava area.	Also planted in gardens	**0**	**-**	
Euphorbia peplus L.	Petty Spurge	1962	Abundant in the Settlement and at the Patches, where is may reach very high cover. Less frequent in other habitats in the settlement plain.		**- - - - -**	**-**	
Festuca arundinacea Schreb.	Tall Fescue	1976	A single patch was found growing along the north wall of the schoolyard. This is most likely the same place as where it was collected by Nigel Wace in 1976.		**0**	**-**	
Festuca rubra L.	Red Fescue	1937	A common grass in pastures in the settlement plain and at Sandy Point. Also found, but in smaller numbers, in open ground in other habitats.		**+ +**	**- -**	
Ficus carica L.	Fig Tree	1938	A few plants were found in the 1961 lava area. These probably got there with garden waste, or were planted on purpose. They survive, despite grazing by cattle, but do not spread.	Also planted in gardens	**0**	**-**	
Fumaria muralis Koch	Scrambling Fumitory	2000	Found locally in gardens at the Settlement and in the Patches. In the Patches it is locally very abundant, forming large plants and reaching high cover.		**- - - - -**	**0**	
Gnaphalium luteo-album L.	Jersey Cudweed	1904	Found commonly on open ground in all habitats all around the island.		**- - - -**	**- -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Gnaphalium purpureum L.	Purple Cudweed	1955	On open ground in all habitats in the settlement plain. Sometimes reaching high cover in the Patches.		**- -**	**- -**	
Hieracium ???		2007	*Requires further identification*		**-**	**-**	
Holcus lanatus L.	Yorkshire Fog	1904	The most abundant and widespread alien species on the island. It is found in all habitats, often reaching high cover values.		**+ + +**	**- - - - -**	
Hydrangea macrophylla (Thunb.) Ser.	Hydrangea	2007	Several plants were found in the 1961 lava area, probably brought in with garden waste. These plants are doing well, but do not seem to spread.	Also planted in gardens	**0**	**-**	
Hypochaeris glabra L.	Smooth Catsear	1873	Commonly found, although usually not in large numbers, in grasslands in the settlement plain, and locally at Cave Point.		**- -**	**-**	
Hypochaeris radicata L.	Catsear	2007	Found locally in quite large numbers in a pasture W of the settlement. Also a few plants along the road in the 1961 lava area.		**-**	**- (-)**	
Juncus bufonius L.	Toad Rush	1937	Common in lowland areas all around the island, mostly on open ground.		**-**	**- -**	
Juncus cf. articulatus L.	Jointed Rush	2007	Found at a fenced- in spring near the sheep- pen. Several small clumps of this species were found at this site.		**-**	**(- - -)**	
Juncus effusus L.	Soft Rush	1938	Found at Sandy Point. Most abundant in the previously cultivated areas, but also spreading into the pastures to the south of this area.		**- -**	**- (- - -)**	
Juncus tenuis Willd.	Slender Rush	1852	Widely spread all over the island, and in all habitats.		**- - -**	**- - -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Leontodon autumnalis L.	Autumn Hawkbit	2007	*Identification needs to be checked*		**-**	**- (-)**	
Leptospermum laevigatum F.Muell.	Australian Myrtle; Australian Teatree	2007	Found abundantly on old coastal road through volcano; Here we found a single very large shrub, surrounded by a very large number of smaller plants. Presumably the large plant has been planted here, and has spread by seed. A single, young plant was found in the 1961 lava area near the village.	Also planted in gardens	**0**	**- (- - -)**	
Leucanthemum vulgare Lamb.	Ox- eye Daisy	1904	A very common species in all habitats all around the island.		**- -**	**- - -**	
Lobelia erinus L.	Lobelia	1954	A few plants were found in the old Mission Garden		**-**	**-**	
Lolium perenne L.	Perennial Rye-grass	1937	Commonly found in grassland and in disturbed habitats in the settlement plain.		**+ + +**	**-**	
Lotus corniculatus L.	Birdsfoot Trefoil	2000	Locally abundant around the settlement.		**+**	**- -**	
Malus sylvestris subsp. mitis (Wallr.) Mansf.	Apple	1937	Growing at various locations around the island. Most trees seem to have been planted.	Also planted in gardens	**+**	**0**	**Fruit production: + + +**
Malva parviflora L.	Least Mallow	1852	only a single plant found in the 1961 lava area, at a site with much garden waste		**0**	**-**	
Mariscus congestus (Vahl) C.B. Clarke	Old Bull Grass; Clustered Flat-sedge	1904	Frequently found in all habitats all around the island. In the Patches it reaches high cover values locally.		**- - - -**	**- - -**	
Mentha spicata L.	Spear Mint	2007	Growing in a large patch in a marshy area at Below the Waterfall, spreading vegetatively.	Also planted in some gardens.	**0**	**-**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Mentha x villosa Hudson	Apple-mint	2000	Abundant in a wet area just below the settlement.		**0**	**-**	
Metrosideros (cf. kermadecensis)	Kermadec pohutukawa	2007	A single plant was found in the 1961 lava area, in a gully close to the old cloastal road.		**0**	**-**	
Metrosideros excelsa Sol. ex Gaertn.	New Zealand Christmas Tree; Pohutukawa	2000	Abundant in the 1961 lava area; a few trees (old and young) on slopes up towards the base behind Pigbite. Some of these may have been planted, but most have dispersed independently.	Many trees planted in gardens; some old trees at the old graveyard.	**0**	**- - (- -)**	
Mirabilis jalapa L.	Marvel- of- Peru	2007	A few plants were found in the 1961 lava area, dispersed with garden waste; no sign of spreading.	Also planted in gardens	**0**	**-**	
Myosotis discolor Pers.	Changing Forget-me-not	1937	Found mainly in open ground at the Patches, and elsewhere in the settlement plain.		**- -**	**- -**	
Nasturtium officinale R.Br.	Watercress	1962	Abundant in very wet sites at Under the Waterfall and along the stream E of the Settlement.		**0**	**- -**	
Nigella damascena L.	Love- in- a- mist	2007	A few plants outside gardens in the Settlement.	Also planted in gardens	**0**	**-**	
Oenothera glazioviana P. Micheli ex C.Mart.	Large- flowered Evening Primrose	2007	Found at several sites outside gardens in and around the settlement.	Also planted in gardens.	**0**	**- -**	
Oenothera indecora Cambess. ssp bonariensis Dietr.	Evening Primrose	1953	Common in the Pigbite area, and a few plants in the Settlement and at Hottentot Gulch. Plants range from only a few cm high to (rarely) 50 cm high.		**-**	**-**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Oenothera rosea L. Hér. ex Aiton	Pink Evening Primrose	2007	A few plants naturalized in gardens in the Settlement; common in old Mission Garden.		**- (- -)**	**- (-)**	
Oxalis corniculata L.	Yellow Oxalis	1852	Widely distributed in the settlement plain, mostly in somewhat disturbed habitats, as well as in gardens and the Patches.		**- - -**	**- - -**	
Oxalis purpurea L.	Purple Woodsorrel	1908	Common in grasslands in and around the Settlement and between the Settlement and the Patches.		**- -**	**-**	
Papaver somniferum L.	Opium Poppy	2007	Several plants were found outside gardens in the Settlement.	Also planted in gardens	**0**	**-**	
Paspalum dilatatum Poir.	Water Grass	1962	Widely spread in pastures, gardens and all other habitats, in all lowland areas around the island.		**arable land: - - - pastures: + +**	**- - -**	
Paspalum notatum Flueggé	Bahia Grass	2007	Locally abundant in pastures around the Settlement, near the Patches and in the Cave Point area.		**- - (- -)**	**- -**	
Pelargonium spec. 1	Geranium	2007	Naturalised in the new volcano; presumably dispersed with garden waste	Also planted in gardens	**0**	**-**	
Pennisetum clandestinum Hochst. ex. Chiov.	Kikuyu Grass	1976	Widely spread and abundant in pastures and gardens in all lowland areas around the island; also common, and locally dominant, in all other habitats.		**- -**	**- - - -**	
Petroselinum crispum Nyman ex A.W.Hill	Parsley	2007	Dispersing from seeds from planted parsley plants, locally outside gardens.	Also planted in gardens	**+**	**-**	
Phalaris tuberosa L.	Bulbous Canary Grass	1962	Found in large numbers in grassland in the garden of the Anglican rectory.		**+**	**-**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Phormium tenax J.R. & G. Forster	New Zealand Flax	1900	In large numbers planted in the Settlement; from here spreading to the E, mainly in the 1961 lava area. Also some plants further on in the Pigbite area. Flax appears also to have been planted localy at Sandy Point, and is spreading slowly there.	Also planted around many gardens.	**+ + +**	**- -**	
Physalis peruviana L.	Goldenberry	1938	Common in the Settlement and the new volcano; a few plants in the Pigbite area		**0**	**-**	
Pinus pinaster Aiton	Maritime Pine, Cluster Pine	2007	A few trees in and near the settlement, mostly planted.	Also planted in gardens	**0**	**- (- - -)**	
Pinus radiata D.Don	Monterey Pine	1938	In and near the Settlement, mostly planted, but some young trees come up from seed. A large plantation at Sandy Point, spreading up the mountain and into the surrounding area.	Also planted in gardens	**0**	**- - - (- -)**	**Wood production: + + +**
Pittosporum crassifolium Banks et Sol. ex A.Cunn.	Karo tree	2007	Widely planted in gardens; in the settlement some young plants were found; Also a few trees planted at Sandy Point.	Also planted in gardens	**0**	**-**	
Plantago lanceolata L.	Ribwort Plantain	1904	Abundant in all lowland areas, and on the Base. This species occurs in all habitats, locally reaching high cover values.		**- - -**	**- - -**	
Plantago major L.	Greater Plantain	1904	Uncommon. Found at some sites in and around the Settlement, and in the Cave Point area.		**- -**	**0 (-)**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Poa annua L.	Annual Meadow-grass	1852	Common in a wide range of habitats all around the island; locally reaching high cover values in gardens and at the Patches, as well as in pasture areas.		**- - -**	**- - -**	
Poa humilis Ehrh. ex Hoffm.	Spreading Meadow- grass	1937	Widely spread all around the island, mostly in pastures and in open ground.		**+**	**- -**	
Poa infirma Kunth	Early Meadow-grass	1938	Not found, but the location of the original collection was not visited.		**?**	**?**	
Poa pratensis L.	Smooth Meadow- grass	1873	Common in pastures and other habitats in the settlement plain and in the Sandy Point area.		**arable land: - - pastures: +**	**- -**	
Poa trivialis L.	Rough Meadow-grass	1937	In grassland and disturbed habitats at the Settlement and the Patches as well as in the 1961 lava area.		**arable land:- - pastures: +**	**- -**	
Polycarpon tetraphyllum (L.) L.	Four- leaved Allseed	1852	Common in open ground in the settlement plain.		**- - - -**	**- -**	
Polygonum aviculare L.	Knotgrass	1937	Only at a few sites, growing in small numbers on open ground in ruderal places		**- -**	**-**	
Populus alba L.	White Poplar	2007	In the Sandy Point forest and in a small gulch S of the forest. The original trees probably were planted, but at the latter site poplars are spreading into the surrounding area by root suckers.		**-**	**- (- -)**	
Prunella vulgaris L.	Self- heal	1938	Widely spread in all lowland areas around the island.		**- - -**	**- - -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Prunus domestica L.	Plum	1937	Plum trees are planted in the Settlement and at Sandy point; there are some juvenile plants, away from the old trees, at Sandy Point.	Also planted in gardens	**0**	**- (-)**	**Fruit production: + +**
Raphanus raphanistrum L.	Wild Radish	2007	A few plants in a garden in the Settlement.		**0**	**0 (-)**	
Romulea rosea var. australis	Sand Crocus / Onion Grass	1908	Locally abundant in grassland and dry open ground in an around the Settlement and at some places in the Pigbite area.		**-**	**-**	
Rosa spec.	Rose	2007	In the Settlement, presumably all planted, and at several sites in the 1961 lava area. Here it probably arrived with garden waste. Spreading only vegetatively.	Also planted in gardens	**-**	**- -**	
Rubus loganobaccus L.H.Bailey	Loganberry	1976	At several sites in and around the Settlement and in the 1961 lava area; some very large, dense colonies at Sandy Point. Spreading apparently mostly vegetatively.	Also planted in gardens	**0**	**- - (-)**	**Fruit production: +**
Rumex acetosella L. subsp. angiocarpus (Murb.) Murb.	Sheep's Sorrel	1952	Common in many habitats all over the island.		**- - - -**	**- - - - -**	
Rumex crispus L.	Curled Dock	1817	Not found with certainty in 2007/08, but photographed a few years ago by Gerhard Jakubowski.		**?**	**?**	
Rumex obtusifolius L. subsp. obtusifolius	Broad- leaved Dock	1904	Common in all habitats all over the island; locally reaching high cover values.		**- - - - -**	**- - - -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Sagina apetala Arduino	Annual Pearlwort	1999	Found regularly, usually in small numbers, at trampled sites, on roads and paths, in the Settlement and on the road to the Patches.		-	-	
Sagina procumbens L.	Procumbent Pearlwort	1999	Locally very abundant in the settlement plain and in the Caves area. At a single site near the penguin colony south of Sandy Point. Locally reaching very high cover values in pasture areas.		- - (- -)	- - (- - -)	
Salix caprea L.	Goat Willow	1937 / 2007	Near the Settlement and at Sandy Point; presumably all planted, but at Sandy Point spreading. (Jakubowski suggests this is *S. caprea x cinerea* (personal communication))		0	-	
Saponaria officinalis L.	Soapwort	2000	Naturalized at a few sites in the Settlement.	Also planted in gardens	0	-	
Senecio pterophorus DC	UK: Shoddy Ragwort; Aus: Winged Groundsel; African Daisy	2000	Locally abundant in the 1961 lava area; a few plants were found in Pigbite area and near Hottentot Gulch.		0	- - (- -)	
Senecio vulgaris L.	Groundsel	1873	Widespread in the settlement plain, mostly on open ground. Abundant in many of the Patches.		- - - - -	- -	
Solanum nigrum L.	Black Nightshade	1908	Frequently found in gardens and on open ground in and around the Settlement; also in the 1961 lava area, the Pigbite area and at the Patches.		- -	- -	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Solanum tuberosum L.	Potato	2007	Escaped from cultivation at the Settlement and the Patches. Presumably coming up from thrown away potatoes.	Also planted in gardens and Patches	food production: **+ + + + +**	**-**	
Sonchus asper (L.) Hill	Prickly Sow-thistle	1962	Widely dispersed all around the island. Most abundant in the Patches and in disturbed ground.		**- - - - -**	**- - -**	
Sonchus oleraceus L.	Smooth Sow-thistle	1817	Widely dispersed around the island. Most abundant in the Patches and in disturbed ground.		**- - - - -**	**- - -**	
Sporobolus africanus (Poiret) Robyns & Tournay	Ratstail Grass	1908	Abundant in pastures and in all other habitats all around the island. Locally dominant.		**- - -**	**- - -**	
Stachys arvensis (L.) L.	Field Woundwort	2007	Locally abundant in some of the Patches.		**- - - (- -)**	**0**	
Stellaria media (L.) Vill.	Common Chickweed	1937	Only a few plants were found, in the Settlement and the old Mission garden.		**- -**	**- -**	
Taraxacum officinale Wiggers (agg.)	Dandelion	2000	Found in low numbers in the settlement plain.		**-**	**-**	
Tradescantia fluminensis Vell.	Wandering- jew	2007	A garden escape in the Settlement and in the 1961 lava area. In this area it arrived probably with garden waste, but is spreadling slowly by vegetative means.	Also planted in gardens	**0**	**-**	
Trifolium cernuum Brot.	Nodding Clover	2007	Common in and around the Settlement and in the 1961 lava area. Some plants were also found in the Caves and Stony Hill areas.		**+**	**- -**	
Trifolium dubium Sibth.	Lesser Trefoil	1937	Widely occurring all around the island, in nearly all habitats.		**+**	**- -**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Trifolium fragiferum L.	Strawberry clover	2007	At a few sites in grassland in the Settlement.		**-**	**0**	
Trifolium glomeratum L.	Clustered Clover	2007	Widespread in the settlement plain; found in most habitats.		**+ ?**	**- -**	
Trifolium micranthum Viv.	Slender Trefoil	1955	Widespread in the settlement plain; a few plants at Sandy Point. Found in most habitats.		**+ ?**	**- -**	
Trifolium repens L.	White Clover	1904	Found widely spread, but not very abundant, in pastures and on disturbed ground in the settlement plain.		**+ +**	**- -**	
Trifolium subterraneum L.	Burrowing Clover	1968	Locally abundant in grasslands around the Settlement and in the Pigbite area.		**+ + (+)**	**-**	
Tropaeolum majus L.	Nasturtium	2007	Locally escaped from gardens in the Settlement and in the 1961 lava area. Seeds may have been dispersed with garden waste.	Also planted in gardens	**0**	**-**	
Urtica dioca L.	Common Nettle	2009	One patch in a garden in the Settlement		**-(--)**	**-**	
Vellereophyton dealbatum (Thunb.) Hilliard & B. L. Burtt	White Cudweed	1976	Widely spread in all habitats all around the island, mostly associated with open ground. Locally reaching high cover values in the Patches.		**- -**	**- -**	
Verbascum virgatum Stokes	Twiggy Mullein	1908	Widespread on ruderal sites in and to the east of the settlement.		**0**	**-**	
Verbena officinalis L.	Vervain	1904	Not uncommon, sometimes forming large groups, in the Settlement. Also locally in the 1961 lava area.		**0**	**-**	

Scientific name	Common name	First recorded	Present distribution	notes	Impact on agriculture	Impact on conservation	Other impacts
Veronica agrestis L.	Green Field Speedwell	1938	Abundant in part of the Patches, locally reaching high cover values. Also found in the garden of the Administrator's residence.		**- - - - (-)**	**0**	
Veronica serpyllifolia L.	Thyme- leaved Speedwell	1908	Common in all habitats all around the island.		**- - -**	**- -**	
Viola tricolor L.	Wild Pansy	2007	Sprung up from seed at a few places along road verges in the Settlement.	Also in gardens	**0**	**0**	
Vulpia bromoides (L.) S.F. Gray	Squirrel- tail Fescue	1852	Widely spread, mostly associated with open ground, in all habitats all around the island. Locally abundant in pastures.		**- - -**	**- - -**	
Watsonia spec.	Bugle Lily	2007	Found at a number of places in the Settlement and on the new volcano; distributed with garden waste, and surviving, but apparently not spreading	Also planted in gardens.	**0**	**-**	
Zantedeschia aethiopica (L.) Spreng.	Arum Lily; Calla Lily	2000	Growing at several places in and around the Settlement, and in the 1961 lava area. Dispersed with garden waste. Slowly spreading vegetatively, but not colonizing new areas. At Sandy Point a large patch of this species grows in a wet part of the plantation.	Also planted in gardens.	**-**	**- -**	

Introduction

With the vast increase in transport of people and goods across the globe, many plant and animal species have been dispersed to areas outside their natural distribution. In the new areas they colonize, alien species are a major threat to many of the local ecosystems. They also can have serious adverse economical impacts, for instance by reducing agricultural yields and greatly increasing the cost of weed management.

Alien plant species occur on all islands of the Tristan da Cunha group. The three outer islands (Inaccessible, Nightingale and Gough) remain in a largely undisturbed state, despite the presence of a number of introduced species. They are, however, constantly at risk of introduction of new species as a result of visits by tourists, scientists and Tristan islanders. Sources of alien species are areas visited by calling vessels before they arrive at Tristan, but a major potential source for the dispersal of alien species to the outer islands is Tristan itself, with its large suite of established alien species. Also, alien species with a presently restricted distribution on these islands may well in future increase their area and abundance, thus becoming a threat to the islands they have invaded.

In this report we present the results of an alien plant survey of Tristan. We collected data on the distribution and phenology of the alien species, as well as on their abundance and impact on agriculture and biodiversity. Based on our findings we made suggestions for alien plant species management (control or eradication).

The island

Tristan da Cunha is the main island of the Tristan da Cunha island group, situated in the Southern Atlantic Ocean (37º 05' S, 12 º 18' W), some 2800 km from the southern tip of Africa, and well over 3000 km from South America. The Tristan group consists of four islands, Tristan, Inaccessible and Nightingale, 20 – 40 km away from each other (Fig. 1), and Gough, some 390 km southeast of Tristan. Tristan has a surface area of 96 km^2. The island is a volcanic cone rising up from the seafloor, with steep, up to 800 m high cliffs descending into the sea. Along the northwestern part of the island there is a narrow strip of coastal lowland, the Settlement Plain, measuring some 7 km^2. Other, smaller lowland areas occur at Sandy Point (0.25 km^2), the Caves (1 km^2) and around Stony Hill (1.5 km^2; fig 2) . The central part of the island is formed by the Base, a plateau at ca. 800 – 1200 m altitude, slowly rising op towards the central peak at an altitude of 2060 m above sea level (Fig. 3).

The Tristan islands are of volcanic origin. They are associated with the South Atlantic ocean ridge, where the South American and African tectonic plates are moving away from each other. Tristan is the youngest of the four islands. The oldest rocks on Tristan are about 200,000 years old. In contrast Gough and Inaccessible are some 3-5 million years old, and Nightingale 18 million years. The most recent eruption on Tristan was in 1961, when a new volcanic cone appeared just NE of the Settlement, covering an area of about 0.5 km^2 in new lava.

Detailed satellite images of Tristan are available through Google Earth (http://earth.google.com) or Google Maps (http://maps.google.com).

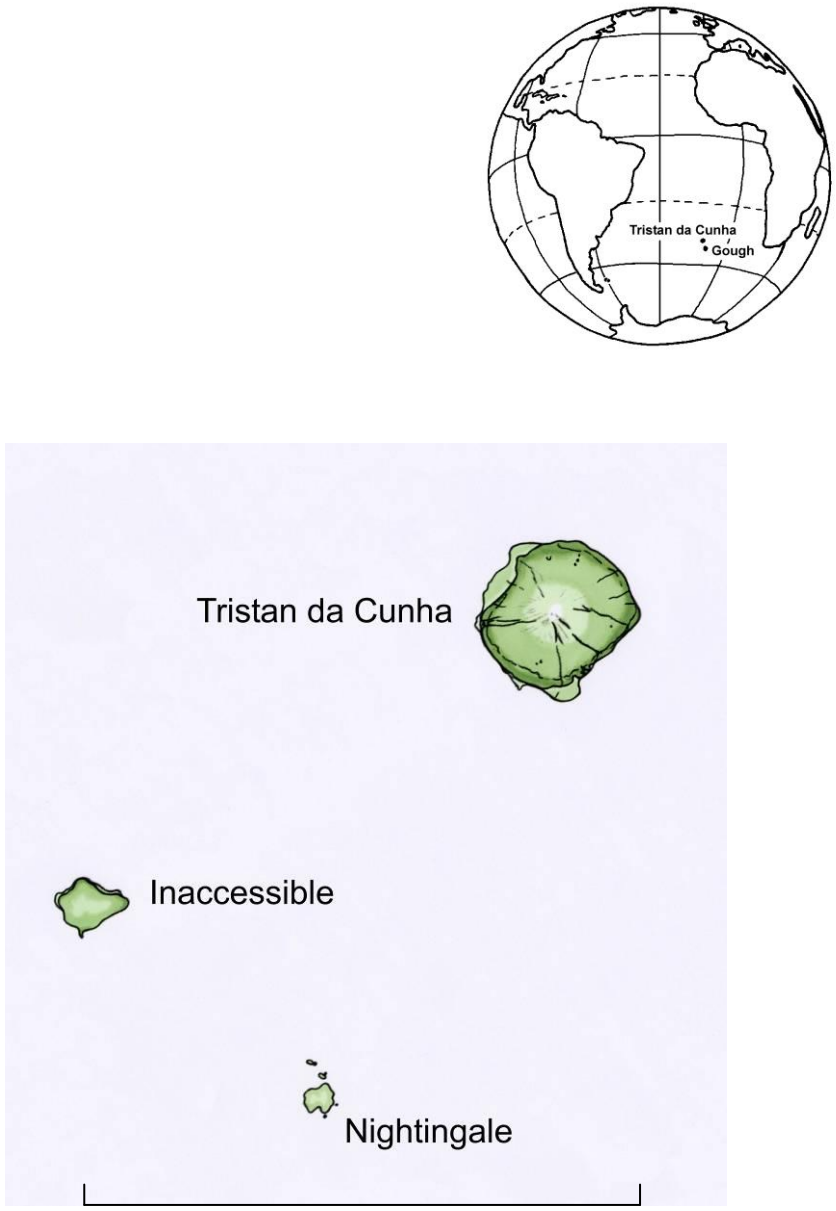

FIGURE 1. *The Tristan islands. Gough Island, 390 km to the SE is not in this map. The scale on the map measures 40 km.*

After the discovery of the islands in 1505/06, there seem to have been few visits by ships, and little exploitation, until the late 18th and 19th century, when sealers exploited the islands' fur seal and elephant seal populations. By the end of the 19th century seal numbers were so reduced as to make sealing not profitable any more. Goats and pigs were introduced in this period, and several alien plants had already become established by 1793.

The first settlement took place in 1811, and some 12 acres of the lowland plain were converted into agricultural land, much of it used to grow potatoes and several kinds of vegetables (Wace & Holdgate 1976). This settlement only lasted a few years. In 1816 Tristan, Inaccessible and Nightingale were annexed by Britain, and Tristan was settled again. But the population remained less than 100 persons for about a century. During the last 100 years the population appears to have slowly increased to about 260 in 1960, and seems to have been fairly constant since then. The temporary establishment of a

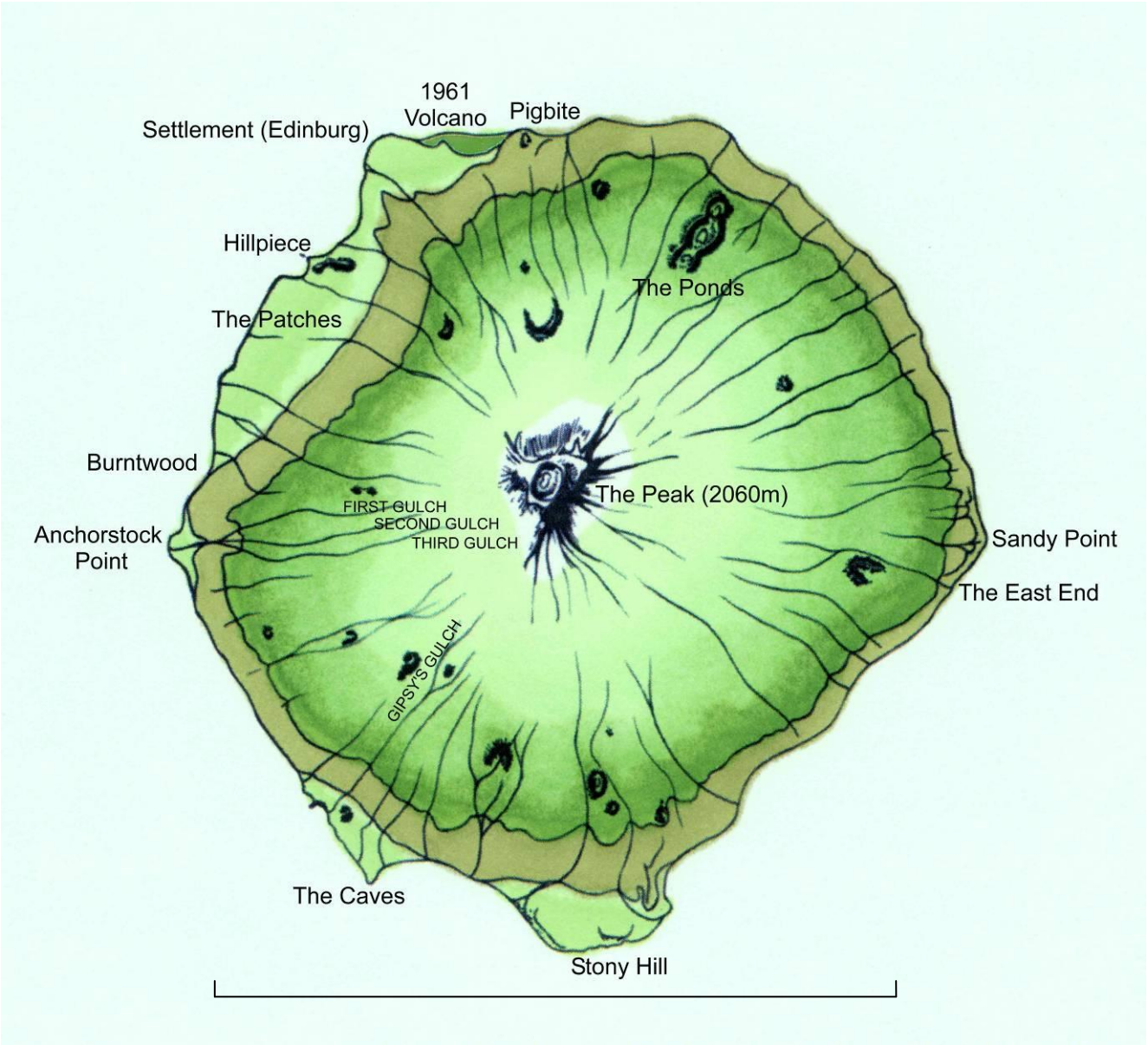

FIGURE 2. *The island of Tristan da Cunha. The scale measures 10 km.*

FIGURE 3. *Tristan da Cunha, seen from the northeast.*

small garrison on Tristan in 1942, and especially the building of a crayfish canning factory on the island increased the contact of the islanders with the outside world. In 1961 a volcanic eruption took place right next to the village, and all people were evacuated from the island. But in 1963 most of them returned to Tristan.

With increasing agricultural activity, most of the lowland areas of Tristan were transformed from the original native plant communities into grasslands and gardens dominated by alien species. Increasing grazing pressure in the uplands and stocking of the island well beyond its carrying capacity resulted in overgrazing, opening up the grassland for invasion by unwanted alien species, and also resulting in considerable loss of livestock in unfavourable winters (Barrow 1910; D. Rogers, personal communication).

Presently Tristan is inhabited by about 280 people. Its major resources are fisheries (Tristan rock lobster and fish), natural biodiversity (endemic plant and animal species; potential for ecotourism), agriculture (subsistence farming, providing fresh food), and geographic position (providing an agreeable place for the inhabitants to live according to their own cultural and social codes).

Wet heath and bogfern vegetation on the Base

The flora

The Tristan da Cunha island group has some 50 native flowering plants, and about 35 native fern and fernlike species. Nearly half of these plant species are endemic, i.e. do not occur anywhere in the world outside the Tristan group. Thus these islands are unique in a botanical sense, and of high conservation value. The uniqueness and importance of the islands is further based on the presence of a large number of bird species, and invertebrate animals, several of which are also endemic to the islands. Many of these species are listed and illustrated in the *Fieldguide for the Tristan da Cunha islands and Gough* (Ryan 2007).

In addition to these native species, a considerable number of plant (and animal) species have been brought to the islands by people, sometimes on purpose (like flowers and vegetables grown in gardens as ornamentals and for food, and grass species brought in to improve the quality of the pasture), others by accident (many weeds, and animal pests like rats, mice, slugs and caterpillars). These species that have reached the islands through human action are called alien species (or non-native, exotic, or introduced species). Some of them have valuable functions (like providing food), but most of them have only negative effects, e.g. because they form pests or weeds in gardens and arable land, or because they replace native species, thus reducing the natural biodiversity of the islands.

Past botanical collecting on Tristan

Botanical collecting started on Tristan in 1793, when Aubert du Petit-Thouars collected four vascular plant species on Tristan, 3 of which were introduced. During the 19th century several expeditions called at Tristan, and by 1910 some 44 alien plants were known from the island. After that various visitors made collections, but the first substantial botanical survey was made by Christophersen and Mejland during the 1937-38 Norwegian Scientific Expedition to Tristan da Cunha. In the 1950s Stableford, Tristan's agricultural officer from 1953-1957, collected a large number of plants, and in the late 1950s and later Wace and Dickson made large collections.

The knowledge on the Flora of the Tristan da Cunha group was brought together in a single paper by Groves (1981), who studied all available collections. Since then no large collections seem to have been made on Tristan itself, but in the 1990s Roux (Roux et al. 1992) made an extensive study of Inaccessible Island, and also collected on Nightingale Island.

The present survey is the first study specifically looking at introduced plants on the islands. Practically all previous collections, however, included alien plants, and from these we can get some idea at least of the history of alien plant invasions on the island (see the Results section).

Alien species and their impact

Alien species are species of plants or animals that have arrived in an area where they do not occur naturally, by means of transport provided by people. Some species are brought in on purpose, for instance to grow them as food for humans or fodder for animals, or as ornamental garden plants. Others have arrived by accident, without the people bringing them in probably being aware of it. Examples of these are weed seeds that were brought in as impurities in vegetable or flower seeds, seeds that were present in hay that was imported from elsewhere, or seeds or plant fragments in soil in which plants were imported, or attached to containers or to imported cars. People may also carry plant seeds and other propagules with them in their clothing, in bags, attached to boots, etc., without being aware of this (Gremmen et al., unpublished data on seeds carried by people travelling to Antarctica).

Generally we do not see these inadvertently imported alien species arriving (a notable exception were the rats that were seen coming ashore from a wrecked ship in 1882). But species that only have been found relatively recently, after people have colonised the islands, and that were first found at sites where goods from outside the islands were brought in (e.g. in the Settlement), and are spreading into other areas from there, most likely are aliens. Especially when it is known that such a species is native to a region far away (for instance Europe or Australia), and when it is known to have been introduced in other parts of the world, such species can be considered aliens. Also if a species is only found in man-made habitats (e.g. gardens, Potato Patches), this is an indication that it is introduced by people.

Weeds in the Potato Patches

Alien plants invading natural vegetation

Alien species may have various impacts in the areas where they are introduced. For some of them the impact may be negligible, but others can completely transform ecosystems. On oceanic islands, where land mammals do not occur, introduced herbivores (e.g. goats, sheep, but also mice), and predators (e.g. cats, rats, and mice) can have very large impacts on native species, because these have been evolved without contact with large herbivores and large land predators, and do not have a defence against them. On Tristan predators (of which at the moment rats are the most important, cats and feral pigs having been eradicated) have decimated the vast numbers of seabirds that must have been breeding on the island before people arrived. Not only is this in itself a serious loss of biodiversity, and possibly of endemic species, but also has this greatly reduced the flow of nutrients from the surrounding ocean to the land, thus reducing the fertility of the soil.

Alien plants can also have considerable impacts. Some of them can out-compete native plants, and in this way replace the original native island vegetation by alien plant communities. As a result vegetation develops that is dominated by a relatively small number of invasive aliens, which are also common elsewhere in the world. Thus the special and unique character of the native plant communities and ecosystems will be lost.

Alien plant species may completely transform the structure of the original plant community (for instance imported trees change fernbrake and shrub vegetation into forest), and also change the soil structure and quality. This then may affect the soil fauna, which in turn may influence nutrient cycling. Alien grasses can invade certain habitats, and replace the native plant species. Grazing strongly facilitates this process. None of the native species is adapted to recover quickly from grazing, and many will rapidly disappear in grazed areas. In contrast, several alien species are able to quickly grow again after grazing, and these will become dominant in grazed area. Ultimately alien invasions in this way may lead to extinction of native species, many of which are endemic, i.e. occur only on the Tristan islands.

Alien plant can also negatively affect the potential of the island to provide food for its human inhabitants. A considerable number of alien species have developed into agricultural pests, in arable land (gardens, potato patches) as well as in pastures. Alien plants may also be carriers of diseases that can affect native species or food plants. They may also directly affect humans or livestock, e.g. by being poisonous.

Aliens also can affect other ecosystem services. As almost any other part of the globe, Tristan contributes to the global regulation of atmospheric composition and climate. Obviously the small surface area of Tristan makes the impact of Tristan on the global system quite small, but this is no reason to completely ignore it. Alien dominated ecosystems on the island (with the possible exception of the Sandy Point forest) contribute little or nothing to the long term storage of carbon, and thus the reduction of CO^2 in the atmosphere. Most of the native plant communities, especially the fernbush, Phylica bush, fernbrake, mires and bogs, however, have high organic matter contents in the soil, thus storing carbon in these soil deposits. Replacement of native vegetation by alien-dominated communities, especially grazed pastures, results in a decrease in carbon storage in the islands soil and vegetation. The increase of biomass by the addition of some alien plants in vegetation of heavily disturbed areas is a small contribution towards carbon storage, but as a result of replacement of native vegetation by alien-dominated communities, resilience against erosion appears to diminish, increasing the area of highly disturbed ecosystems (e.g. outwash areas of erosion gulches), diminishing the island's total carbon storage.

Reduction of soil organic matter content of the soil as a consequence of the replacement of native vegetation by alien communities, is expected also to have an impact on the hydrology of the island. Water retention in the soils becomes reduced, resulting in an increasing rate of runoff, and an increase in erosion. This may have some influence on the moisture supply to pastures and arable land in the lowland plains. The replacement of native vegetation on the Base by alien grasslands may affect the water supply of the settlement. But more data are needed to find out if there is a significant impact.

The replacement of the original plant communities with their organic-rich soils by pastures and arable land, covered by alien species, and with little organic content in the soil, also increases the leaching of nutrients, making soils less productive. The overall productivity of the island has presumably already been diminished strongly by the vast reduction of bird numbers by alien predators (rats, mice, in the past also cats and other animals), with the consequent reduction in mineral inputs by bird excreta, feathers, etc.

The impact of alien plants on ecosystem goods and services on Tristan is hard to quantify, and we have restricted ourselves to general remarks here. These impacts, however, should not be ignored just because we cannot quantify them at present.

The costs of the impact of alien species is often difficult to establish. In case of yield reduction of crops, the impact can be expressed in monetary units, if the yield reduction is known. Equally the cost of the extra work caused by alien weed species involved in growing crops can in principle be estimated, based on labour costs. On Tristan, however, where a large part of the local economy is not based on money, estimating these costs is quite difficult. Crop yield reduction and more time needed to grow the necessary crops generally will not mean that people will spend more money, but means that they need to spend more time growing potatoes and vegetables, and/or live on a less variable (and healthy) diet. Estimating the costs of loss of ecosystem services and of natural biodiversity is still more complicated. In this report we have not attempted to cost alien plant impacts, but have quantified impacts on a simple scale running from nil or negligible to very heavy (see further on).

In the table and the discussions above we have mainly described the impact of single species. Sometimes the impact of separate species is not very large, but do the impacts of all alien species occurring in a certain habitat together add up to a serious threat to the integrity of the natural communities. Several species that colonize open ground, and generally do not reach high cover values by themselves (e.g. White Cudweed, Purple Cudweed, Sticky Mouse-ear, Toad Rush, Silvery Hairgrass, Squirrel-tail Fescue, Common Mouse-ear, and various small clover species), but together they may make out most of the biomass in such habitats, dominating the native species, and significantly changing the structure of the natural vegetation communities. In this way together they cause considerable modification of the vegetation, and presumably also of associated soil characteristics.

Alien species management

Obviously, the best way to control alien invasive species is to make sure they do not reach the island. This aspect of alien species management will be discussed in a separate report (John Cooper, in preparation). For the species that have already established themselves on the island it is too late for that, and other control measures have to be taken to reduce their numbers or to completely eradicate them, if control is at all possible.

Before sensible decisions can be made about the management of alien species (or about any other management questions, for that matter), the objectives of this management have to be clearly stated. Although the basic management objectives for the Tristan main island do not seem to have been formulated explicitly, we have based our estimates of the impact of alien plants on the following: The basic objective of the management of the island is the maintenance in a sustainable way of the resources that maintain life on the island. As stated before, the main resources of Tristan are the fisheries (Tristan rock lobster and fish), which form the basis of the economy of the island. The second resource is the land, soils, hydrology, and ecosystems of the island, which make local food production possible, as well as providing a place to live, providing a good quality water supply, etc. A third major resource is formed by the natural biodiversity of the island, including a large number of endemic plants and animals. The first two (fisheries and land with associated ecosystems as a place to live) are primarily of local importance. They provide the local community with an economic basis and a place to live. The third resource (natural biodiversity), however, has a global importance. From this global importance obligations arise for the maintenance of this biodiversity. The Tristan islands' flora forms a significant part of the endemic biodiversity of the United Kingdom. International treaties (e.g. the Convention on Biological Diversity) require nations to protect their biodiversity. One of the local reasons for conservation of this unique biodiversity is that it is a potential source of attracting outside funds for its safeguarding and management, as well as through ecotourism. The latter, however, on Tristan has serious practical restrictions, e.g. because of the limited shipping access, but it should not be discounted as a potentially important economic factor.

Fisheries and other marine resources are not affected by alien terrestrial plant species on Tristan, and will not be considered here. As the major objective of the management of the terrestrial system of the island we take therefore : 1) the sustainable maintenance of all aspects of the island that are necessary to provide a safe place to live, the possibility to produce sufficient food, the assured availability of fresh water, and the presence of a sufficiently agreeable and interesting environment, and 2) the presence of large areas of native ecosystems with their associated plant communities, and the survival of all native, and especially endemic species, with sufficiently large populations of each species to minimize the risk of extinction.

Tristan is a potential source of alien invaders to the other islands of the group harbouring a large number of introduced plants that have proven their ability to establish themselves and thrive in the islands' environment. There are regular visits from Tristan to the other islands, and preventing alien species already established on the main island to reach the outlying islands is of vital importance for the conservation of the native biodiversity in these islands.

In this report we list suggestions for the management and control of alien plants based on the above objectives, i.e. aimed at the reduction of negative impacts on agriculture and at the reduction of the effects of alien plants on native plant communities. We have made no specific

suggestions for the reduction of impacts on other island resources (soil quality, water supply, etc.).

Feasibility of control

With control we generally mean eradication. In an island setting this often is a feasible option, as there is usually no immediate threat of new invasions of the same species (given the presence of measures to prevent transport of plant propagules to the island). Alien species control will require a serious investment of time and other resources, and results will not generally be immediately visible, especially when one starts control in time, when an alien species is still restricted in distribution and low in numbers. The results of not taking any measures will undoubtedly become visible over time, but once these (i.e. serious impacts of new invaders) are clearly visible, it will generally be too late to do anything about it.

Feasibility of eradication depends on:

1. the abundance and distribution of the species: a species occurring only at a single site, and with low numbers is much easier to control than a species occurring at many sites and in large numbers.

2. the rate of dispersal: species spreading slowly are easier to control than species spreading rapidly. In this respect species producing small numbers of heavy seeds are more easy to control than species producing large numbers of wind-disperse seeds.

3. species that can sprout again from roots or other underground organs are more difficult to control than species not able to do so.

4. species that are easily recognised and seen in the field are easier to control than species that are difficult to recognise or see in the field. Thus large species are easier to control, because it is easier to find all individuals of the specific species. Small plants are harder to find, and it is easier to overlook some, which can then become a source for new spread of the species.

Importance and urgency of control

Importance of control depends firstly on the impact of the species. If a species has a high negative impact, it is more important to control it than if the impact of the species is small. Here not only the present impact is important (those species that already have a serious impact now are generally already abundant and widely dispersed, and have already become virtually impossible to control), but possibly even more important is the expected or possible future impact: species that are at this moment still restricted in numbers and in invaded area are relatively easy to control. For species that are presently restricted, but can spread rapidly, and may have serious impacts, control measures should be started as soon as possible.

What we did and how we did it

Our first objective was to make a full inventory of the alien plant species occurring on the island. For each species we wanted to find out where on the island it occurred, and in what numbers. Secondly we wanted to find out if alien species had any serious impact on native biodiversity and conservation values, or on aspects of the economy or the wellbeing of the Tristan islanders. The results of this survey form the basis for an alien plant management plan.

The survey was done by walking as much of the area as possible, visiting each part several times during our stay, in order to find species with different growing and flowering periods. We collected all different plant species, if possible with flowers, and pressed and dried several specimens of each species. We were too late to catch the spring flowers, and consequently the data on species such as Onion Grass (*Romulea rosea*) and Purple Woodsorrel (*Oxalis purpurea*) are likely to be incomplete. Also the distribution of species only developing their flowers in autumn, like some of the grasses, is presumably incompletely known.

We tried to identify all species immediately, but for a number of specimens we could not find out with certainty to what species they belonged. The identifications of all specimens are being checked by botanists at the Herbarium of the Royal Botanic Gardens at Kew. A herbarium including specimens of all these species will be housed at the Tristan Conservation Department or at the Tristan Museum, with duplicates at Kew and in the Compton Herbarium (NBG) at the Kirstenbosch National Botanical Garden in Cape Town.

We did not include ornamental plants or species grown for food that only were found in gardens. Some annual ornamentals did reproduce and propagate themselves. If their population was restricted to gardens (as was the case for e.g. Sweet Alyssum, *Lobularia maritima* (L.) Desv.), the species was not listed in our alien plant list. Garden plants that were brought in as ornamentals or vegetables, but escaped and dispersed outside gardens, were included in our list. Sometimes garden ornamentals were found outside gardens, in places where they obviously were not planted, but where they probably were brought with garden refuse. These plants were included in our list, if they were surviving at these places. There are a few species of trees that were planted outside the settlement. These are also listed, but are included in the alien plant counts only when there were indications that they could or did reproduce. For example, several Eucalypt species were found, but for most of them there was no indication that they flowered or reproduced on Tristan.

We surveyed all major lowland areas of Tristan, i.e. the Settlement Plain, the Stony Hill and the Cave Bay areas, as well as the Sandy Point area. In addition a number of visits were made to the uplands, but because of poor weather or the lack of available guides, these surveys were necessarily of a limited nature. In addition to collections of alien plant specimens, we made full species lists for 296 locations. These *vegetation assessment points* were taken at more or less regular intervals during our fieldtrips. The purpose was to get an idea of the distribution and abundance of the alien species, and their impact on native vegetation, without too much bias in the data. For this reason we did not select sites, e.g. on the basis of the occurrence of many alien plants, but we tried to select sites in a somewhat random fashion, while at the same time having different habitats and geographic areas represented in the data. However, the location of the vegetation assessment points was restricted by the logistic limitations imposed upon us. Figure 4 shows the locations of these vegetation assessment points.

The collection sites and vegetation assessment points together yielded over 4000 site records of alien plants on the island. Each record listed the abundance of an alien plant species plus data on the location and the habitat in which it was found, and on the phenology of the plant. At the vegetation assessment points the ground cover of each plant species was estimated. This provides information on the competition between alien and native species at these sites, and has been used to estimate the impact of the alien species.

When collecting site information for the collections and vegetation species lists, we used a detailed set of different habitat types to characterize the site. In analysing the data for this report, we grouped these habitats in a few major habitat types, which are listed below.

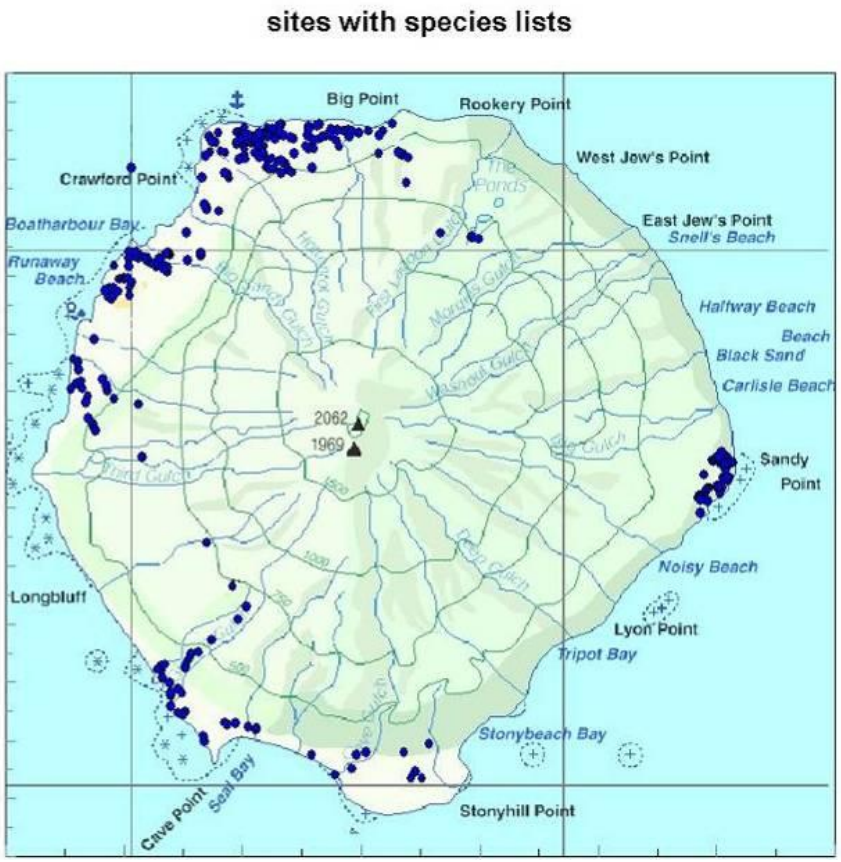

FIGURE 4. *Location of vegetation assessment points, where full species lists of the vegetation were made.*

Major Tristan habitats

Arable land and gardens
These include the Patches and the gardens at the Settlement. Characteristic is that species are more or less controlled (crops or ornamentals are planted, weeds are removed to a smaller or greater extent), and the soil is regularly disturbed by digging. Soils generally have low organic matter content.

Dynamic human-influenced habitats
Habitats that are disturbed by human activities, such as road verges, building sites, and waste dumps. Characteristic is the disturbance of the soil and vegetation. Soils have a low organic matter content, and soil moisture content can vary a lot over time, depending on weather conditions. Vegetation is usually open, not completely covering the ground.

The 1961 lava field and volcano
This area is characterized by the young volcanic substratum, and the absence of any soil formation. The new volcano itself is covered in relatively fine-grained sandy deposits, as are a few small areas in the lava field near the coast, but the surface of the lava field itself consists of a loose deposit of 10 – 40 cm large black lava blocks. Characteristic is a very low water retention capacity.

Pastures and other grasslands
Much of the lowland areas (the Settlement Plain from the Settlement to Burntwood, the lower plateaus south of Sandy Point, and the lowland areas in the Caves and Stony Hill areas), are grazed by livestock, and covered in grassland, almost entirely consisting of introduced species. The pastures of the Settlement Plain are very intensively grazed. As a result the sod is quite open in many places, allowing weedy species to enter the vegetation. Soils are often shallow, with relatively low organic matter content.

Dynamic native habitats
These are habitats with natural disturbance, generally not much influenced by human activities. Examples are beaches, where there is a lot of sand movement by wind and water, and the outwash areas of the gulches where the soil is heavily disturbed by flash floods after heavy rains. Also the areas of volcanic sand in the Stony Hill area are in this category. Soil organic matter content is very low.

Stable native habitats
These habitats are characterized by little disturbance (no grazing, no strong soil movement). Much of the Base, where it is not strongly grazed, belongs in this category. The Island tree (*Phylica arborea*) woodland, the bogfern (*Blechnum palmiforme*) fernbush, and the different forms of fernbrake, mires, bogs, and upland heathland are examples of stable native habitats. The soil organic matter content is generally high.

Forest
This is the forest plantation at Sandy Point. The dominant species is the Monterey Pine (*Pinus radiata*), while a small area in the centre of the plantation has been planted with Eucalypts. Soil organic matter content is generally quite high.

Other habitats
A few sites did not fit into the above categories, and have been lumped together in the group “other habitats”. These are mainly stream banks and springs.







A. pasture habitat
B. natural, dynamic habitat
C. arable land habitat (the Patches)
D. native habitat, stable
E. forest (Sandy Point)
F. spring
G. lava area from the 1961 eruption

Quantifying alien plant species impacts

We separately quantified the impact of each alien plant species on agriculture and on natural biodiversity. With respect to agriculture some species have a positive impact. i.e. they contribute significantly towards sustaining local food production. We have not included possible positive effects of alien plants as garden ornamentals. In judging the feasibility of control measures, however, we have assumed that people would not readily want to remove well-liked ornamental species from their gardens.

Impact on natural biodiversity was quantified in the following classes:

0 = impact is so small as to be negligible (the species occurs only in a tiny area, in very low numbers, with no risk of a significant increase in numbers or area, and not found in undisturbed habitats)

\- = low impact (the species occurs in a small area only, with little risk of spreading into undisturbed habitats; species with poor dispersal capabilities)

\- - = between the previous and the next class

\- - - = moderate impact (the species is moderately abundant in disturbed as well as in undisturbed habitats, but does not reach high cover values. The species is widely dispersed.

\- - - - = between the previous and the next class

\- - - - - = very large impact (the species is, or has the potential to become widely dispersed, and replaces natural vegetation in large areas (or can be expected to do so in future); the species has good dispersal capabilities).

For the **impact on agriculture** we have used a similar set of classes, where 0 = not or very rarely found in agricultural land; - = only found in small numbers in gardens and agricultural fields; to - - - - - = a very abundant weed, often reaching high cover values.

Results

In total we found some 137 species of alien vascular plants (Table 1). The final number may be slightly different, as some specimens have not yet been properly identified. Of the 131 alien plant species previously listed for the island (Groves 1981; Gremmen & Jakubowski 2007), 32 have not been found by us (Table 2). For most of these species we had information on the location where they were found previously, and these locations were carefully searched. It seems therefore likely that most of these have not been able to establish themselves permanently on the island, and have disappeared. For two species we were not able to get to the original location, and these may well be present still. Conversely, we have found some 38 species not previously recorded on Tristan (Table 1). Some of these have been noticed before, but not identified at species level. For instance pine trees (*Pinus* spec.) have been recorded on Tristan, and the two species of pine that we identified (Cluster pine, *Pinus pinaster* and Monterey pine, *Pinus radiata*) are undoubtedly the same pines, and do not represent new introductions. But some of the newly listed species are recent introductions that were not present on the island during previous surveys.

Figure 5 shows the number of aliens that have been recorded from Tristan over time, based mainly on information provided by Groves (1981), and our own observations. The number of alien plant species shows a steady increase over time. The occasional periods with a very steep rise in the number of alien plant species should not be interpreted as sudden increases in invasions, but are most probably caused by more extensive surveys at these dates.

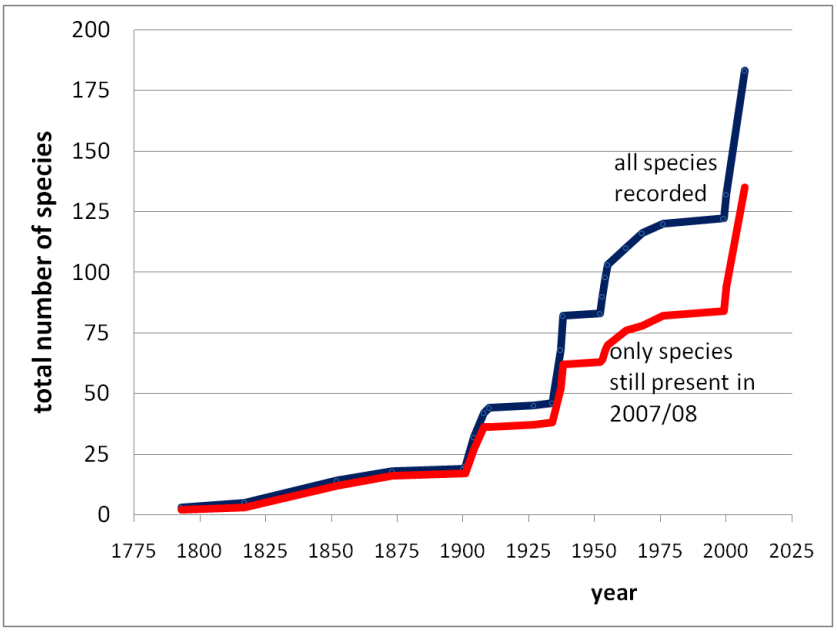

FIGURE 5. *The increase in number of alien plant species on Tristan da Cunha over time. The upper line is based on all alien plant species ever recorded for the island, while the second line only includes those species that are still present on the island now. Species of which only planted specimens were found are not included.*

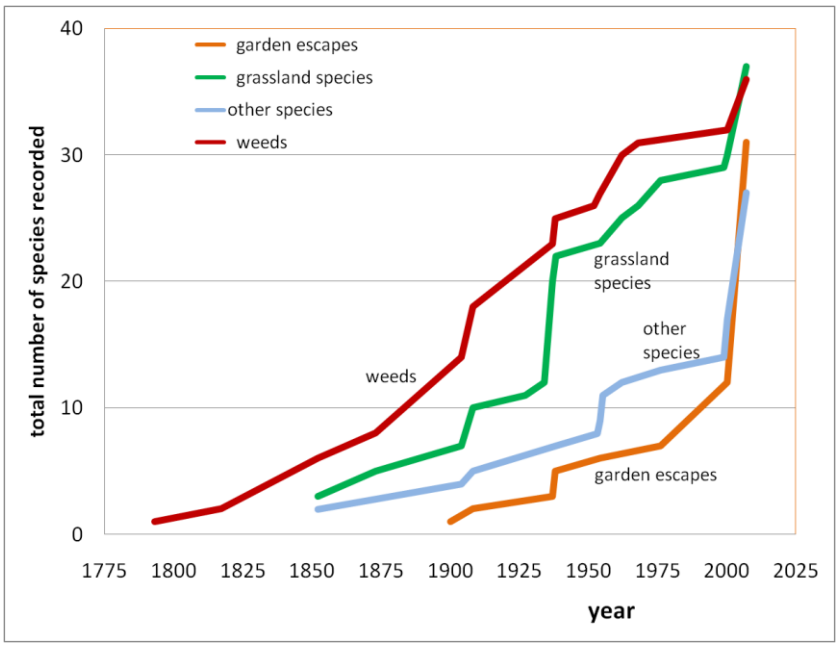

FIGURE 6. *The increase in the number of alien plant species of different ecological groups on Tristan da Cunha over time. Weeds are species most commonly found as weeds in gardens and the Patches; grassland species are grasses and other species most commonly found in grasslands; garden escapes are species imported as garden plants (ornamentals, vegetables, etc.), which have escaped; and the remainder (other species) do not fit in the first three categories, and are mostly ruderal species. Only species observed during the 2007/08 survey are included in this figure.*

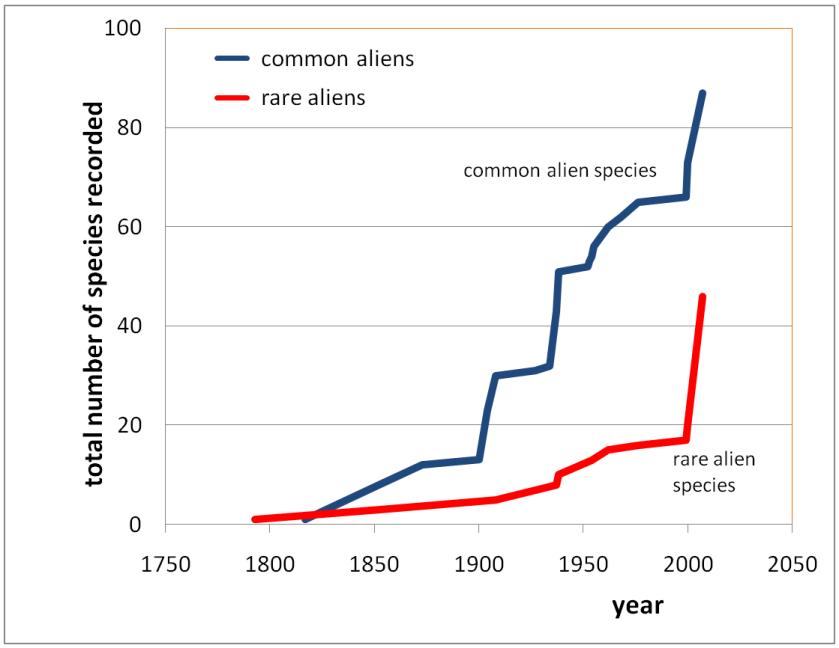

FIGURE 7. *Increase in number of alien plant species on Tristan da Cunha over time, separately for species that are at present common on the island, and species that are found at only a small number of sites.*

Figure 6 shows separately the increase in numbers of aliens that are presently common and those that are rare. This figure shows that relatively few alien species remain rare over time. In our survey we found a considerable number of rare aliens, as shown by the very steep rise of the line of rare alien species. It can be expected that a significant number of these will become widespread on the island in the course of the next decades. We have no information on the commonness or rarity of the aliens that have been found in the past and now seem to have disappeared again.

To see if certain groups of aliens increased in numbers more rapidly than others, Figure 7 shows the increase separately for species mostly found in grassland, for weed species from gardens and the Patches, for garden escapes, and for other species. The latter group consisted mostly of ruderal species, i.e. species occurring on disturbed soils with usually open vegetation. The weeds increase steadily over time, but the grassland species show a sudden increase in the 1930s. This may partly reflect the extensive collecting done by the Norwegian Expedition to Tristan da Cunha, but may also be caused by the import of grass seeds in the preceding period, in an attempt to improve the island's pastures. Our survey increased the number of species in all four groups, but especially so for the garden escapes and for the "other species".

The numbers of new alien species from different ecological groups is illustrated in Figure 8. Nearly half of the newly listed species are garden escapes, and it seems unlikely that these will ever become widespread. However, of the newly listed species several are already widespread, and there is no reason to suppose they will not continue to spread. Also some of the species with at present a very restricted distribution seem likely to become much more widespread and abundant in the coming years.

The above results show clearly that invasions by alien plant species are a continuing process. The data on the time of introduction are not precise enough for a detailed statistical analysis of the rate of introduction. Assuming a constant rate over time, which is not unreasonable looking at the graphs in Figure 5, 6 and 7, and taking into account that several of the new introductions we found have arrived quite some time ago, there is on average about 1 new successful introduction every 1.5 year. There is no reason to suppose that new species will not continue to arrive at this rate in future. Measures to stop or at least greatly reduce this influx are therefore of vital importance.

In the next section we will discuss the alien species per ecological group, based on the preferred habitat of the species, or on their growth form. In Part 2 of this report we provide accounts per species, with pictures of the plants, a short description, a summary of their distribution and impact, and suggestions for control.

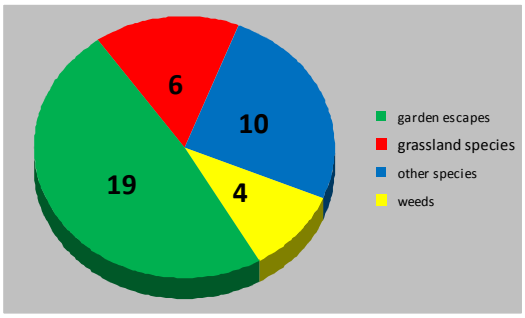

FIGURE 8. *De distribution of the in 2007/08 newly found alien plant species over the ecological plant groups. Of 40 newly recorded species, 19 were garden escapes. Many of the latter are surviving at a few sites, where often they have arrived with garden waste, and it is unlikely that these will spread much in the future. However, some of them, and especially many of the new species in the other ecological groups, can be expected to become more widespread.*

Table 1. *Introduced species found during the 2007/08 survey , including two species from sites we did not visit. * = new record (some of these we have already listed in the Tristan Fieldguide) ; p) = all planted ; n) = not seen, but site not visited.*

p)	*Acacia mearnsii*	Black Wattle
p)	*Acacia melanoxylon*	Blackwood
*	*Agapanthus praecox*	African Lily
	Agrostis castellana	Highland Bent
	Agrostis gigantea	Black Bent / Red Top
	Agrostis stolonifera	Creeping Bent
	Agrostis tenuis	Common Bent / Brown Top
	Aira caryophyllea	Silvery Hair-grass
*	*Amaranthus hybridus*	Green Amaranth
	Anagallis arvensis	Scarlet Pimpernel
	Anthoxanthum odoratum	Sweet Vernal-grass
	Avenella flexuosa	Wavy Hair Grass
*	*Barbarea verna*	American Wintercress
	Bellis perennis	Daisy
n)	*Brassica juncea*	Mustard
	Brassica rapa	Wild Turnip
	Bromus willdenowii	Rescue Grass
	Calystegia sepium	Hedge Bindweed
	Centella asiatica	Asiatic Pennywort
	Centranthus ruber	Red Valerian
	Cerastium fontanum	Common Mouse-ear
	Cerastium glomeratum	Sticky Mouse-ear
	Chenopodium album	Fat Hen
	Chenopodium murale	Nettle-leaved Goosefoot
*	*Chlorofytum comosum*	Spider Plant
	Conyza sumatrensis	Guernsey Fleabane
	Coronopus didymus	Lesser Swinecress
	Cotula australis	Australian Brass Buttons
	Crassula pellucida	Stonecrop
	Crepis capillaris	Smooth Hawksbeard
*	*Crocosmia x crocosmiiflora*	Montbretia
	Cynodon dactylon	Bermuda Grass
*	*Cynoglossum*	Hound's-tongue
	Cyperus esculentus	New Bull Grass; Nutgrass
	Cyperus longus	New Bull Grass; Galingale
	Cyperus tenellus	Tiny Flat-sedge
	Dactylis glomerata	Cocksfoot

*	*Eschscholzia californica*	Californian Poppy
p)	*Eucalyptus globulus*	Tasmanian Bluegum
p)	*Eucalyptus* large broad leaves	Eucalypt
p)	*Eucalyptus* long narrow leaves, bent	Eucalypt
p)	*Eucalyptus* small, green leaves	Eucalypt
p)	*Eucalyptus* small, reddish leaves	Eucalypt
p)	*Eucalyptus lehmannii*	Bushy Yate
p)	*Eucalyptus viminalis*	Manna Gum
	Euphorbia peplus	Petty Spurge
	Festuca arundinacea	Tall Fescue
	Festuca rubra	Red Fescue
	Ficus carica	Fig Tree
	Fumaria muralis	Scrambling Fumitory
	Gnaphalium luteo-album	Jersey Cudweed
	Gnaphalium purpureum	Purple Cudweed
*	*Hieracium ?*	?
	Holcus lanatus	Yorkshire Fog
*	*Hydrangea macrophylla*	Hydrangea
	Hypochaeris glabra	Smooth Catsear
*	*Hypochaeris radicata*	Catsear
	Juncus bufonius	Toad Rush
*	*Juncus cf. articulatus*	Jointed Rush
	Juncus effusus	Soft Rush
	Juncus tenuis	Slender Rush
*	*Leontodon autumnalis ?*	Autumn Hawkbit
*	*Leptospermum laevigatum*	Australian Myrtle; Australian Teatree
	Leucanthemum vulgare	Ox-eye Daisy
	Lobelia erinus	Lobelia
	Lolium perenne	Perennial Rye-grass
	Lotus corniculatus	Birdsfoot Trefoil
	Malus sylvestris	Apple
	Malva parviflora	Least Mallow
	Mariscus congestus	Old Bull Grass; Clustered Flat-sedge
*	*Mentha spicata*	Spear Mint
*	*Mentha x villosa*	Apple-mint
*	*Metrosideros excelsa*	New Zealand Christmas Tree; Pohutukawa

*	*Metrosideros cf. kermadecensis*	Kermadec Pohutukawa
*	*Mirabilis jalapa*	Marvel-of-Peru
	Myosotis discolor	Changing Forget-me-not
	Nasturtium officinale	Watercress
*	*Oenothera glazioviana*	Large-flowered Evening Primrose
	Oenothera indecora	Evening Primrose
*	*Oenothera rosea*	Pink Evening Primrose
	Oxalis corniculata	Yellow Oxalis
	Oxalis purpurea	Purple Woodsorrel
*	*Papaver somniferum*	Opium Poppy
	Paspalum dilatatum	Water Grass
*	*Paspalum notatum*	Bahia Grass
*	*Pelargonium* spec. *1*	Geranium
p)	*Pelargonium* spec. *2*	Geranium
	Pennisetum clandestinum	Kikuyu Grass
*	*Petroselinum crispum*	Parsley
	Phalaris tuberosa	Bulbous Canary Grass
	Phormium tenax	New Zealand Flax
	Physalis peruviana	Goldenberry
*	*Pinus pinaster*	Maritime Pine, Cluster Pine
	Pinus radiata	Monterey Pine
*	*Pittosporum crassifolium*	Karo tree
	Plantago lanceolata	Ribwort Plantain
	Plantago major	Greater Plantain
	Poa annua	Annual Meadow-grass
	Poa humilis	Spreading Meadow-grass
n)	*Poa infirma*	Early Meadow-grass
	Poa pratensis	Smooth Meadow-grass
	Poa trivialis	Rough Meadow-grass
	Polycarpon tetraphyllum	Four-leaved Allseed
	Polygonum aviculare	Knotgrass
*	*Populus x canescens*	Grey Poplar
	Prunella vulgaris	Self-heal
	Prunus domestica	Plum
p)	*Prunus persica*	Peach
*	*Raphanus raphanistrum*	Wild Radish
	Romulea rosea	Sand Crocus / Onion Grass
*	*Rosa* spec.	Rose

*	*Rubus loganobaccus*	Loganberry
	Rumex acetosella subsp. angiocarpus	Sheep's Sorrel
	Rumex crispus	Curled Dock
	Rumex obtusifolius	Broad-leaved Dock
	Rumex steudelii	Dock
	Sagina apetala	Annual Pearlwort
	Sagina procumbens	Procumbent Pearlwort
p)	*Salix babylonica*	Weeping Willow
*	*Salix caprea*	Goat Willow
	Saponaria officinalis	Soapwort
*	*Senecio pterophorus*	Shoddy Ragwort; African Daisy
	Senecio vulgaris	Groundsel
	Solanum nigrum	Black Nightshade
*	*Solanum tuberosum*	Potato
	Sonchus asper	Prickly Sow-thistle
	Sonchus oleraceus	Smooth Sow-thistle
	Sporobolus africanus	Ratstail Grass
*	*Stachys arvensis*	Field Woundwort
	Stellaria media	Common Chickweed
	Taraxacum officinale	Dandelion
*	*Tradescantia fluminensis*	Wandering-jew
*	*Trifolium cernuum*	Nodding Clover
	Trifolium dubium	Lesser Trefoil
*	*Trifolium fragiferum*	Strawberry Clover
*	*Trifolium glomeratum*	Clustered Clover
	Trifolium micranthum	Slender Trefoil
	Trifolium repens	White Clover
	Trifolium subterraneum	Burrowing Clover
*	*Tropaeolum majus*	Nasturtium
	Urtica dioca	Common Nettle
	Vellereophyton dealbatum	White Cudweed
	Verbascum virgatum	Twiggy Mullein
	Verbena officinalis	Vervain
	Veronica agrestis	Green Field Speedwell
	Veronica serpyllifolia	Thyme-leaved Speedwell
*	*Viola tricolor*	Wild Pansy
p)	*Vitis vinifera*	Grape-vine
	Vulpia bromoides	Squirrel-tail Fescue
*	*Watsonia* spec.	Bugle Lily
	Zantedeschia aethiopica	Arum Lily; Calla Lily

TABLE 2. *Aliens plant species previously listed for Tristan (data mainly from Groves 1981), but not found during the present survey. Conyza bonariensis has also been listed for the island (Wace 1967), but Groves suggests this actually is C. sumatrensis.*

scientific name	common name	first record	previous localities etc.
species not found in 2007/08, but the original localities were not visited, so they may well still be there			
Brassica juncea (L.) Czern.	Mustard	1938	Anchorstock Bay in pasture
Poa infirma Kunth	Early Meadow-grass	1938	a single collection in 1938, Hottentot Gulch, 1000 m asl
species not found in 2007/07, despite a careful search of the original localities; presumably these species have disappeared			
Anthemis cotula L.	Stinking Chamomile	1904	weed of cultivation near Settlement
Cynosurus cristatus L.	Crested Dog's-tail	1953	probably imported in mixed pasture seed
Cyperus longus L.	New Bull Grass; Galingale	1968	stream bank by Big Watron
Digitaria sanguinalis (L.) Scop.	Hairy Finger-grass	1953	near Settlement; with *Echinochloa crus-galli*
Echinochloa crus-galli var. *breviseta* (Doell) Neilr.	Cockspur Grass	1953	near Settlement; with *Digitaria sanginalis*
Eleusine indica subsp. *africana* (O'Byrne) Phillips	Goosegrass	1962	bare ground at the Settlement
Galium aparine L.	Common Cleavers	1937	weed in garden at the Settlement
Geranium dissectum L.	Cut-leaved Cranesbill	1937	weed outside Settlement gardens and in pastures at the Patches
Hordeum glaucum Steudel	Wall Barley	1953	probably introduced with animal fodder from the Cape
Hordeum leporinum Link	Hare Barley	1968	beside the bull pen in an old fenced garden W of Big Watron
Lactuca serriola L.	Prickly Lettuce	1793	not found since then
Leonotis leonurus (L.) R.Br.	Dwarf Lion's Tail	1938	a single specimen near the Settlement; probably a garden escape
Leontodon taraxacoides (Vill.)Mérat	Lesser Hawkbit	1955	not collected since then
Lithospermum spec.	Gromwell	1937	a single collection
Lolium multiflorum Lam.	Italian Rye-grass	1953	introduction in imported seed mixture
Lolium rigidum Gaudin	Annual Rye-grass	1968	levelled and seeded playing field NE of the Settlement; with *Trifolium subterraneum*
Lolium x *hybridum* Hausskn.	Short Rotation Rye-grass	1953	introduction in imported seed mixture
Medicago polymorpha L.	Toothed Medick	1954	near Mission Garden
Medicago sativa L.	Lucerne	1954	Sandy Point

Myosotis collina	Forget-me-not	1937	near the Settlement and at Patches
Polypogon monspeliensis (L.) Desf.	Annual Beard-grass	1908	in 1968 Wace found it east and west of Pigbite at the margin of swamps, and on the eastern edge of the new lava growing amongst beach sand and pebbles
Ranunculus repens	Creeping Buttercup	1938	weed near a garden and in Patches
Rosa rubiginosa	Sweet Briar	1937	in a gorge on the road to the Patches
Rosa spinosissima	Scotch Rose	1904	no precise locality given
Rubus saxatilis L.	Stone Bramble	1901	first mentioned by Mrs Barrow (1910); collected on Hillpiece in 1937
Rumex crispus L.	Curled Dock	1817	apparently not collected since
Rumex steudelii Hochst.	Dock	1938	grass field at Settlement
Scleranthus annuus L.	Annual Knawel	1954	Settlement: in mission grounds
Silene alba (Mill.) Krause	White Campion	1955	weed in the Settlement
Silene gallica L.	Common Catchfly	1954	weed in mission garden at the Settlement
Spergula arvensis L.	Corn Spurrey	1955	weed in the Settlement
Trifolium pratense L.	Red Clover	1937	first noted in pasture in 1937; collected in 1953-54
Ulex europaeus L.	Gorse	1910	a few bushes near the houses; first noted in 1910; collected in 1937. (these were possibly all planted and in that case should not be listed as aliens)
presumably erroneous records			
Conyza bonariensis (L.) Cronquist	Argentine Fleabane	-	Groves (1981) states that all specimens he has seen are *C. sumatrensis*, suggesting that *C. bonariensis* is a misidentification
Ranunculus acris L.	Meadow Buttercup	-	Listed by Wace & Dickson (1965), but no material has been found to substantiate this record (Groves (1981)

Alien trees and shrubs

No large species of native trees occur on Tristan da Cunha, but one indigenous species of large shrub is present: the Island Tree (*Phylica arborea*), which occurs widely on all islands of the group, and is endemic to the islands. Trees and shrubs were imported to the island, either as a source of wood, or as garden ornamentals. In table 3 we have listed the introduced tree and shrub species occurring on Tristan, with some notes on their mode of dispersal and their impact on the native ecosystems.

Several species of pine trees were introduced in 1937 (Groves 1981), including Canary Island Pine (*Pinus canariensis*), Aleppo Pine (*P. halepensis*), Monterey Pine (*P. insignis = P. radiata)* and Cluster Pine (*P. pinaster*). Of these only the Cluster Pine and the Monterey pine appear to have survived, with the Monterey Pine being the most successful.

In the 1950s fruit trees were planted at Sandy Point, on the most sheltered side of the island. These included apples (*Malus sylvestris*), plums (*Prunus domestica*) and peach-trees (*Prunus persica*). In the same period pine trees, eucalypts, wattles, poplars and willows were planted (Wace & Holdgate 1976). The plantation at Sandy Point included Monterey pines (*Pinus radiata*) and various eucalypt species (e.g. the Manna Gum, *Eucalyptus viminalis*). This plantation has developed into a dense forest. The *Eucalyptus* trees do not seem to have spread much, and only a few young trees were seen. The pines however, are spreading widely, and occurring up to an altitude of at least 250 m. There is no reason to believe they have yet reached their altitudinal limit.

Pines were also planted near the village, some (Cluster Pine and Monterey Pine) in a damp little valley between the Settlement and the new volcano, while a single large Cluster Pine grows at the old Mission garden. At Stony Hill a large Cluster Pine grows along a gulch at the bottom of the escarpment. At least three young trees occur nearby. Also at the Settlement some young Cluster Pines were found, so this species, although not spreading as rapidly as the Monterey Pines at Sandy Point, is also naturalized on Tristan.

Australian Myrtle (*Leptospermum laevigatum*)

Monterey Pine (*Pinus radiata*)

Several other species of trees and shrubs have been planted near the Settlement, e.g. along the edge of the pasture below the village along the coast, and on the old coastal road through the new volcano. These include several eucalypt and *Acacia* species (Black Wattle, *Acacia mearnsii*, and Blackwood, *Acacia melanoxylon*). None of these is spreading. Another shrub, Australian Myrtle or Australian Tea tree, *Leptospermum laevigatum*, appears to have been planted in the Settlement, and also on the old coastal road through the volcano. On this road Australian Myrtle now forms a big, dense patch of many small plants (about 50 cm high) with a few clearly older and much larger shrubs. Near the Settlement a young Australian Myrtle plant was found. It is impossible to predict with any confidence how the Australian Myrtle distribution and abundance on the island will be in future, but it is quite possible that in the long run this species will disperse into other areas and other habitats.

Several species of fruit trees have been listed as introduced species on the islands. We did find apple trees (*Malus sylvestris*) at a number of sites around the island, as well as plum trees (*Prunus domestica*) and peaches (*Prunus persica*). All apple and peach trees we saw were planted, we think. Only some young plum trees were found at Sandy Point that were clearly not planted but had come up from seed. Fig trees (*Ficus carica*) are planted in several gardens in the Settlement, flowering and fruiting profusely, although it is not clear if the fruits are becoming completely ripe. A few fig trees occur in the new volcano, possibly arrived with garden refuse. They are small, kept down by grazing by cattle, and no seedlings have been seen.

Two species of willow occur on the island: Weeping Willow (*Salix babylonica*) and Goat Willow (*Salix caprea*). Both have been planted in the wet valley between the Settlement and the new volcano along the Big Watron river. We assume that the willow copse at Under the Waterfall also has been planted. It consists of Goat Willow. In a narrow gulch just south of Sandy Point a small, dense copse of Goat Willow and Grey Poplar (*Populus x canescens*) occurs. The poplars spread into the surrounding area by shoots coming up from roots of the older trees. A few small Poplar trees were also found in the forest at Sandy Point, north of the present hut. Here also a copse of willows occurs. This was already mentioned in the diary of Munch (1937 Norwegian Expedition) as a source of wood for boat construction.

Several large New Zealand Christmas Trees (*Metrosideros excelsa*) occur in the Settlement. From there this species has spread to the new volcano, where it occurs in great numbers. Some isolated trees were found on the slopes inland of the Pigbite area. *Metrosideros* flowers profusely on the island, and produces large numbers of light seeds, which are dispersed by wind. This may be the reason why no New Zealand Christmas Trees were found to the west of the village, but only to the east. Until now this species seems to be restricted to the open, dry, stony habitats of the new volcano and of the Pigbite slopes. But, once the presently young trees in the lava area mature, enormous numbers of seeds will be produced and dispersed into the surrounding areas. This will make it quite likely that these trees will also invade other habitats and more or less undisturbed native vegetation. At one site, in a narrow valley in the new volcano near the old coastal road a single plant of another species of *Metrosideros* was found. It keys out as *M. kermadecensis*. This tree grows in a place where it is unlikely that it was planted, and it is not clear how it arrived on the island.

The two species of Rose previously recorded for the island (Sweet Briar, *Rosa rubiginosa* L. and Burnet Rose, *Rosa pimpinellifolia* L.) were not found during our survey. A Rose species with small, double flowers occurs locally outside gardens, at a few places in the new volcano area, as well as in the settlement. They have presumably been dispersed with garden waste, and spread vegetatively once

they have arrived at a site. This species does not seem to produce fruit. Other, cultivated roses with large flowers are planted in many gardens in the Settlement, but were not found elsewhere.

The Gorse listed for Tristan was not found. In one garden a single shrub of a species of probably *Cytisus* was found, which locally is called Gorse, but this is not the species (*Ulex europaeus*) that was recorded in earlier reports. Although seed was formed, no juvenile plants were observed, and we did not include it in the list of aliens.

Impact of alien trees and shrubs

The impact of the trees is potentially large, as especially the large trees represent a growth form not found in the native species on the island. As most alien tree and shrub species are very restricted in their distribution, their impact on the island as a whole is quite small (see Table 3), even though they completely transform the vegetation at the sites where they occur. A few species, however, are more abundant, and are spreading relatively fast. These are the Monterey Pine, *Pinus radiata*, and the New Zealand Christmas Tree, *Metrosideros excelsa*.

Monterey Pines form an extensive forest in the Sandy Point area, spreading by seed away from the area where they were originally planted, steadily extending the forested area. Although at present hardly any use is made of the wood of these trees, potentially they are a useful resource for timber for building and for fence poles on the island. At this moment all wood for these purposes is imported from South Africa. A practical problem is that any wood harvested from the Sandy Point forest has to be transported by barge from Sandy Point to the Settlement, or to wherever it is going to be used.

The number of native species in these dense pine forests seems to be smaller than in non-forested areas, but more quantitative data need to be collected on this subject. Conversion of native vegetation to forest reduces the availability of nesting areas for birds. In addition it will drastically change the quality of plant litter in the soil, as well as the microclimate at soil level, which is expected to have a large impact on invertebrate species.

The New Zealand Christmas Tree, *Metrosideros excelsa*, is abundant in the area covered by lava from the 1961 eruption. A few trees were found outside this area, but several of these possibly have been planted. Thus this species has a considerable impact on the new lava areas, but given that most of the areas where it is found have hardly any native vegetation yet (except for some mosses, ferns and lichens), it is not clear how to judge this impact at present. Obviously, in the long run, instead of the expected vegetation of mosses, lichens, ferns, grasslike plants, and Island Berry (*Empetrum rubrum*) we now can expect a dense forest of New Zealand Christmas Trees to develop. At this moment we do not think that *Metrosideros* is spreading much outside the 1961 lava area. However, once large numbers of trees start producing seed in this area, this species may well start spreading rapidly into other areas, becoming a serious threat to native biodiversity.

Loganberry (*Rubus loganobaccus*) occurs at the Settlement, both in and locally outside gardens, but is most abundant at Sandy Point. Here over a large area the ground-layer of the forest, as well as some slopes outside the forest, is completely overgrown by Loganberry. Apart from transforming the structure of the vegetation it is not clear what the impact is on the botanical biodiversity of the invaded areas. But invasion by Loganberry has displaced several albatrosses from their nesting sites.

Australian Myrtle or Australian Tea tree (*Leptospermum laevigatum*) forms a big, dense patch of many small plants (about 50 cm high) with a few clearly older and much larger shrub on the old coastal road through the 1961 lava area, with some plants at other sites. In dense Australian Myrtle stands few native species occur. Australian Myrtle is clearly spreading, and it is quite possible that in the long run this species will disperse into other areas and other habitats. In Australia this is a coastal species, but it is not known how far from the coast it can grow on Tristan.

The other trees and shrubs have little impact at present, but in future this may change. For instance it seems likely that in the long run the Cluster Pine (*Pinus pinaster*) can spread over large areas, and have a similar impact as Monterey Pine. Its present low rate of increase is presumably related to the presently small number of seed-producing mature trees of this species on the island.

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New Zealand Christmas Tree (*Metrosideros excelsa*) colonizing the 1961 lava area.

TABLE 3. *List of tree and shrub species found on Tristan da Cunha. Only species found outside gardens are listed. Species with 'not found' under the Dispersal heading have been recorded previously, but were not found by us. Some species not classified as aliens (i.e. non-native plants occurring outside cultivation) are included in this table. See the species accounts in Part 2 of this report for more details per species.*

Latin species name	**Common name**	**Dispersal**	**Impact**	**First recorded**
Acacia mearnsii	Black Wattle	Planted, not spreading	Impact negligible (very few plants)	2007
Acacia melanoxylon	Blackwood	Planted, not spreading	Impact negligible (very few plants)	2007
Eucalyptus globulus	Tasmanian Bluegum	Originally planted. Possibly spreading by seed.	Impact negligible (only a few trees)	2007
Eucalyptus I (long narrow, curved leaves)		Planted, not spreading	Impact negligible (very few plants)	2007
Eucalyptus II (small, green leaves)		Planted, not spreading	Impact negligible (very few plants)	2007
Eucalyptus III (small, reddish leaves and branches)		Planted, not spreading	Impact negligible (very few plants)	2007
Eucalyptus lehmannii	Bushy Yate	Planted, not spreading	Impact negligible (very few plants)	2007
Eucalyptus viminalis.	Manna Gum	Originally planted, some young trees. Possibly spreading by seed.	Impact small. Where it was planted the trees are forming a dense forest, but the area covered is quite small, and the species does not seem to spread outside the forested area.	1971
Ficus carica	Fig Tree	Planted, not spreading	Impact negligible (very few plants)	1938
Hydrangea macrophylla	Hydrangea	Planted, or dispersed with garden waste; not spreading	Impact negligible (very few plants)	2007

Latin species name	Common name	Dispersal	Impact	First recorded
Leptospermum laevigatum	Australian Myrtle; Australian Teatree	Spreading by seed.	Impact presently quite small. On the old coastal road it forms extensive, dense shrub vegetation. Given that this road is presently completely overgrown by alien plants, it is not clear if any native vegetation is being replaced. Outside this area, and outside the Settlement very few plants were found. However, over the years this species may well spread further and invade other habitats.	2007
Malus sylvestris subsp. *mitis*	Apple	Planted, not spreading	Impact negligible (very few plants)	1937
Metrosideros excelsa	New Zealand Christmas Tree	Spreading widely by seed	Impact moderate. Abundant in the new lava areas, but given that most of the areas where it is found have hardly any native vegetation yet (except for some mosses, ferns and lichens) it has at present no great impact on the local biodiversity. It may, however, in future spread much wider, and invade native vegetation all over the island, and become a serious problem.	2007
Metrosideros cf. *kermadecensis*		Only one plant	Impact negligible (only one plant found)	2007
Pinus pinaster	Maritime Pine, Cluster Pine	Originally planted; some young trees. Spreading by seed.	Impact negligible (only a few trees). May increase in future.	2007 (1937)
Pinus radiata	Monterey Pine	Spreading widely. Spreading by seed.	Impact considerable. Forming quite extensive, dense forests in the Sandy Point area, replacing the original communities. Spreading away from the planted areas. Reducing available nesting area for albatrosses and possibly other bird species.	2007 (1937)
Pittosporum crassifolium	Karo tree	Planted; locally some seedlings and young trees; spreading by seed.	Impact negligible (very few plants outside gardens)	2007

Latin species name	Common name	Dispersal	Impact	First recorded
Populus x *canescens*	Grey Poplar	Presumably planted, some young trees; spreading vegetatively.	Impact small. Where it occurs it changes the original native vegetation into a poplar copse, thus having locally a large impact, but the area affected is negligible.	2007
Prunus domestica	Plum	Originally planted, some young trees. Spreading by seed.	Impact small. In the orchard this species completely changes the structure of the original vegetation, but outside the orchard only a few small trees were found, hardly affecting the local vegetation.	1937
Prunus persica	Peach	Planted, not spreading	Impact negligible (few plants)	1937
Rosa spec.	Rose	Originally planted, spreading vegetatively	Impact small; forms dense stands where it occurs, but covers a negligible area.	2007
Rubus loganobaccus	Loganberry	Spreading locally. Spreading vegetatively, and rarely, if at all, by seed.	Impact moderate, potentially large. Displacing native plant communities, and reducing potential nesting area for albatrosses and possibly other birds.	2007 (1968)
Salix babylonica	Weeping Willow	Planted; not spreading	Impact negligible (few plants)	1937 (1910)
Salix caprea	Goat Willow	Planted, spreading vegetatively, very slowly	Impact small. Three small copses of this tree were found; where it occurs it changes the original native vegetation into a willow copse, thus having locally a large impact, but the area affected is negligible.	2007 (1937)
Unidentified tree		Planted; not spreading	Impact negligible (few plants)	2007
Vitis vinifera	Grape-vine	Planted; not spreading	Impact small. Where it occurs it outcompetes the native vegetation, but the area affected is negligible.	2007

Suggested control measures for alien trees and shrubs

Figure 9 shows the impact and feasibility of control. Combining these two characteristics we can work out which species should have the highest priority in an alien plant species control programme. Obviously one would like to control the species with high impacts, but for many of the high-impact species control is impossible, or at least costs are prohibitive. Thus species with a high impact or a high potential impact, for which control (preferably eradication) is feasible, are the best candidates to start a control program.

We suggest the following actions:

Remove Monterey Pines (*Pinus radiata*) outside the Sandy Point forest area, and also prevent the spread of trees towards the higher reaches of the island, by cutting the trees up there before they start to produce seed. Alternatively one could kill the trees by ringbarking them.

Remove those trees outside the settlement or other planted areas that are producing seed, and thus can spread into new areas. The most important of these is the Cluster Pine (*Pinus pinaster*). A few young trees of this species occur in the new volcano; Some *Eucalyptus* and *Acacia* species also flower and produce seed in gardens and other areas near the settlement. *Metrosideros* cf *kermadecensis*, of which we found only a single tree, can also be removed. Some of these species are planted in gardens, and completely removing them may not be acceptable. As all of these species take quite a long time to mature and become reproductive, one needs only to check for new plants once every 5 – 10 years, and then remove them all.

A species that potentially can have a very large negative impact on biodiversity is the New Zealand Christmas Tree (*Metrosideros excelsa*; see above). It would be important to develop a control program for this species, before the numerous trees in the new lava area start to produce seed.

Most of the above are not very urgent or will not make a big difference in the short run for the integrity of the island's ecosystems. But in the long run they will be imperative, as invasion by trees does completely change the nature of the plant communities in the invaded areas, strongly reducing the local biodiversity of native species. And the longer control measures are postponed, the more work will have to be done to get these species under control.

More urgent is the eradication of Loganberry (*Rubus loganobaccus*), as this species strongly affects the invaded areas, not only changing the vegetation completely, but also making these areas unsuitable as a nesting ground for albatrosses. An eradication program for this species at Sandy Point is presently underway and we suggest to continue the eradication of the Loganberry in all areas outside the Settlement.

Grey Poplars (*Populus x canescens*) occur at a few sites on the island. They seem to spread mostly vegetatively, increasing their area by root-suckers. Once the trees are older, seed production may take place, and poplars may spread to other areas. As this species does not seem to have any use, it may as well be removed.

In one garden in the Settlement we saw a birch tree (*Betula* spec.). The tree was cut off not far above the ground, because of storm damage, and regrowing vigorously from this stump. As it only occurred in a garden, and did not disperse, it was not included in our alien species list. It is not known if it did produce seed before it was damaged. It would be advisable to check for seedlings. We see no reason

why birches could not grow very well on Tristan, both in the lowlands and up on the base. Given their wind-dispersed seeds, they could spread very rapidly, once seeds are starting to be produced. To avoid this risk, it would be best to remove this birch tree, if the owner consents.

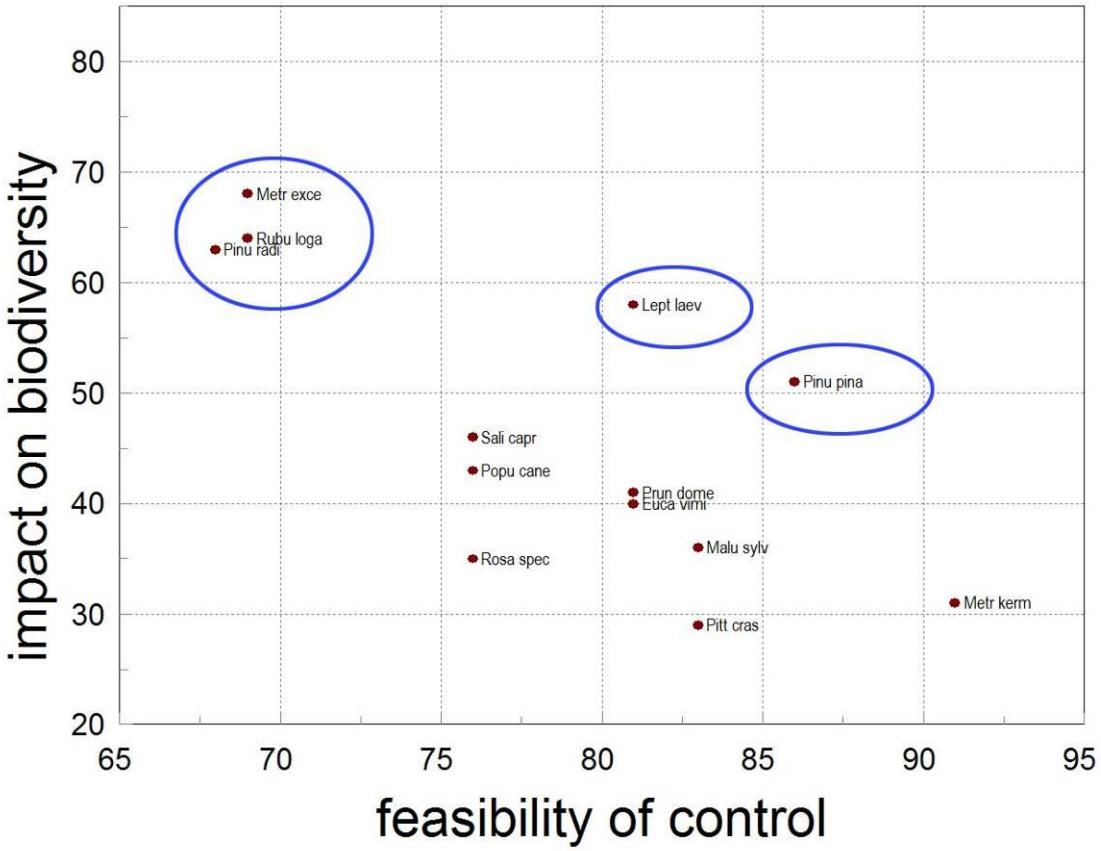

FIGURE 9. *Ranking of alien tree and shrub species with respect to impact on biodiversity and feasibility of control. High numbers indicate strong impacts and easy control, respectively. The species marked with blue are prime candidates for control measures. Species names are abbreviated to the first four letters of the Latin genus and species name, e.g. Pinu pina = Pinus pinaster, Cluster Pine.*

Weeds of gardens and arable land (Potato Patches)

The Potato Patches are used mainly to grow potatoes. Only few other crops are grown, and these in small quantities only. This allows limited possibilities for crop rotation. Pumpkins or squashes are planted in small planting areas dug clear of weeds in patches where otherwise weeds have not been removed. The advantage of this is that the soil is covered by vegetation, stabilizing soil water content, and adding organic matter to the soil, thus improving soil water retention capacity, soil structure and fertility. A drawback is that large numbers of weed seeds are produced, building up large seedbanks in the soil, not only in the plot itself, but also in the surrounding patches.

All weeds in arable land on Tristan are introduced. Hardly any of the native plant species have a significant negative impact on the effort needed for cultivation in gardens and the Potato Patches, and on the yield of the crops. Only in patches that have not been tilled for two seasons or more some native species occur (e.g. the Small Fern, *Blechnum penna-marina* and the indigenous dock, *Rumex frutescens*). Over 80 alien plant species were found in the Patches or in gardens in the Settlement. Of these 36 are either restricted to or most abundant in gardens and Potato Patches (Table 4). These species are treated in this chapter.

About ten weed species regularly cover more than 50% of the area in some patches (e.g. Petty Spurge (*Euphorbia peplus*), Prickly Sow-thistle (*Sonchus asper*), Smooth Sow-thistle (*Sonchus oleraceus*), Smooth Hawksbeard (*Crepis capillaris*), Scrambling Fumitory (*Fumaria muralis*), Green Field Speedwell (*Veronica agrestis*), Groundsel (*Senecio vulgaris*), and Nutgrass (*Cyperus esculentus*)). Patches that are not intensively cultivated for a year or more are completely covered in dense growth of alien grass species (e.g. Yorkshire Fog (*Holcus lanatus*), Water Grass (*Paspalum dilatatum*) and annual and perennial weeds (Broad-leaved Dock (*Rumex obtusifolius*), Smooth Hawksbeard (*Crepis capillaris*), and Hedge Bindweed (*Calystegium sepium*)).

Some weed species are widely distributed in the Patches, while others, although sometimes reaching very high numbers in some plots have a much more localized distribution. This seems to be related to the dispersal mechanism of the seeds (Table 5 and 6). Species with wind as the main factor for seed dispersal, like Prickly Sow-thistle (*Sonchus asper*), Smooth Sow-thistle (*Sonchus oleraceus*), Smooth Hawksbeard (*Crepis capillaris*), and Groundsel (*Senecio vulgaris*), occur in many of the patches, and are not restricted to specific patches-complexes. Other species, however, were mainly found in patches that were close together. These species, e.g. Hedge Bindweed (*Calystegium sepium*), Green Field Speedwell (*Veronica agrestis*), Lesser Swinecress (*Coronopus didymus*), and Field Woundwort (*Stachys arvensis*), have larger seeds, not adapted to wind dispersal, and are therefore spread less rapidly over large distances. The stone walls separating the individual plots in the Patches will to some extent also hinder seed dispersal for these species. In the case of Hedge Bindweed, dispersal appears to be mainly, if not completely, by vegetative means and not by seed. Species not dispersed by wind will spread much slower than the wind-dispersed species from one field into the next one, sometimes by animals, possibly also with soil attached to garden implements, to boots, or attached to seed potatoes.

Of the species with a relatively wide distribution on the island most have light seeds, and/or are adapted to wind distribution. A few species with large seeds, however, are also widely distributed. Examples are Broad-leaved Dock (*Rumex obtusifolius*), and Water Grass (*Paspalum dilatatum*). The Broad-leaved Dock has seeds which easily stick in animal fur, and can be dispersed this way over relatively long distances. The Water Grass may have been intentionally dispersed to areas away from the settlement plain, in an attempt to improve the pastures.

Four species show a very restricted distribution, and are considered to be very recent introductions. Amaranth (*Amaranthus* cf. *hybridus*) has never been recorded before. It was found at two sites at the settlement, one of these next to a chicken run. At the same site we found Fat Hen (*Chenopodium album*), and it seems likely that both species have been introduced recently with chicken feed. Fat Hen was found before in 1793, but has not been recorded since. The same is the case for Nettle-leaved Goosefoot (*Chenopodium murale*). These three species are serious weeds in other parts of the world, and all effort should be made to prevent them reaching the Patches. The best way to do this is to eradicate them completely. The fourth species with a very restricted distribution is the Common Nettle (*Urtica dioca*), which was found in a single garden in the Settlement. This species has male and female flowers on separate plants, and probably only a single gender occurs presently on Tristan. The species, however, can spread vegetatively, forming large dense patches, and may be spread to new sites with garden waste or with soil. It is advisable to eradicate this species before it spreads any further.

Petty Spurge (*Euphorbia peplus*), a dominant weed in many Patches.

TABLE 4. *List of weeds in gardens and Potato Patches on Tristan da Cunha, their dispersal, and their impact on agriculture. For more details per species, see the species accounts in Part 2 of this report.*

		distribution on Tristan	dispersal	impact
Agrostis gigantea	Black Bent / Red Top	Found in a garden and in grassland near the Settlement and at Cave Point; but possibly overlooked elsewhere.	spreading vegetatively and by seed	negligible, but maybe underestimated
Amaranthus cf. *hybridus*	Green Amaranth	Found in a vegetable plot near the Settlement, and next to the chicken coop in the garden of the Administrator's residence.	spreading by seed	presently negligible, but may become a serious problem; recent introduction
Anagallis arvensis	Scarlet Pimpernel	A frequent species in the Settlement, at the Patches and in the 1961 lava area. Locally reaching high cover in arable land.	spreading by seed	locally a bad weed in the Patches
Bromus willdenowii	Rescue Grass	Locally abundant in gardens and arable land in the Settlement and at the Patches, locally reaching very high cover values. Also a few plants in the 1961 lava area.	spreading vegetatively and by seed	locally a nuisance in gardens and the Patches
Calystegia sepium	Hedge Bindweed	In large numbers at a few sites in Tristan: locally in the Patches, at Sandy Point and at Stony Hill. At all sites associated with human activity (agriculture, and tree planting). Locally dominant.	presumably spreading mainly vegetatively	locally a very bad weed, causing serious reduction of crop yield, and requiring much work for control
Chenopodium album	Fat Hen	Found in two gardens at the Settlement. At one site it seems to have sprung up from chicken feed.	spreading by seed	presently negligible, but is likely to become a serious problem; recent introduction
Chenopodium murale	Nettle-leaved Goosefoot	Found on disturbed ground in a single garden in the Settlement.	spreading by seed	presently negligible, but is likely to become a serious problem; recent introduction
Conyza sumatrensis	Guernsey Fleabane	Commonly found in all habitats all around the island.	spreading by seed	a nuisance in gardens and the Patches
Coronopus didymus	Lesser Swinecress	Common in gardens and at the Patches, locally reaching very high cover values; also found on open ground in other habitats in the settlement plain.	spreading by seed	locally a bad weed in the Patches

		distribution on Tristan	dispersal	impact
Crepis capillaris	Smooth Hawksbeard	Abundant in arable land and in pastures and other habitats in the settlement plain; much less common at Cave Point and Sandy Point. Often reaching high cover values in the Patches.	spreading by seed	a bad weed in the Patches
Cynoglossum spec.	Hound's-tongue	Several plants, with seeds, in the hospital garden.	spreading by seed	presently negligible, may increase in future
Cyperus esculentus	New Bull Grass; Nutgrass	Abundant and locally reaching high cover values in arable land and gardens; rarely found in other habitats.	spreading mainly vegetatively, but presumably also by seed	a very bad weed, causing serious reduction of crop yield, and requiring much work for control
Cyperus tenellus	Tiny Flat-sedge	Frequently found on open ground in many different habitats in the lowlands all around the island.	spreading by seed	little impact
Dactylis glomerata	Cocksfoot	Found in the settlement and in the Patches. Generally growing in small clumps, but sometimes dense stands of several m^2.	spreading very slowly, presumably by seed, but also vegetatively	little impact; locally dominant, but very localized
Euphorbia peplus	Petty Spurge	Abundant in the Settlement and at the Patches, where is may reach very high cover. Less frequent in other habitats in the settlement plain.	spreading by seed	a very bad weed, causing serious reduction of crop yield, and requiring much work for control
Fumaria muralis	Scrambling Fumitory	Found locally in gardens at the Settlement and in the Patches. In the Patches it is locally very abundant, forming large plants and reaching high cover.	spreading by seed	locally a bad weed in the Patches, resulting in reduced crop yield and requiring much effort to control
Gnaphalium luteo-album	Jersey Cudweed	Found commonly on open ground in all habitats all around the island.	spreading by seed	a nuisance in the Patches, low impact elsewhere
Gnaphalium purpureum	Purple Cudweed	Found commonly on open ground in all habitats all around the island.	spreading by seed	a weed in the Patches, low impact elsewhere

		distribution on Tristan	dispersal	Impact
Juncus tenuis	Slender Rush	Widely spread all over the island, and in all habitats.	spreading by seed	little impact
Mariscus congestus	Old Bull Grass; Clustered Flat-sedge	Frequently found in all habitats all around the island. In the Patches it reaches high cover values locally.	spreading by seed	locally a bad weed in the Patches; little impact elsewhere
Myosotis discolor	Changing Forget-me-not	Found mainly in open ground at the Patches, and elsewhere in the settlement plain.	spreading by seed	little impact
Oxalis corniculata	Yellow Oxalis	Widely distributed in the settlement plain, mostly in somewhat disturbed habitats, as well as in gardens and the Patches.	spreading by seed	little impact
Plantago lanceolata	Ribwort Plantain	Abundant in all lowland areas, and on the Base. This species occurs in all habitats, locally reaching high cover values.	spreading by seed	locally a serious nuisance in the Patches, as well as elsewhere
Poa annua	Annual Meadow-grass	Common in a wide range of habitats all around the island; locally reaching high cover values in gardens and at the Patches, as well as in pasture areas.	spreading by seed	a nuisance in the Patches; moderate impact in some other habitats
Polycarpon tetraphyllum	Four-leaved Allseed	Common in open ground in the settlement plain.	spreading by seed	locally a bad weed in the Patches, reducing crop yield and requiring much effort for control
Polygonum aviculare	Knotgrass	Only at a few sites, growing in small numbers on open ground in ruderal places	spreading by seed	impact insignificant
Rumex acetosella subsp. angiocarpus	Sheep's Sorrel	Common in many habitats all over the island.	spreading vegetatively and by seed	locally a bad weed in the Patches, reducing crop yield and requiring much effort for control; high impact in high altitude areas
Rumex obtusifolius	Broad-leaved Dock	Common in all habitats all over the island; locally reaching high cover values.	spreading by seed	a bad weed in the Patches, reducing crop yield and requiring much effort for control; locally moderate impact on native vegetation

		distribution on Tristan	dispersal	impact
Senecio vulgaris	Groundsel	Widespread in the settlement plain, mostly on open ground. Abundant in many of the Patches.	spreading by seed	locally a bad weed in the Patches, reducing crop yield and requiring much effort for control
Solanum nigrum	Black Nightshade	Frequently found in gardens and on open ground in and around the Settlement; also in the 1961 lava area, in the Pigbite area, and at the Patches.	spreading by seed	a nuisance locally in the Patches, low impact elsewhere
Sonchus asper	Prickly Sow-thistle	Widely dispersed all around the island. Most abundant in the Patches and in disturbed ground.	spreading by seed	a bad weed in the Patches, reducing crop yield and requiring much effort for control
Sonchus oleraceus	Smooth Sow-thistle	Widely dispersed around the island. Most abundant in the Patches and in disturbed ground.	spreading by seed	a bad weed in the Patches, reducing crop yield and requiring much effort for control
Stachys arvensis	Field Woundwort	Locally abundant in some of the Patches.	spreading by seed	locally a serious nuisance in the Patches
Stellaria media	Common Chickweed	Only a few plants were found, in the Settlement and the old Mission garden.	spreading by seed	impact insignificant
Urtica dioca	Common Nettle	One small patch in a garden in the Settlement	spreading vegetatively	locally a nuisance, but presently only at a single site
Veronica agrestis	Green Field Speedwell	Abundant in part of the Patches, locally reaching high cover values. Also found in the garden of the Administrator's residence.	spreading by seed	locally a bad weed in the Patches, reducing crop yield and requiring much effort for control
Veronica serpyllifolia	Thyme-leaved Speedwell	Common in all habitats all around the island.	spreading by seed	a nuisance in the Patches, low impact elsewhere

TABLE 5. *Characteristics of weeds with a restricted distribution. "–" for vegetative spread means usually not spreading vegetatively; "-" for presence or abundance means the species was not found here. Agrostis gigantea is not included in this table, as we think the distribution of this species has been underestimated in our survey.*

	presence in Settlement	abundance in Settlement	abundance in the Patches	presence in the Patches	distribution	seed weight (g/1000)	lifeform	vegetative spread	seed dispersal	first recorded
species with very localised distribution, most likely because they are recent introductions; they can be expected to spread, but not very rapidly because of high seed weight.										
Amaranthus cf. *hybridus* (Amaranth)	rare	low			very localised	ca 0.2-0.5	annual	-	unspecific	2007
Chenopodium album (Fat Hen)	rare	low			very localised	0.600	annual	-	unspecific	1793; not seen again until now; probably recently introduced again
Chenopodium murale (Nettle-leaved Goosefoot)	rare	low			very localised	0.600	annual	-	unspecific	1793; not seen again until now; probably recently introduced again
species with a restricted distribution, because they are 1) relatively recent introductions, and 2) have heavy seed that disperse not far from the parent plants. They will spread slowly.										
Fumaria muralis (Scrambling Fumitory)	rare	low	high	occasional	localised	ca 2-4	annual	-	unspecific	2000
Stachys arvensis (Field Woundwort)	rare	low	high	occasional	localised	0.700	annual	-	unspecific	2007
other species with restricted distribution: plants all of the same gender , so no seed production										
Urtica dioca (Common Nettle)	rare	low			very localised		perennial	yes		2009

	presence in settlement	abundance in settlement	abundance in the Patches	presence in the Patches	distribution	seed weight (g/1000)	lifeform	vegetative spread	seed dispersal	first recorded
species with a less restricted, but not very widespread distribution, with have heavy seed that disperse not far from the parent plants. Within their distribution area they often are very abundant. They will spread slowly.										
Anagallis arvensis (Scarlet Pimpernel)	occasional	low	very high	common		0.500	annual	-	unspecific	1873
Coronopus didymus (Lesser Swinecress)	common	low	very high	common		0.500	annual	-	unspecific	1954
Solanum nigrum (Black Nightshade)	common	low	high	common		0.700	annual	-	unspecific	1908
Veronica agrestis (Green Field Speedwell)			very high	occasional	localised	0.569	annual	-	unspecific	1938
species with a restricted distribution, because presumably they do not disperse easily by seed over large distances; locally they can reach high cover by vegetative spread. They will spread very slowly.										
Bromus willdenowii (Rescue Grass)	occasional	low	very high	occasional	localised	9.500	perennial, or annual	forms tussocks, slowly spreading	unspecific	1852
Calystegia sepium (Hedge Bindweed)	absent	absent	very high	occasional	localised	25.580	perennial	far-creeping rhizome	unspecific	1908
Dactylis glomerata (Cocksfoot)	occasional	low	high	occasional	localised	0.900	perennial	forms tussocks, slowly spreading	unspecific	1954

TABLE 6. *Characteristics of weeds with a widespread distribution. "–" for vegetative spread means usually not spreading vegetatively; "-" for presence or abundance means the species was not found here.*

	presence in Settlement	abundance in Settlement	abundance in the Patches	presence in the Patches	distribution	seed weight	lifeform	vegetative spread	seed dispersal	first recorded
weed species with a widespread distribution, indicating introduction quite long ago, or easy dispersal over large distances by wind or animals										
Conyza floribunda (Guernsey Feabane)	abundant	low	moderate	abundant	widespread	0.040	annual		wind	1938
Crepis capillaris (Smooth Hawksbeard)	abundant	high	very high	abundant	widespread	0.240	annual, or biennial	-	wind	1962
Cyperus esculentus (New Bull Grass / Nutgrass)	common	low	high	abundant	widespread	0.160	perennial	spreading by tubers	?	1968
Cyperus tenellus (Tiny Flat-sedge)			low	common	widespread	?	annual	-	?	1904
Euphorbia peplus (Petty Spurge)	abundant	low	very high	abundant	widespread	0.650	annual	-	unspecific	1962
Gnaphalium luteo-album (Jersey Cudweed)	very common	low	moderate	abundant	widespread	0.090	annual		wind	1904
Gnaphalium purpureum (Purple Cudweed)	occasional	low	moderate	very common	widespread	0.037	annual	-	wind	1955
Juncus tenuis (Slender Rush)	abundant	low	low	abundant	widespread	0.010	perennial		unspecific	1952
Mariscus congestus (Old Bull Grass / Clustered Flat-sedge)	abundant	low	very high	abundant	widespread	0.240	perennial	-	unspecific	1904
Myosotis discolour (Changing Forget-me-not)			low	common	widespread	0.200	annual	-	unspecific	1937
Oxalis corniculata (Yellow Oxalis)	abundant	low	moderate	abundant	widespread	0.190	perennial or annual	creeping and rooting at the nodes	unspecific	1852

Paspalum dilatatum (Water Grass)	abundant	high	very high	abundant	widespread	1.500	perennial	short rhizomes	unspecific / animals?	1962
Plantago lanceolata (Ribwort Plantain)	abundant	high	high	abundant	widespread	1.300	perennial	Short, creeping rhizome	unspecific	1904
Poa annua (Annual Meadow-grass)	abundant	low	very high	abundant	widespread	0.300	annual, or perennial	-	unspecific	1852
Polycarpon tetraphyllum (Four-leaved Allseed)	common	low	high	common	widespread	0.050	annual	-	wind	1852
Polygonum aviculare (Knotgrass)	.	.	low	rare	widespread	1.300	annual	-	unspecific	1937
Rumex acetosella ssp. angiocarpus (Sheep's Sorrel)	occasional	low	high	abundant	widespread	0.360	perennial	suckering from roots	unspecific	1952
Rumex obtusifolius (Broad-leaved Dock)	abundant	high	very high	abundant	widespread	1.500	perennial	-	animals (fruits with hooks)	1904
Senecio vulgaris (Groundsel)	very common	low	high	abundant	widespread	0.220	annual	-	wind	1873
Sonchus asper (Prickly Sow-Thistle)	abundant	high	high	abundant	widespread	0.280	annual	-	wind	1962
Sonchus oleraceus (Smooth Sow-Thistle)	abundant	low	moderate	very common	widespread	0.300	annual	-	wind	1817
Veronica serpyllifolia (Thyme-leaved Speedwell)	abundant	low	moderate	abundant	widespread	0.050	perennial		unspecific	1908

Impact and management or agricultural weeds

The impact of alien weed species on agriculture and gardening on Tristan is summarized in Table 5. Some of these species also occur outside gardens and arable land, and their impact on pastures and native biodiversity is treated elsewhere. It is clear that weeds (as well as some animal and fungal pests) are a very serious problem in gardens and in the Patches. The small fields, surrounded by stone walls (which prevent soil erosion, and ameliorate microclimatic conditions), are not suited to mechanization of weed control. Weed control on Tristan is therefore very labour-intensive and time-consuming. Given the small human population on the island and thus the limited availability of labour, and the fact that there is no real scope for mechanization of the agriculture, weeds have a very serious negative impact on the ability of the island to be self-sufficient in agricultural produce.

How certain agricultural practices can reduce the long-term effort required for weed management is beyond the scope of this report. However it is clear that the last thing that is needed is invasions by more weed species. The prevention of new introductions should therefore be a first priority, immediately followed by the removal of any introduced weeds that are still manageable.

Figure 11 shows the weed species arranged according to their impact and the feasibility of control. Four species are immediate candidates for eradication: Amaranth (*Amaranthus* cf. *hybridus*), Fat Hen (*Chenopodium album*), Nettle-leaved Goosefoot (*Chenopodium murale*), and Common Nettle (*Urtica dioca*). These are presently found at a few sites only, and are known as serious agricultural pests elsewhere. To prevent new introductions the importation of chicken feed containing weed seeds has been discontinued some years ago. Supplies of vegetable and flower seeds should be checked for the presence of seeds of unwanted species. The same goes for soil that is imported together with plant material brought in from elsewhere.

The control and ultimate eradication of a number of weeds that are presently showing a limited distribution in the Patches can also be considered. In the short term eradication of alien weed species will require an investment of resources (mostly labour). However in the long run, this can be expected to reduce the effort needed for weed control in the Patches and gardens. Of the weeds that reach high cover values, Field Woundwort (*Stachys arvensis*), Scrambling Fumitory (*Fumaria muralis*) and Green Field Speedwell (*Veronica agrestis*) are possible candidates for an eradication program. Both species have long-lived seeds, and eradication requires a prolonged commitment, but would ultimately reduce the effort required for weed control in the patches. Another species for which eradication (at least locally in the Patches) could be considered is Hedge Bindweed (*Calystegia sepium*). At present several fields in the Patches are not used for growing crops as a result of heavy infestations with this species, or, when attempts are made to grow potatoes on infested plots, these seem often to be abandoned in the course of the season. Hedge Bindweed does not seem to spread much, if at all, by seed. It spreads by long rhizomes, but also by stems that can form roots from parts of the stem that get covered by soil. Getting rid of this species requires a sustained effort during several years, combining chemical and mechanical control. The alternative to eradication of this species would be to abandon the infested fields, and to prevent dispersal to uninfested Patches.

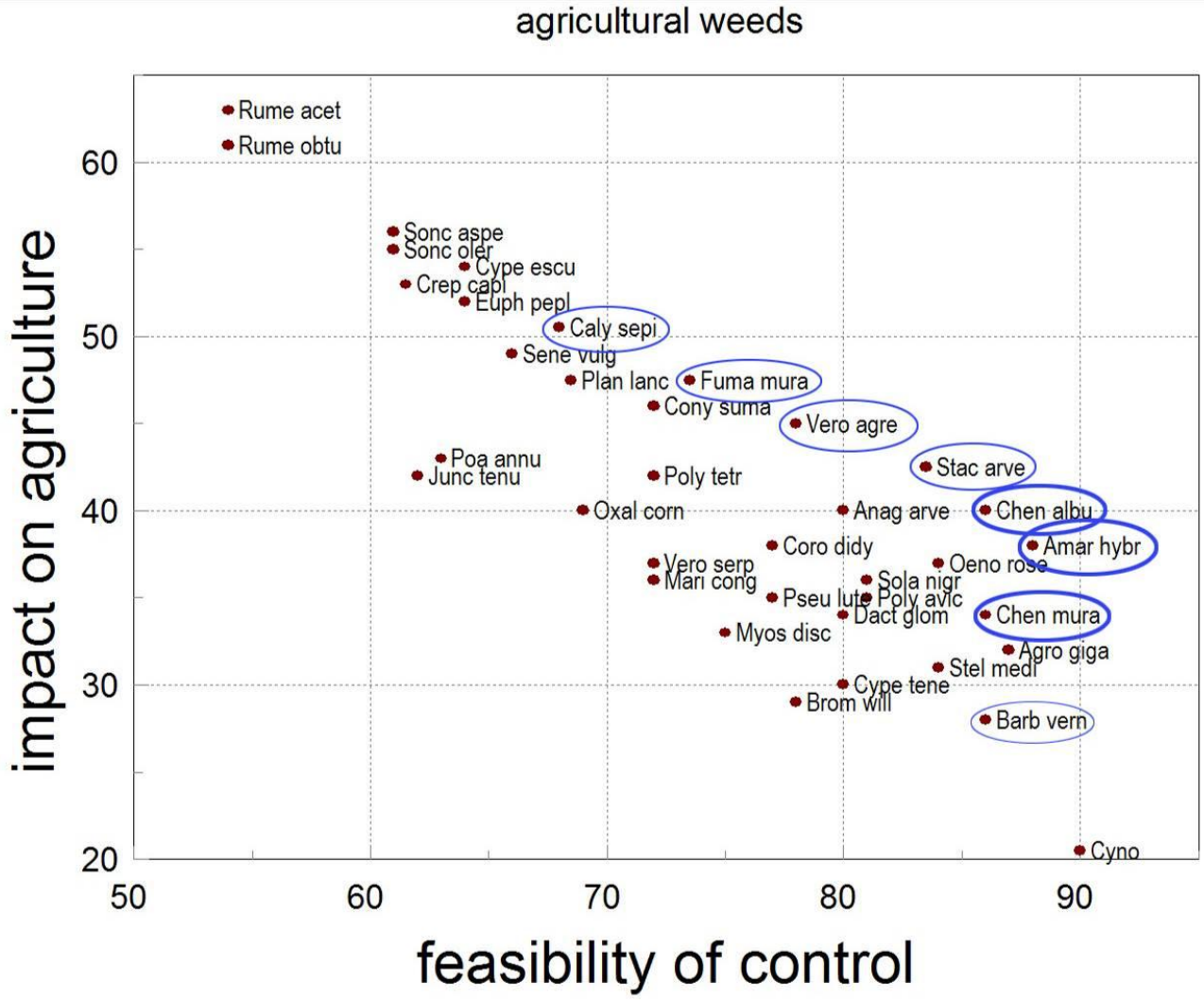

FIGURE 11. *Ranking of alien weed species with respect to impact on agriculture and feasibility of control. High numbers indicate strong impacts and easy control, respectively. Species marked with blue ovals are candidates for eradication (see text).*

Pasture species

In much of the lowland areas of Tristan, especially the settlement plain, but also large areas at Sandy Point, and in the Cave Point and Stony Hill areas, the original native vegetation has completely been replaced by grasslands consisting of introduced species. The island's native plant species have mostly evolved in the absence of large grazers, and are not able to regenerate quickly after being damaged by trampling or grazing. As a result of the high grazing pressure nearly all native species have disappeared from the grazed lowland areas, or have been reduced to small numbers. Only where grazing intensity is low, e.g. on the slopes of the escarpment, and on much of the Base, native vegetation retains its natural biodiversity.

Some of the species occurring in these grasslands, especially some forage grasses, have been introduced on purpose. Others have arrived presumably as seed impurities, or in some other accidental way. Some of the introduced species occurring in the grasslands are important food sources for cattle and sheep, but others are useless as forage plants, and their presence reduces the carrying capacity of the pastures.

Our survey was not aimed at studying the forage quality of the Tristan grasslands, but some remarks may be made here: At present the ecosystems of Tristan are essentially low-nutrient systems. Before the settlement by people, and especially before the arrival of mammal predators (cats, rats), the main island probably was as rich in birds as the outlying islands are today. These birds, feeding at sea, but depositing excrements, etc. on land, were a source of vast quantities of nutrients for the island's plants. Due to the enormous reduction in bird numbers by the imported predators, this nutrient input has been reduced to only a very small amount. Combined with the high rainfall, which results in leaching of nutrients from the soil, the available nutrient content of the Tristan soils is quite low. As a result forage production is not very high, and the carrying capacity for livestock is reduced. The present numbers of livestock seem to exceed the pastures' carrying capacity, resulting in overgrazing. This in turn results in open patches in the turf, allowing ruderal weeds to invade the grasslands. Most of these weeds have no value as forage species, but take up space, nutrients and other resources, further reducing the carrying capacity of the pastures. Several high quality forage grasses are present in the Tristan pastures, but it seems likely that their abundance is reduced by overgrazing and the relatively low nutrient status of the soils. A discussion of possible agricultural measures to alleviate this problem falls outside the scope of this report.

Quite a number of alien grasses and other plant species are found in abundance in these pastures, both in the lowland plains and on the Base. Our data on the distribution and abundance of alien plants on the Base and on the mountain itself, however, are very incomplete. The pasture species are listed in Table 7.

Of 38 alien species which occur mainly in pastures, 20 seem to be restricted to the Settlement Plain, i.e. the lowland area from Plantation Gulch to Burntwood. For many of those there is no reason why they should not be able to grow in other parts of the island, but their present limited distribution simply reflects the fact that they have not had sufficient time to spread any further. For some species, however, it may be expected that they will not easily disperse away from the settlement plain without help. Examples are Onion Grass (*Romulea rosea*), Purple Woodsorrel (*Oxalis purpurea*), and Burrowing Clover (*Trifolium subterraneum*). The heavy seeds of Onion grass and Burrowing Clover

preclude easy dispersal over long distances, while Purple Woodsorrel seems not to produce seed, and appears to spread only vegetatively (Table 8).

Native Bogfern (*Blechnum palmiforme*) vegetation becoming replaced by alien grassland, under the influence of grazing.

Impacts of introduced species on pasture quality

In the next tables the distribution and impact of introduced species mainly found in pasture are summarized (Table 7), as well as some properties of these species (Table 8).

A number of imported species contribute greatly towards the quality of the island's pastures. However, more than half of the species that are most commonly found in grasslands, have no value as forage plants. Looking at the forage quality value of the species and the height of the plants, one can see that all low-growing species, except for White Clover (*Trifolium repens*), are of very little value. Several of these, e.g. Silvery Hair-grass (*Aira caryophyllea*), Squirrel-tail Fescue (*Vulpia bromoides*), and Procumbent Pearlwort (*Sagina procumbens*), occur in large numbers, adversely affecting the forage production of the pastures. Species occurring in the pastures that have no value for livestock reduce the carrying capacity of the pastures, by using resources (space, nutrients) without any useful return.

Although several of the high value forage species occur commonly in the pastures, they either occur with low cover values (e.g. Perennial Rye-grass, *Lolium perenne*, Smooth Meadow-grass, *Poa pratensis*, and Rough Meadow-grass, *Poa trivialis*), or they are restricted to small areas (e.g. Burrowing Clover, *Trifolium subterraneum* and Strawberry Clover, *Trifolium fragiferum*). In contrast several grass species with little or no forage value (e.g. Bermuda Grass, *Cynodon dactylon*, and Ratstail Grass, *Sporobolus africanus*), are locally very abundant.

Two grass species. Water Grass and Bahia Grass, may cause problems because they are often infected with ergot (*Claviceps paspali*), a poisonous fungal infection of the flower heads, which may cause livestock poisoning.

Several of the grasses that are common in the pastures also are very abundant in many natural habitats. Yorkshire Fog (*Holcus lanatus*), Creeping Bent (*Agrostis stolonifera*), and Common Bent (*Agrostis tenuis*) locally dominate the vegetation – also outside the pasture areas – completely.

Control of the pasture species appears quite impossible. They are mostly very widely dispersed and abundant, and some are also difficult to distinguish in the field. Two species may be controlled, if enough resources are available. One is Soft Rush (*Juncus effusus*). This species is quite restricted in its distribution (presently only found at Sandy Point), and is expected over time to invade the pastures in this area, as well as damp natural habitats, both in this area and eventually all over the island. It may form very dense colonies, which are unpalatable for livestock, and strongly reduce the number of useful pasture species in grasslands, and native plants in invaded natural areas. The second possible candidate for control (eradication) is Bahia Grass (*Paspalum notatum*). This grass, although a useful pasture species in some other (warm climate) parts of the world, does no appear to contribute to the pasture quality on Tristan. Rather the opposite, it forms very dense patches with leaves closely appressed to the ground, which seem not or hardly to be grazed by livestock. In addition, the flowerheads often suffer from poisonous fungal infections. This grass does not seem to establish itself readily from seed, but once established, out-competes all other species, forming dense patches. At present most of these patches are quite small (not more than a few square metres), but it is expected that the number and size of these patches will increase over time, seriously detracting from the carrying capacity of the pastures. A detailed mapping of this species is required before it can be judged if eradication will be a feasible option.

TABLE 7. *Introduced plant species found abundantly or mostly in pastures and other grasslands.*

		first recorded	present distribution	impact
Agrostis castellana	Highland Bent	1908	observed in Hottentot Gulch, ca 150 m asl, but presumably much more widespread	Transforms native vegetation, when grazed, into alien grasslands.
Agrostis stolonifera	Creeping Bent	1938	all around the island	Transforms native vegetation, especially when grazed, into aliens-dominated grasslands. Completely replaces native vegetation alongside streams, reaching absolute dominance.
Agrostis tenuis	Common Bent / Brown Top	1937	all around the island; also abundant on Base	Transforms native vegetation, especially when grazed, into alien grasslands. Often reaches dominance.
Aira caryophyllea	Silvery Hair-grass	1937	all around the island	Adds to the alien species component in vegetation with open ground, only rarely reaching dominance. Reduces pasture quality.
Anthoxanthum odoratum	Sweet Vernal-grass	1934	abundant in lowland pastures between Settlement and Patches	Transforms native vegetation, when grazed, into alien grasslands. Not found outside pastures.
Bellis perennis	Daisy	1937	lowland pastures between Settlement and Patches	Reduces pasture quality. Not found outside pastures.
Cotula australis	Australian Brass Buttons	1852	pasture E of the Patches	Reduces pasture quality. Not found outside pastures.
Cynodon dactylon	Bermuda Grass	1937	all around the island	Reduces pasture quality. Locally strongly modifies native vegetation, especially that with open ground.
Festuca arundinacea	Tall Fescue	1976	in schoolyard, presumably same location as in 1976	Found at only a single site. Completely dominates the vegetation there.
Festuca rubra	Red Fescue	1937	settlement plain and Sandy Point pastures	Adds to the alien species component in vegetation with open ground, only rarely reaching dominance. Common and locally abundant in pastures, but of low quality as a pasture grass
Holcus lanatus	Yorkshire Fog	1904	all around the island and on the Base	Often completely dominating the areas it invades, strongly reducing native biodiversity; a troublesome weed in the Patches; of moderate quality as a pasture grass.
Hypochaeris glabra	Smooth Catsear	1873	settlement plain and Sandy point	Reduces pasture quality, but not very abundant.
Hypochaeris radicata	Catsear	2007	in pasture W of Settlement and along road verge in new volcano	Reduces pasture quality, but not very abundant.

		first recorded	present distribution	impact
Juncus effusus	Soft Rush	1938	Sandy Point	Replaces pasture grasses; restricted in distribution. Potential to invade many other areas and habitats. Future impact both on agriculture as on conservation may be very serious.
Leucanthemum vulgare	Ox-eye Daisy	1904	all around the island	Replaces more useful pasture species; modifies open native vegetation on damp soils.
Lolium perenne	Perennial Rye-grass	1937	common in Settlement and pastures of Settlement Plain	Important as a high-quality pasture grass; little impact on native vegetation.
Oxalis purpurea	Purple Woodsorrel	1908	widely spread from the Settlement to The Patches	Reduces pasture quality, but restricted in distribution.
Paspalum dilatatum	Water Grass	1962	widely spread in pastures and gardens in all lowland areas around the island	Useful as a pasture grass; a troublesome weed in gardens and the Patches; contributes to the transformation of native vegetation into aliens-dominated vegetation.
Paspalum notatum	Bahia Grass	2007	locally abundant in pastures around the Settlement, near The Patches and in the Cave Point area	Reduces pasture quality by replacing more useful species; contributes locally to the transformation of native plant communities into aliens-dominated vegetation.
Pennisetum clandestinum	Kikuyu Grass	1976	widely spread in pastures and gardens in all lowland areas around the island	Value as a pasture grass is not clear; contributes considerably to the transformation of native plant communities into aliens-dominated vegetation.
Phalaris tuberosa	Bulbous Canary Grass	1962	only found in grassland in the back garden of the Anglican rectory	Impact negligible, because of very restricted distribution.
Poa pratensis	Smooth Meadow-grass	1873	in pastures in Settlement Plain and Sandy Point	Useful pasture grass; a weed in the Patches and gardens; contributes to the transformation of native vegetation into aliens-dominated plant communities.
Poa humilis	Spreading Meadow-grass	1937	all around the island	Useful pasture grass; contributes to the transformation of native vegetation into aliens-dominated plant communities.
Poa trivialis	Rough Meadow-grass	1937	locally common in the Settlement and the Patches	Useful pasture grass; a weed in the Patches and gardens; contributes to the transformation of native vegetation into aliens-dominated plant communities.

		first recorded	present distribution	impact
Prunella vulgaris	Self-heal	1938	widely spread in lowland areas an on lower slopes up to the Base	Replaces more useful species in pastures; contributes to the transformation of native vegetation into aliens-dominated plant communities.
Romulea rosea var. australis	Sand Crocus / Onion Grass	1908	locally abundant in grassland in and around the Settlement; a few plants in the Pigbite area	Replaces more useful species in pastures; locally contributes to the transformation of native vegetation into aliens-dominated plant communities.
Sagina procumbens	Procumbent Pearlwort	1999	widely spread	Forms locally large, dense patches in pastures, thus strongly reducing the production of more useful herbage; locally contributes to the transformation of native vegetation into aliens-dominated plant communities. Likely to strongly increase in area and abundance over time, with a very serious impact on both pasture quality and native biodiversity; may also become a troublesome weed in gardens and the Patches.
Sporobolus africanus	Ratstail Grass	1908	all around the island	Replaces more useful species in pastures; contributes to the transformation of native vegetation into aliens-dominated plant communities, seriously affecting natural biodiversity.
Taraxacum officinale	Dandelion	2000	northern part of Settlement Plain	Impact presently small, but is expected to increase in distribution area and abundance over time.
Trifolium cernuum	Nodding Clover	2007	in and around the Settlement and at the Patches; some plants in the Stony Hill and Cave Point areas	Possibly useful as a nitrogen producer in pastures; contributing to the alien plant component in native vegetation, especially on open ground.
Trifolium dubium	Lesser Trefoil	1937	all around the island	Useful as a nitrogen producer in pastures; contributing to the alien plant component in native vegetation, especially on open ground.
Trifolium fragiferum	Strawberry Clover	2007	at a few sites in the Settlement	A very useful forage species; useful as a nitrogen producer in pastures; not found in other habitats.
Trifolium glomeratum	Clustered Clover	2007	Settlement Plain	Possibly useful as a nitrogen producer in pastures; contributing to the alien plant component in native vegetation, especially on open ground.

		first recorded	present distribution	impact
Trifolium micranthum	Slender Trefoil	1955	Settlement Plain and Sandy Point area	Possibly useful as a nitrogen producer in pastures; contributing to the alien plant component in native vegetation, especially on open ground.
Trifolium repens	White Clover	1904	Settlement Plain	A very useful pasture species; locally contributing to the alien plant component in native vegetation, especially on open ground.
Trifolium subterraneum	Burrowing Clover	1968	around Settlement and in Pigbite area	A useful pasture species; useful as a nitrogen producer in pastures; not found in other habitats.
Verbena officinalis	Vervain	1904	locally abundant in the Settlement; also some plants in the new lava area	Locally contributing to the alien plant component in native vegetation, especially on open ground.
Vulpia bromoides	Squirrel-tail Fescue	1852	all around the island	Replaces more useful species in pastures; contributes to the transformation of native vegetation into aliens-dominated plant communities, especially on open ground.

TABLE 8. *Characteristics of pasture species on Tristan. Height indicates the usual height of the (not grazed) plants; individual plants in favourable conditions can grow higher.*

"**Lateral spread**" indicates the distance over which plants spread by means of rhizomes, stolons, etc; 1 = no appreciable lateral spread; 2 = very little (<10 cm) lateral spread; 3 = some (<25 cm) lateral spread; 4 = lateral spread up to 1 m; 5 = much lateral spread, long stolons, rhizomes, etc., spreading > 1 m. "**Seed weight**" gives the weight of 1000 seeds. "**forage value**" gives an indication of the quality of the species as forage (production and palatability). - = useless, + = some value; ++ = moderate value; +++ = high value. "**frequency of occurrence**" indicates how often the species was found; "**abundance**" indicates the number of plants at the sites where the species was found. "locally high" and "locally dominant" mean that the species can reach high numbers, in the case of locally dominant, reaching cover values of 50 – 100% of the surface area at some of the sites where it was found. These species of course can also occur in low numbers at other sites.

*) The forage value of Water grass and Bahia grass (*Paspalum dilatatum* and *P. notatum*) is reduced because of the common occurrence of ergot (*Claviceps paspali*), a poisonous fungal infection of the flower heads, which may cause livestock poisoning.

**) most leaves are closely appressed to the soil, only the flowering stalks reaching above ca 10 - 15 cm.

		life history	height	lateral spread	seed weight (g/1000)	forage value	frequency of occurrence	abundance (when present)
Agrostis castellana	Highland Bent	perennial	15 - 50 cm	5	0.17	?	rare	low
Agrostis stolonifera	Creeping Bent	perennial	15 - 50 cm	5	0.06	++	very common	locally dominant
Agrostis tenuis	Common Bent / Brown Top	perennial	15 - 50 cm	4	0.07	+	very common	locally dominant
Aira caryophyllea	Silvery Hair-grass	annual	< 15 cm	1	0.14	-	very common	locally high
Anthoxanthum odoratum	Sweet Vernal-grass	perennial	15 - 50 cm	2	0.53	+	frequent	locally high
Bellis perennis	Daisy	perennial	< 15 cm	3	0.13	-	occasional	low
Cotula australis	Australian Brass Buttons	annual	< 15 cm	1	?	-	rare	locally high
Cynodon dactylon	Bermuda Grass	perennial	15 - 50 cm	5	0.2	-	very common	locally dominant
Festuca arundinacea	Tall Fescue	perennial	> 50 cm	4	3.05	+	rare	locally high

		life history	height	lateral spread	seed weight (g/1000)	forage value	frequency of occurrence	abundance (when present)
Festuca rubra	Red Fescue	perennial	15 - 50 cm	4	1.2	+	common	locally high
Holcus lanatus	Yorkshire Fog	perennial	15 - 50 cm	3	0.3	++	very common	locally high
Hypochaeris glabra	Smooth Catsear	annual	< 15 cm	1	0.69	-	frequent	low
Hypochaeris radicata	Catsear	perennial	15 - 50 cm	2	0.8	-	rare	low
Juncus effusus	Soft Rush	perennial	> 50 cm	4	0.02	-	rare	locally high
Leucanthemum vulgare	Ox-eye Daisy	perennial	15 - 50 cm	2	0.41	-	very common	locally high
Lolium perenne	Perennial Rye-grass	perennial	15 - 50 cm	3	2	+++	common	low
Oxalis purpurea	Purple Woodsorrel	perennial	< 15 cm	4	?	-	occasional	low
Paspalum dilatatum	Water Grass	perennial	> 50 cm	3	1.5	++ *)	very common	locally dominant
Paspalum notatum	Bahia Grass	perennial	15 - 50 cm**)	3	3	++ *)	occasional	locally high
Pennisetum clandestinum	Kikuyu Grass	perennial	15 - 50 cm	5	2.18	+	very common	locally dominant
Phalaris tuberosa	Bulbous Canary Grass	perennial	15 - 50 cm	3	1.66	+	rare	locally high
Poa humilis	Spreading Meadow-grass	perennial	15 - 50 cm	3	0.27	?	frequent	low
Poa pratensis	Smooth Meadow-grass	perennial	15 - 50 cm	3	0.25	+++	frequent	low
Poa trivialis	Rough Meadow-grass	perennial	15 - 50 cm	2	0.2	+++	occasional	low
Prunella vulgaris	Self-heal	perennial	< 15 cm	3	1	-	frequent	locally high
Romulea rosea var. australis	Sand Crocus / Onion Grass	perennial	< 15 cm	2	3.52	-	occasional	low
Sagina procumbens	Procumbent Pearlwort	perennial	< 15 cm	2	0.02	-	frequent	locally high
Sporobolus africanus	Ratstail Grass	perennial	> 50 cm	3	0.19	-	very common	locally dominant
Taraxacum officinale	Dandelion	perennial	15 - 50 cm	2	0.7	+	occassional	low
Trifolium cernuum	Nodding Clover	annual	< 15 cm	1	0.2	-	occassional	low
Trifolium dubium	Lesser Trefoil	annual	15 - 50 cm	1	0.4	++	very common	low

		life history	height	lateral spread	seed weight (g/1000)	forage value	frequency of occurrence	abundance (when present)
Trifolium fragiferum	Strawberry Clover	perennial	15 - 50 cm	3	1.2	+++	rare	locally high
Trifolium glomeratum	Clustered Clover	annual	< 15 cm	1	0.4	-	common	low
Trifolium micranthum	Slender Trefoil	annual	< 15 cm	1	0.34	-	common	low
Trifolium repens	White Clover	perennial	< 15 cm	4	0.6	+++	common	low
Trifolium subterraneum	Burrowing Clover	annual	15 - 50 cm	4	6.6	+++	occasional	locally dominant
Verbena officinalis	Vervain	perennial	15 - 50 cm	2	0.33	-	rare	low
Vulpia bromoides	Squirrel-tail Fescue	annual	< 15 cm	1	0.48	-	very common	locally high

Garden and cultivation escapes

Importations of plants as ornamentals or for cultivation as vegetables are an obvious way for alien plants reach the island. Of course not all, or not even most plant species brought in for planting in gardens will be able to establish themselves outside cultivation, but some of them have done so. In our survey we listed all plants occurring outside gardens at sites where they were apparently not planted.

Most of the garden escapes were found in the volcano area, where garden refuse is dumped (Table 8). A few species seem to be spreading slowly by vegetative means from the site where they were dumped (e.g. Montbretia (*Crocosmia* x *crocosmiiflora*) and Rose (*Rosa* spec.)). Others survive where they are but do not spread noticeably (e.g. African Lily (*Agapanthus praecox*), Spider plant (*Chlorofytum comosum*), and Marvel-of-Peru (*Mirabilis jalapa*).

A number of these garden escapes are spreading further afield, for instance New Zealand Flax (*Phormium tenax*), which was found on several sites in the volcano area away from places where old plants where dumped, as well as on the slopes up to the escarpment behind Pigbite. At Sandy Point the Arum Lily (*Zantedeschia aethopica*) appears to be spreading vegetatively, now covering an area of several hundred square meters. The Large-flowered Evening Primrose (*Oenothera glazioviana*) spreads by seed from its area of probable introduction at the Settlement into the surrounding area.

Young Parsley plants (*Petroselinum crispum*) were found in large numbers at several places in and outside gardens, It does appear that this species springs up from seed produced by planted Parsley plants, but does not permanently establishes itself outside cultivated ground. It is a transient alien, i.e. surviving for only a short time, but remains on the island because of repeated introductions from seed formed by planted Parsley plants.

Impact and management

The present impact of these garden escapes is small (Table 9). Most species occur only with a few clumps of plants, and increase their area only by vegetative means, which for these species is generally very slow. A few, however, disperse freely by seed, and can be expected to increase their area on the island in the future. Examples are the Large-flowered Evening Primrose (*Oenothera glazioviana*) and the New Zealand Flax (*Phormium tenax*). Of these the Primrose does not appear to have a large impact, as it does not occur in large numbers (at present at least) and does not cause significant changes in the areas where it grows. The Flax can locally form dense clumps, and outcompetes the native vegetation in the areas where it occurs. However, because the area invaded by Flax on Tristan is very small, the overall impact is very limited.

For most of these garden escapes it does not seem necessary to do anything about them. From a nature conservation viewpoint it may be useful to keep an eye on the dispersal of New Zealand Flax, and remove any plants in areas away from the Settlement.

Equally there are arguments to try and keep the Large-flowered Evening Primrose restricted to the settlement. This species seems to be a relatively recent introduction, and can be expected to spread

eventually into open, disturbed habitats all over the island. Because it does not seem likely that this species has a large impact on the native biodiversity of the island, however, the priority for such an action is not high. On the other hand, however, it is advisable to do something about it while its distribution is still quite restricted, rather than wait until it is widely spread.

In the Patches people keep an eye on the condition of the potato plants, and when diseases are observed, something will be done about it. But in potato plants growing away from gardens and patches diseases will not be controlled. Therefore it may be advisable to remove any potato plants growing wild. We have insufficient information about the potato diseases occurring on the island at the moment to judge the urgency of this.

Arum Lily (*Zantedeschia aethopica*) invading a wet site in the Sandy Point forest.

TABLE 8. *Garden escapes and their distribution on Tristan.*

		First recorded	Present distribution
Agapanthus praecox	African Lily	2007	found at a number of places in the Settlement and on the new lava; dispersed with garden waste, and surviving, but apparently not spreading.
Chlorofytum comosum	Spider plant	2007	found at the Settlement and new volcano; presumably not spreading independently, but dispersed with garden waste.
Crocosmia x crocosmiiflora	Montbretia	2007	escaping from gardens in the Settlement and also found at a number of places in the new volcano; distributed with garden waste, and spreading vegetatively from there; also in the Patches (presumably planted, but slowly spreading).
Eschscholzia californica	Californian Poppy	2007	garden escape in the Settlement and on the new volcano; only a few plants found, maybe from seeds dispersed with garden waste.
Mirabilis jalapa	Marvel-of-Peru	2007	a few plants in new volcano, dispersed with garden waste; no sign of spreading.
Oenothera glazioviana	Large-flowered Evening Primrose	2007	in gardens and naturalized on ruderal places in and around the Settlement; spreading by seed.
Papaver somniferum	Opium Poppy	2007	a few plants at one site in grassland outside a garden in the Settlement.
Pelargonium spec. *1*	Geranium	2007	naturalized in the new volcano; presumably dispersed with garden waste; probably not spreading independently.
Pelargonium spec. *2*	Geranium	2007	only found in a disused garden; producing viable seed abundantly, but apparently not spreading at all.
Petroselinum crispum	Parsley	2007	dispersing by seeds from planted parsley plants, locally outside gardens, but seems not to spread independently.
Phormium tenax	New Zealand Flax	1910	in and to the E of the Settlement; spreading mainly in the new volcano; localy at Sandy Point, where it presumably also was planted. Spreading slowly, but at some places forming dense patches.

		First recorded	Present distribution
Physalis peruviana	Goldenberry	1938	common in the Settlement and new volcano; a few plants in Pigbite area; spreading by seed.
Rosa spec.	Rose	2007	in the Settlement and new volcano; in the Settlement presumably planted, in the volcano area probably dispersed with garden waste.
Saponaria officinalis	Soapwort	2000	locally as a garden escape in the Settlement; does not seem to spread much, if at all.
Solanum tuberosum	Potato	2007	escaped from cultivation at the Settlement and the Patches; not spreading much. Mostly coming up from discarded or lost tubers.
Tradescantia fluminensis	Wandering-jew	2007	settlement and new volcano; slowly spreading vegetatively.
Tropaeolum majus	Nasturtium	2007	in and around the Settlement and in new volcano; not spreading much, if at all.
Watsonia spec.	Bugle Lily	2007	found at a number of places in the Settlement and on the new volcano; distributed with garden waste, and surviving, but apparently not spreading.
Zantedeschia aethopica	Arum Lily; Calla Lily	2007	common around the Settlement; spread with garden waste; one large patch in a wet part of the forest at Sandy Point.

TABLE 9. *Characteristics of garden escapes, their present impact and expected future changes in distribution and impact. For a number of species we cannot judge if they are naturalized (i.e. are able to sustain a population without human help) or not. This requires observation over a longer time period.*

		life form	**dispersal**	**naturalized ?**	**impact**	**expected future changes**
Agapanthus praecox	African Lily	perennial	vegetatively (bulbs) **	?	impact negligible (very small area covered)	no significant change
Chlorofytum comosum	Spider plant	perennial	vegetatively	?	impact negligible (very small area covered)	no significant change
Crocosmia x crocosmiiflora	Montbretia	perennial	vegetatively (bulbs) *	naturalized	impact small (quite small area covered)	very slow increase in area, but no new areas colonized
Eschscholzia californica	Californian Poppy	annual	seed	?	impact negligible (very small area covered)	no significant change
Mirabilis jalapa	Marvel-of-Peru	perennial	seed	?	impact negligible (very small area covered)	no significant change
Oenothera glazioviana	Large-flowered Evening Primrose	biennial	seed	naturalized	impact negligible (few single plants)	slowly spreading into other areas
Papaver somniferum	Opium Poppy	annual	seed	?	impact negligible (very small area covered)	no significant change
Pelargonium spec. *1*	Geranium	perennial	?	naturalized	impact negligible (very small area covered)	no significant change
Pelargonium spec. *2*	Geranium	perennial	?	?	impact negligible (very small area covered)	no significant change
Petroselinum crispum	Parsley	perennial	seed	?	impact negligible (very small area covered)	no significant change
Phormium tenax	New Zealand Flax	perennial	seed, vegetatively	naturalized	impact negligible (very small area covered)	very slowly spreading into other areas

		life form	**dispersal**	**naturalized ?**	**impact**	**expected future changes**
Physalis peruviana	Goldenberry	perennial	seed	naturalized	impact negligible (very small area covered)	slowly spreading into other areas
Rosa spec.	Rose	perennial	vegetatively	naturalized	impact negligible (very small area covered)	very slow increase in area, but no new areas colonized
Saponaria officinalis	Soapwort	perennial	seed	?	impact negligible (very small area covered)	no significant change
Solanum tuberosum	Potato	perennial	seed, vegetatively (tubers)	naturalized	impact negligible (very small area covered), but possibly a refuge for potato diseases	very slow increase in area, but no new areas colonized
Tradescantia fluminensis	Wandering-jew	perennial	vegetatively	naturalized	impact negligible (very small area covered)	very slow increase in area, but no new areas colonized
Tropaeolum majus	Nasturtium	annual	seed	?	impact negligible (very small area covered)	no significant change
Watsonia spec.	Bugle Lily	perennial	vegetatively (bulbs) *	?	impact negligible (very small area covered)	no significant change
Zantedeschia aethopica	Arum Lily; Calla Lily	perennial	vegetatively (bulbs) **	naturalized	impact negligible (very small area covered)	very slow increase in area, but no new areas colonized

- * these are actually nor bulbs but corms (strongly thickened underground stems);
- ** these are actually nor bulbs but rhizomes (horizontal underground stems)

Other alien species

A number of alien plants do not fit in any of the earlier categories. These have been grouped in this section. Most of them are ruderal species, i.e. species most commonly found on open ground, but not restricted to, or not even most common in gardens and the Patches. Information on their distribution and date of first record is given in Table 10. In Table 11 we have summarized information on life form and dispersal characteristics of the species, and in Table 12 their impact is summarized.

Some of the species in this group probably have been introduced on purpose (like the Mint species (*Mentha x villosa* and *M.* cf. *spicata*), Lobelia (*Lobelia erinus)*, Wild Pansy (*Viola tricolor*) and the Red Valerian (*Centranthus ruber*), and these species could as well be included in the section about garden escapes. Also for two species of primrose (the Evening Primrose, *Oenothera indecora*), and the Pink Evening Primrose, *Oenothera rosea*), it is not clear whether they have been introduced on purpose (they have nice flowers), or have arrived as seed impurities or in some other way. Both species are agricultural weeds in other parts of the world. The Evening Primrose occurs locally in the settlement as well as commonly in the area to the east (the volcano and Pigbite). The Pink Evening Primrose is much more restricted in distribution. It forms large groups in the old Mission garden, and a few single plants where found in gardens in the Settlement. The Pink Evening Primrose is a perennial species, and is found in less disturbed places than the other Evening Primrose species. Here it may reach quite high cover values. As at present this species is restricted to a few localities, and we suggest it would be worthwhile to eradicate it now, rather than wait until it becomes a problem.

Several of these species do not appear to produce seed, and spread vegetatively (e.g. Purple Woodsorrel, *Oxalis purpurea*, and both Mint species). They seem to reach new sites mainly by being planted there on purpose, or by being transported with garden waste or soil. Other species seem to have limited possibilities for dispersal because they have heavy seeds, and require habitats that are only available in small patches. An example of this is Watercress (*Nasturtium officinale*), which only occurs in springs and along streams, requiring permanently wet conditions in shallow, running water. As the seeds are relatively heavy, they are not easily dispersed over large distances. Thus, if no suitable environments are available within a short distance of the parent population, they are not able to spread easily.

Other species, however, produce large numbers of small seeds, that are easily blown away by wind, and thus disperse easily into new areas. Examples are Twiggy Mullein, (*Verbascum virgatum*), Annual Pearlwort (*Sagina apetala*), White Cudweed (*Vellereophyton dealbatum*), Sticky Mouse-ear (*Cerastium glomeratum*), and Toad Rush (*Juncus bufonius*). Some species with small seeds nevertheless are not widely dispersed (e.g. Pink Evening Primrose, *Oenothera rosea*, and Stonecrop (*Crassula pellucida*). Possibly viable seed is not produced regularly in these species.

Impacts and management

The impact of these species is listed in Table 12. The position of the species of this group in the impact / feasibility of control diagram is illustrated in Figure 11. The diagram shows a few species that have relative high (potential) impacts, for which control is still feasible. For three of those (Jointed Rush, *Juncus articulatus*, Wavy Hair Grass, *Avenella flexuosa*, and Pink Evening Primrose, *Oenothera*

rosea) eradication should not pose too much of a challenge, as they have at present a very restricted distribution, and are not spreading rapidly.

The fourth species which should be seriously considered for eradication is Shoddy Ragwort (also called African Daisy, *Senecio pterophorus*). This shrubby herb is widely spread in the 1961 lava area, producing seed in abundance. A few plants occur in the Pigbite area. It is likely that over time it will spread all over the island, strongly modifying many natural plant communities. Therefore it would be important to try and eradicate this species, before it is too late. This will require a lot of effort, but from a biodiversity conservation viewpoint, is of vital importance.

American Wintercress (*Barbarea verna*) was found only in a road verge in the settlement, and at one site in the 1961 lava area. This species is know as a weed in some parts of the world. In Tristan it has not (yet?) reached the Patches, and is not a serious problem. Because it has at present a very restricted distribution, it would be easy to remove this species, and we see no reason why this should not be done. In the worst case it will be a waste of half a day's work, butit may well prevent a lot of effort in controlling it once it becomes a weed in the Patches. (Note: this species is not included in Figure 11, but , although it is not at present an agricultural weed on Tristan, it may become so in future. Therefore it is included in the diagram with the weed species, Figure 10).

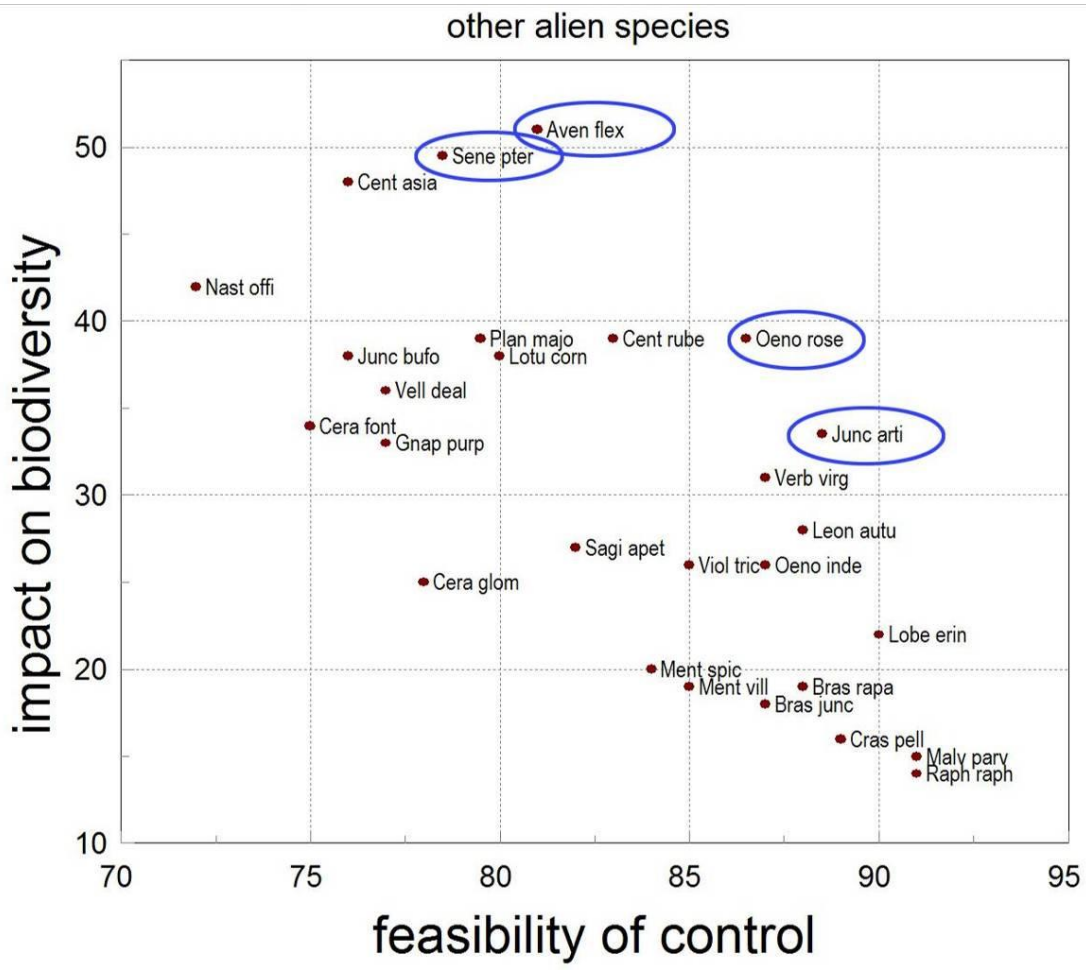

FIGURE 11. *Diagram showing the impact of alien species in the "other species" group on conservation values, and the feasibility of control on Tristan. The species marked with blue are prime candidates for control measures.*

African Daisy (*Senecio pterophorus*) colonizing the 1961 lava area.

TABLE 10. *Alien plant species not included in the lists of pasture species, weeds, garden escapes, and trees and shrubs on Tristan, their date of first recording, and their distribution on the island.*

Scientific name	**Common name**	**First record**	**Present distribution**
Avenella flexuosa	Wavy Hair Grass	2000	a single patch on the Base near Second Gulch
Barbarea verna	American Wintercress	2007	very localised in the Settlement and volcano
Brassica juncea	Mustard	1938	Previously recorded from Anchorstock Bay. Location not visited, so not known if it is still there.
Centella asiatica	Asiatic Pennywort	1904	all around the island
Centranthus ruber	Red Valerian	2000	in and around the Settlement, mainly along the coast, and locally in the 1961 lava area
Cerastium fontanum	Common Mouse-ear	1852	common all over the island.
Cerastium glomeratum	Sticky Mouse-ear	2000	settlement plain, from volcano to the Patches
Crassula pellucida	Stonecrop	1954	probably same site near Settlement as in 1954, also one site in new volcano
Cynoglossum spec.	Hound's-tongue	2007	in the garden at the hospital and the doctor's house
Juncus bufonius	Toad Rush	1937	all around the island
Juncus cf. articulatus	Jointed Rush	2007	in spring area W of Patches
Leontodon autumnalis ?	Autumn Hawkbit ?	2007	Distribution unknown; NOTE: identification needs to be checked
Lobelia erinus	Lobelia	1954	a few plants in old Mission Garden
Lotus corniculatus	Birdsfoot Trefoil	2000	locally abundant around the Settlement
Malva parviflora	Least Mallow	1852	only a single plant found in the new lava in area with much garden waste
Mentha spicata	Spear Mint	2007	a few gardens in the Settlement; large patches around the willow bush at Below the Waterfall; spreading vegetatively

Scientific name	Common name	First record	Present distribution
Mentha x villosa	Apple-mint	2000	abundant in a single wet area below the Settlement
Nasturtium officinale	Watercress	1962	abundant at Under the Waterfall and along Big Watron stream E of Settlement
Oenothera indecora ssp. *bonariensis*	Evening Primrose	1953	common in Pigbite area; a few plants in the Settlement and near Hottentot Gulch
Oenothera rosea	Pink Evening Primrose	2007	a few plants naturalised in gardens in the Settlement; quite common in old Mission Garden
Oxalis purpurea	Purple Woodsorrel	1908	widely spread from the Settlement to The Patches
Plantago major	Greater Plantain	1904	in and near the Settlement; a few plants in the Cave Point area
Poa infirma	Early Meadow-grass	1938	not found, but original locality not visited, so it may well still be there
Raphanus raphanistrum	Wild Radish	2007	a few plants in a garden in the Settlement
Sagina apetala	Annual Pearlwort	1999	in Settlement and on road to The Patches
Senecio pterophorus	Shoddy Ragwort; African Daisy	2007	locally abundant in new volcano; a few plants in Pigbite area and near Hottentot Gulch
Vellereophyton dealbatum	White Cudweed	1976	all around the island
Verbascum virgatum	Twiggy Mullein	1908	at ruderal sites around the Settlement, on new volcano and Pigbite area
Viola tricolor	Wild Pansy	2007	some plants along roadverges in the Settlement; garden escapes?, not (yet) spread outside the Settlement

TABLE 11. *Characteristics of alien species not included in the lists of pasture species, weeds, garden escapes, and trees and shrubs on Tristan.*

Lateral spread indicates the distance over which plants spread by means of rhizomes, stolons, etc; 1 = no appreciable lateral spread; 2 = very little (<10 cm) lateral spread; 3 = some (<25 cm) lateral spread; 4 = lateral spread up to 1 m; 5 = much lateral spread, long stolons, rhizomes, etc., spreading > 1 m.
Seed weight gives the weight in gram of 1000 seeds.

Scientific name	Common name	lifeform	Lateral spread	dispersal	Seed weight
Avenella flexuosa	Wavy Hair Grass	perennial	4	spreading slowly, vegetatively	0.56
Barbarea verna	American Wintercress	biennial	1	spreading by seed	0.86
Brassica juncea	Mustard	perennial	2	no data	1.7
Centella asiatica	Asiatic Pennywort	perennial	4	spreading probably both vegetatively and by seed	1.501
Centranthus ruber	Red Valerian	perennial	2	spreading vegetatively as well as by seed	1.8
Cerastium fontanum	Common Mouse-ear		2	spreading by seed	0.14
Cerastium glomeratum	Sticky Mouse-ear	annual	1	spreading by seed	0.05
Crassula pellucida	Stonecrop	perennial	3	spreading slowly vegetatively; not known if seed is produced	0.06
Cynoglossum spec.	Hound's-tongue	perennial	1	spreading by seed	ca 25 g
Juncus bufonius	Toad Rush	annual	1	spreading by seed	0.02
Juncus cf. articulatus	Jointed Rush	perennial	4	spreading slowly vegetatively; not known if seed is produced	0.02
Leontodon autumnalis ?	Autumn Hawkbit ?	perennial	2	no data; NOTE: identification needs to be checked	0.7
Lobelia erinus	Lobelia	annual	1	not spreading appreciably	0.04

Lotus corniculatus	Birdsfoot Trefoil	perennial	2	spreading very slowly, presumably by seed	1
Malva parviflora	Least Mallow	annual	1	not spreading appreciably	3.4
Mentha spicata	Spear Mint	perennial	4	spreading slowly vegetatively; not known if seed is produced	?
Mentha x villosa	Apple-mint	perennial	4	spreading slowly vegetatively; not known if seed is produced	?
Nasturtium officinale	Watercress	perennial	5	spreading slowly vegetatively and by seed	1
Oenothera indecora	Evening Primrose	biennial	1	spreading by seed	0.27
Oenothera rosea	Pink Evening Primrose	Biennial or perennial	3	spreading slowly vegetatively and by seed	0.07
Oxalis purpurea	Purple Woodsorrel	perennial	3	spreading probably only vegetatively	
Plantago major	Greater Plantain	perennial	2	not spreading much, vegetatively and by seed.	0.2
Poa infirma	Early Meadow-grass	annual	1	no data	0.25
Raphanus raphanistrum	Wild Radish	annual	1	spreading by seed	21.6
Sagina apetala	Annual Pearlwort	annual	1	spreading rapidly, mainly by seed	0.01
Senecio pterophorus	Shoddy Ragwort; African Daisy	perennial	4	spreading by seed and vegetatively	?
Vellereophyton dealbatum	White Cudweed	annual	1	spreading by seed, widely dispersed by wind	0.02
Verbascum virgatum	Twiggy Mullein	biennial	1	spreading by seed, dispersed by wind	0.14
Viola tricolor	Wild Pansy	annual	1	spreading by seed	0.9

TABLE 12. *Impact of alien species not included in the lists of pasture species, weeds, garden escapes, and trees and shrubs on Tristan.*

		Impact
Avenella flexuosa	Wavy Hair Grass	Only found at a single site. Here this grass is completely dominant, nearly completely excluding all native species.
Barbarea verna	American Wintercress	Small groups of plants only, impact at present negligible, but species may well increase in future and become a weed.
Brassica juncea	Mustard	Impact not known
Centella asiatica	Asiatic Pennywort	Occurring in may habitats, locally reaching high cover values, but presumably not outcompeting native species. Impact moderate.
Centranthus ruber	Red Valerian	Locally reaching high cover. Not (yet) spreading beyond the Settlement and its immediate surroundings. Impact very localised.
Cerastium fontanum	Common Mouse-ear	Never reaching high cover values. Impact quite small.
Cerastium glomeratum	Sticky Mouse-ear	Never reaching high cover values. Impact small.
Crassula pellucida	Stonecrop	Very localised. Impact negligible.
Cynoglossum spec.	Hound's-tongue	Small number of plants only, impact at present negligible
Juncus bufonius	Toad Rush	Widely distributed, generally not reaching high cover values. In itself not having much impact.
Juncus cf. articulatus	Jointed Rush	A few groups impact negligible at this moment.
Leontodon autumnalis ?	Autumn Hawkbit ?	A few plants only, impact negligible. NOTE: identification needs to be checked
Lobelia erinus	Lobelia	Only a few plants; impact negligible.
Lotus corniculatus	Birdsfoot Trefoil	Locally dominant; impact restricted to small area.
Malva parviflora	Least Mallow	Only a single plant, impact negligible.

		Impact
Mentha spicata	Spear Mint	Only a few groups, impact small.
Mentha x villosa	Apple-mint	Locally abundant, but overall impact negligible.
Nasturtium officinale	Watercress	Locally reaching dominance, and completely changing the original vegetation.
Oenothera indecora ssp. *bonariensis*	Evening Primrose	Not reaching high cover values; not much impact.
Oenothera rosea	Pink Evening Primrose	Although found only at a few sites, at the Mission garden it locally reaches dominance. Potentially a serious weed.
Oxalis purpurea	Purple Woodsorrel	Locally reaching high values, mostly in grassland. Reducing the value of the pasture.
Plantago major	Greater Plantain	Not seen in large numbers or high cover values. Impact small.
Poa infirma	Early Meadow-grass	Impact not known.
Raphanus raphanistrum	Wild Radish	Few plants, impact negligible.
Sagina apetala	Annual Pearlwort	Not reaching high cover values; impact negligible.
Senecio pterophorus	Shoddy Ragwort; African Daisy	Locally dominant. Presently largely restricted to the 1961 lava area where it is very locally abundant. It is not clear how much this species will invade other areas on the island.
Vellereophyton dealbatum	White Cudweed	Common in many open areas around the island. Locally reaching high cover values. A serious weed in some Patches. Impact moderate.
Verbascum virgatum	Twiggy Mullein	Not reaching high cover values. Impact small.
Viola tricolor	Wild Pansy	Only a few plants; impact negligible.

Conclusions

During the 2007/2008 alien plant survey of Tristan da Cunha we found some 138 species of introduced plant species on the island. Some 38 of these are new records. Our survey was most intensive in lowland areas. The uplands, and especially the mountain remains very much underexplored.

Historical data on the discovery of alien plant species on Tristan suggest a rate of successful introduction of on average one new alien plant species per 1 - 1.5 year. There is no reason to assume that this influx of alien invaders will decline unless measures are taken. Measures to prevent new invasions are therefore of vital importance.

Alien plants have serious negative impacts on agriculture and on biodiversity conservation on Tristan da Cunha. It does not appear feasible to reduce the impact of those species presently widely dispersed. However, by controlling a number of species that are at this moment still restricted in distribution and numbers, more adverse future impacts may be avoided. For several alien species eradication appears to be quite feasible.

Details of the ecology, distribution and impact of the species are given in the main body of the report (Part 1), and in the species accounts in Part 2 of this report. For species that require control – and for which control is feasible – information is summarized in the summary.

Because of the high rate of new introductions, regular surveys of the sites where species are most likely to be introduced are an urgent requirement. If new arrivals are discovered soon after they have arrived, before they start spreading, control generally will be easy and inexpensive, and will prevent a lot of problems later on.

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References

In general we have not made detailed reference to the literature or other sources of information throughout the text of this report. Information on previous botanical collections, and species lists and dates of first record or collection were taken from Groves (1981). Information on worldwide distribution of species was taken from various literature sources, as well as from sources on the web (e.g. the USDA GRIN database). Data on seed weights came from various literature sources, and from the Kew Seed Database on the web. Information on functional characteristics of the species (reproduction, seed dispersal, etc.) also came from various literature sources, one of the most important of which was Grime et al. (1988).

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