

Darwin Plus: Overseas Territories Environment and Climate Fund Annual Report

To be completed with reference to the "Project Reporting Information Note"
(<https://darwinplus.org.uk/resources/information-notes>)

It is expected that this report will be a **maximum of 20 pages** in length, excluding annexes)

Submission Deadline: 30th April 2023

Submit to: BCF-Reports@niras.com including your project ref in the subject line

Darwin Plus Project Information

Project reference	DPLUS144
Project title	Protecting South Georgia from climate change-invasion synergies
Territory(ies)	South Georgia and South Sandwich Islands; Falkland Islands
Lead Partner	Durham University
Project partner(s)	Royal Botanic Gardens Kew (Kew), British Antarctic Survey (BAS), South Atlantic Environmental Research Institute (SAERI)
Darwin Plus grant value	£323780
Start/end dates of project	1 July 2021/30 June 2024
Reporting period (e.g. Apr 2022-Mar 2023) and number (e.g. Annual Report 1, 2)	Apr 2022-Mar 2023; Annual Report 2
Project Leader name	Wayne Dawson
Project website/blog/social media	www.conservationecology.org/sg_bio_invasion.html Twitter: @SG_bio_invasion
Report author(s) and date	Pierre Tichit; Wayne Dawson 26.04.2023

1. Project summary

Climate change effects are marked on South Georgia (SG), with rapid glacial retreat. As warming continues, the island's unique terrestrial communities will respond more dynamically. SG continues to harbour non-native invasive plants and invertebrates, with some now so widespread that eradication is impractical, and posing the risk that changing communities will become dominated by non-native species. Eight invasive plant species will require longer term management to limit further spread. Invasive invertebrates include two novel predatory carabid beetle species, but their current distributions and magnitude of impacts on SG's invertebrate dominated fauna are unknown. In addition to current threats, future introductions of non-native species may pose a greater risk in a warmer climate; the Falkland Islands (FI), through which most traffic to/from SG is routed, is recognised as the most likely source of current high-risk invasive species. There is a pressing need to study how plant and invertebrate communities are changing with climate warming, and to understand how interactions between native and non-native species may impact future communities. We will address this by 1) generating baseline data on non-native colonisation of plant and invertebrate communities in deglaciated areas and at vegetation fronts, 2) identifying 'winners' and 'losers' among native and non-native plant species under simulated climate change, 3) establishing non-native invertebrate distributions and associations with native invertebrates and vegetation, and 4) identifying high risk species to SG under future climate change originating from FI. The Government of South Georgia and the South

Sandwich Islands (GSGSSI) support this project, because it will assist in meeting several objectives of the current biodiversity action plan: enhancing knowledge of SGSSI biodiversity and habitats, effectively managing non-native species, and evidence-based management. The GSGSSI has committed to continued management of invasive species beyond its current action plan and Non-Native Plant Management Strategy. Our project outputs will support future strategy development and joint biosecurity efforts between FI and SGSSI.

2. Project stakeholders/partners

The formal project partners have been fully engaged with the project this year. This included project partner individuals (W Dawson, Durham; R Newton, Kew; P Brickle, SAERI; P Convey, BAS).

All partners were present during two bi-yearly Project Management Committee Meetings chaired by Colin Clubbe (RBG Kew) in June 2022 and January 2023 (See Annex 3.1a and 3.1b with meeting minutes).

Additionally, an in-person 1.5 day workshop took place at Durham University in September 2022 with W Dawson, P Tichit, R Newton and P Convey (See Annex 3.2 with meeting agenda). A summary was shared with P Brickle who was unable to attend.

Three in-person meetings between Paul Brickle and Pierre Tichit were held in January 2023 (planning) and May 2022 and March 2023 (debriefing), respectively, prior and subsequent to both field seasons (See Annex 3.3 with agenda for the latest meeting).

Regular (at least bi-monthly) planning and discussion meetings between Wayne Dawson and Pierre Tichit were held (See Annex 3.4 for an example of notes after post-field season debriefing). Pierre Tichit is also interacting weekly with other members of DISc (<https://durhaminvasionscience.org>) and CEG (www.conservationecology.org) at Durham University.

Simon Browning, the field assistant for the second field season, was selected in December 2023 from 32 candidates following an early and broad advertisement of the position (See Tweet from SAERI: https://twitter.com/SAERI_FI/status/1581989632174338048) followed by detailed interview (Annex 3.5).

We have been in regular contact with representatives of the GSGSSI: the Director of Operations (emails and one online meeting for planning of 2nd field season, see Annex 3.5 for notes from this meeting), the Operations Manager (emails and direct interaction on South Georgia for planning of 2nd field season and season debrief), the Environment Manager (emails, one online meeting and direct interaction on South Georgia for Regulated Activity Permit (RAP) updates and scientific debrief), the Visitor Manager (emails and short in-person meeting in the Falklands for citizen science project and logistics). Pierre Tichit also organised a short in-person meeting with the Chief Executive on 7 March 2023 to present preliminary data and discuss biosecurity policies after the 2nd field season (See Annex 3.6 for slides from this presentation).

A new collaboration is being initiated with Prof David Renault (Rennes University, France) to compare the physiology and morphology of invasive carabid beetles (in relation to Output 3) in South Georgia and in the Kerguelen Islands (French OT). To enable this study, live carabid beetles were delivered to David Renault on 17 March 2023 and a detailed meeting with Pierre Tichit to coordinate the collaborative work took place (See Annex 3.7 for meeting minutes). Informal cooperation and knowledge transfer occurred with members of the invasive plant control team on South Georgia. For example, we shared geo-localised pictures of invasive berry lobelia (*Lobelia pratiana*) to facilitate eradication (See Annex 3.8 for picture with GPS coordinates), while members of the weed control team performed hand searches for invasive beetles on sites that were outside our reach (Ocean Harbour, Hound Bay).

3. Project progress

3.1 Progress in carrying out project Activities

On 11 April 2022, Pierre Tichit returned to Durham University after a short stay at partner institution SAERI, where a debriefing of the first field season with Paul Brickle took place. In June 2022, Project Management Committee Meeting 3 (1.14) took place to discuss outcomes of the first field season and plan future work (Annex 3.1a). Fulfilling activity 1.13, invertebrate and plant data from the three deglaciated sites surveyed in 2022 were identified with the help of a summer placement student, and subsequently collated and analysed by Pierre Tichit in September 2022 (See Annex 3.9 for an example of figures from this analysis). Three additional sites (around inland ice remnants) were surveyed during the second field season in January-February 2023 ((See Annex 3.10 for a picture of the field work). These new data need to be analysed and combined with the previous results from May-June 2022.

In May 2022, Wayne Dawson, Pierre Tichit and Rosemary Newton planned the climate simulation experiments for Output 2 (2.2). Pilot germination trials (See Annex 3.11 for results) were conducted over June and July 2022 to determine the appropriate methodology (contributing to 2.5). In parallel, the temperature and humidity settings that best emulate current and future climatic conditions on South Georgia were determined using WorldClim 2 and historical weather data (2.4, see Annex 3.12 for calculation), and material for the experiment was purchased (2.3). The experiment was set up with the support of 2 summer placement students in July and August 2022. Germination and then growth rates of the plants were monitored weekly from August to December 2022 (See Annex 3.13a for a picture of the growth experiment). In November, an undergraduate research project student was trained to lead the experiment and her support was essential to its completion. Unfortunately, one of the climate chambers broke during a weekend in mid-November, generating abnormally high temperatures for 50 hours, invalidating the data collected afterwards. On 5-12 December 2022, plants were harvested and dried to weigh shoot and root biomass (See Annex 3.13b). The experimental data (except biomass that has not been weighed yet) was collated and analysed on 6 January 2023 (activity 2.7, see Annex 3.14a and 3.14b for a summary of this analysis). On 5 January 2023, all partners agreed during the project Management Committee Meeting 4 (2.13, Annex 3.1b) to perform a follow-up experiment for Output 2, if possible, in 2023, since the climate chambers are being replaced by new reliable ones.

The planning of the second field season started in June 2022 through interactions with members of GSGSSI. Sampling locations and protocol were discussed during the physical workshop at Durham University in September 2022, fulfilling activities 3.1 and 3.2 (Annex 3.3). The Regulated Activity Permit (RAP) application was submitted to the Environment Officer on 30 November 2022 and approved on 9 January 2023 (3.3). The field season (including boat crossings) occurred between 14 January and 04 March 2023. Invertebrate communities were surveyed using pitfall traps and quantitative hand searches across 10 replicates of 7 habitat types (totalling 70 locations, 3.1), as well as across 10 replicates of elevation gradients (totalling 100 locations) leading to a total of more than 500 pitfall traps and 150 hand searches, exceeding the ambition levels of 3.6 (10 sites). Compilation of invertebrate and plant records was started on South Georgia and is now near completion (~80%, See Annex 3.15 for invertebrate records; please note, this annex should remain confidential).

To allow monitoring of sites that we were unable to visit due to logistical constraints, the citizen science project “Beetle vs Stones” was launched in collaboration with the Polar Collective (polarcollective.org) in October 2022 with online and physical material (See Annex 3.16a, 3.16b and 3.16c) aimed at tourist cruise guides and guests (contributing to 3.6 and 5.3/5.4). The project attracted attention on social media (twitter: #BeetlesVsStones) and enabled to gather at least 5 independent datasets. To complement this, an i-naturalist project gathering invertebrate records from South Georgia was created in May 2022 (www.inaturalist.org/projects/invertebrates-of-south-georgia-and-the-south-sandwich-islands). Numerous other outreach and communication activities occurred in 2022-2023 (see next section).

In February 2023, Wayne Dawson and Peter Convey discussed a preliminary list of invertebrate taxa with high invasion potential on South Georgia, to form the basis of the Horizon Scanning Output 4. This list is provided below:

Taxon	Common name	Known distribution in region
Invertebrates		
<i>Vespulina germanica</i>	German wasp	Navarino Island, Chile
<i>Trichocera</i> spp	Snow flies	<i>T. maculipennis</i> arrived on King George Island (Antarctica) from S America in 2006. Native range for genus: northern hemisphere (boreal). At least 1 species already present on SG
Formicidae: <i>Tetramorium caespitum</i>	Pavement ant	Chile (native to Europe, Siberia)
Blattodea	Cockroaches	Formally on SG, at whaling stations, died out without inhabitants.
Arachnida	1 species of Opiliones, 15 species of Araneae (spiders)	Falklands: see https://doi.org/10.1038/s41597-023-02113-2
Diplopoda	Centipedes	FI
Dermaptera Dermaptera: <i>Forficula auricularia</i>	Earwigs	FI, Chile
Isopoda: Oniscoidea	Woodlice	FI; other sub-Antarctic islands NZ
Turbellaria <i>Arthurdendyus triangulatus</i>	New Zealand Flatworm	Scotland, NZ
<i>Bockella</i>	Copepods	1 species in Antarctic, 2 recorded in SG FI
Dipterans	Various genera, including non-biting midges TBC	
<i>Culex</i> sp. <i>Aedes</i> sp.	Mosquitos TBC	
Aphis sp. Aphididae	Aphids: <i>Dysaphis crithmi</i> <i>Lachnus tatakaensis</i> <i>Macrosiphum euphorbiae</i>	FI
Pentatomidae (Heteroptera): <i>Halyomorpha halys</i>	Shield bugs	Chile
Reduviidae (Heteroptera): <i>Zelus renardii</i>	Assassin bugs	Chile
Coccinelidae:	Ladybirds: <i>Harmonia axyridis</i>	FI Chile

	Harmonia quadripunctata	
Odonata	Dragonflies	Navarino and Cape Horn islands
Coleoptera: <i>Chiasognathus grantii</i>	Darwin's beetle	FI

3.2 Progress towards project Outputs

Output 1. Presence of plant and invertebrate species (including non-natives) in areas of glacial retreat and vegetation fronts established.

We are mostly on track to achieve this output, with the data and samples of plant and invertebrate communities collected around tidal glaciers during the first field season in March-April 2022 being mostly compiled and analysed and 3 new inland deglaciating locations (Behind Husvik, Hodges Bowl, and Glacier Col (Annex 3.10)) collected in January-February 2023, leading to a total of 6 surveyed sites (SMART Indicator 1.1 to 1.4 complete for most sites). These data now need to be combined with data collected in three inland deglaciating sites from the second field season by the end of May 2023. We aim at submitting a manuscript in relation to Output 1 in August 2023.

Output 2. 'Winners' and 'losers' of competition between non-native plant species and native plant communities under climate change (ex-situ experiment) identified

We made significant progress on this output: climate simulation germination and growth experiments were carried out to near completion (except biomass measurements) from May to December 2022 (Annex 3.11 to 3.14). Unfortunately, due to a malfunction of the climate chambers, the data generated are not reliable for a peer-reviewed publication. To allow a second run of the experiment, we collected fresh seeds from 7 invasive and 7 native plants during the field season in February 2023 (Annex 3.17). Preliminary results are therefore available in time for indicators 2.4 and 2.5, but higher quality results are not to be expected before the end of 2023. We aim to perform a higher quality follow-up of the experiment over the summer and autumn of 2023. We believe that this significant delay in the schedule is necessary to guarantee the completion of a high-quality Output 2.

Output 3. Distribution of invasive carabid beetles, native herbivorous beetles and association with each other and vegetation types established

We are entirely on track to completing this output, with ample amount of data collected during the second field season (~100 locations across three peninsulas, indicators 3.1 and 3.2, Annex 3.18a and 3.18b) as well as some viable observations at inaccessible locations realized via the citizen science project "Beetles vs Stones". Given the low productivity of Tullgren funnels in 2022, we did not take soil samples at each site (indicator 3.3). Compilation of invertebrate and plant records is near completion and should be finished by mid-May 2023 (Annex 3.15). Most macroarthropods were identified at species level (3.3), while smaller invertebrates were often assigned to broader categories (e.g., Abatid mites). Data analyses and write up will be performed in summer 2023 with a submission goal of September 2023. The data collected for Output 3 will support existing collaborations with e.g. Prof David Renault or future cooperative work to be determined with the help of project partner Peter Convey.

Output 4. Non-native terrestrial species from FI that pose greatest invasion risk to SG under a future climate identified

The work for this output started in February 2023 as Wayne Dawson and Peter Convey established a preliminary list of plant and invertebrate species present on the Falklands that may pose a high risk of invading South Georgia. While we will have a list of 50 species to

screen by July 2023 (Indicator 4.1), we anticipate a delay in screening for climate suitability into the summer of 2023.

Output 5. Increased awareness of invasive species and climate change impacts on SG

The project's webpage (http://www.conservationecology.org/sg_bio_invasion.html) and twitter account (https://twitter.com/SG_bio_invasion) are regularly updated with increasing engagement being monitored regularly (Annex 3.19 for a log, fulfilling 5.1). The citizen science project "Beetle vs Stones" (Annex 3.16) launched in October 2023 also contributes to raising the awareness of invasive species among tourist operators and guests (5.3 and 5.4).

Other outreach and communication activities that occurred in 2022-2023 are listed below:

- 3 August 2022: the webinar was replaced by a video compilation of the Field Team's experiences during the first field season: <https://youtu.be/fazRVLus1h8>
- 8 August 2022: Online scientific presentation by Pierre Tichit at SCAR (Science Committee on Antarctic Research) conference 2022: <https://www.youtube.com/watch?v=YAAksQcX1TU> (starts at 1.08.50).
- 23 August 2022: In-person presentation (Annex 3.20) by Pierre Tichit at 6th European Congress of Conservation Biology (Czech Republic).
- 12-16 September 2022: Online poster by Pierre Tichit at Neobiota Conference (www.elus.ee/index.php/en/neobiota-tartu-2022).
- 23 September 2022: In-person presentation by Pierre Tichit at Durham University for the Postdoc Appreciation Day.
- 17 November 2022: In-person poster by Pierre Tichit at the Polarforum conference (Sweden, www.polar.se/en/research-support/polarforum).
- 23 February 2023: In-person outreach presentation by Pierre Tichit and Simon Browning at King Edward Point BAS station on South Georgia (https://twitter.com/SG_bio_invasion/status/1628932808952389633).
- 1 March 2023: Interview of Pierre Tichit and Simon Browning with conservation journalist Gregory Taylor (<https://gregtaylorcamera.com/>) on South Georgia.
- 2 March 2023: In-person outreach presentation by Pierre Tichit and Simon Browning for the guests and crew of National Geographic Explorer ship (https://twitter.com/SG_bio_invasion/status/1631689249446678528).
- 22 March 2023: Release of an interview of Pierre Tichit to Falkland Islands TV in
- 1 April 2023: Release of an interview on page 6 of the South Georgia Association Newsletter, Number 44 (Annex 3.21) (<https://southgeorgiaassociation.org/newsletters-latest-unprotected/>).

While we are aware that the activities listed above do not exactly match the ones planned in the log frame, we believe that they all efficiently contribute to the main output of increasing awareness of invasive species and climate change impacts on South Georgia.

3.3 Progress towards the project Outcome

The project Outcome is that 'South Georgia's evidence-based management of invasive species will be improved by identifying which non-native species pose the greatest risk to SG (pre- and post-introduction) in a future climate.'

We have nearly reached indicator 0.1 "Species in early successional communities identified in at least 3 sites by October 2022." Because we have surveyed plant and invertebrate communities

in 6 deglaciated sites overall, thus exceeding the initial goal, and that identification and data analysis will be finished in the coming months; we are confident that this indicator will be reached.

We have made important efforts to reach indicator 0.2 “‘Winning’ and ‘Losing’ plants under future climate identified, among at least 14 species (8 invasive and 6 native) by July 2023”, but malfunction in the equipment prevented us from generating fully reliable data by the scheduled deadline. We are planning a follow-up climate simulation experiment over 2023 with new equipment, and thus despite some delays, we are confident we will achieve this indicator.

We are confident that achieving indicator 0.3 “Associations between vegetation type and occurrence of invertebrates established by October 2023” is entirely possible within the time frame indicated. We have collected data during the second field season that largely exceeds the ambitions of SMART indicators 3.1 and 3.2.

For indicator 0.4 “Top 10 plant and invertebrate species present on FI that pose a high invasion risk to SG under future climate identified by March 2024”, we have recently initiated the work in February 2023. As explained above we will have at least 50 species ready for screening by July 2023, and climate suitability of those species will be quantified over the summer.

For indicator 0.5 “Final workshop on evidence base for future management and biosecurity by June 2024”, we do not anticipate beginning to plan for this until late 2023, although we are making sure to engage regularly with GSGSSI (see section 2) to facilitate future interactions towards the final workshop.

3.4 Monitoring of assumptions

0.1 Covid pandemic subsides, allowing field work to proceed

Correct

0.2 Weather conditions allow boat access to SG and access to field sites for surveys

Weather was less limiting during the second field season that occurred earlier in the summer than the first field season.

0.3 Seeds are viable and germinate in sufficient quantity to allow climate experiment and germination trials to proceed

This assumption was proven largely valid (Annex 3.11), except for the invasive species *Agrostis capillaris*, that did not seem to produce any viable seed.

0.4 Species samples from the field are identifiable

The plants were all identifiable to species level in the field. Most macro-arthropods were identified at species level (cf. Annex 3.15), while smaller invertebrates are often assigned to broader categories (e.g., Abatid mites). The involvement of Peter Convey and his collaborators in the coming months may improve the taxonomic accuracy for some groups (e.g., Collembola).

1.1 Covid pandemic subsides by field season in year 1, permitting fieldwork

See comment on Assumption 0.1

1.2 Weather conditions permit safe completion of surveys, and access to field sites

See comment on Assumption 0.2

1.3 Plant and invertebrate species are identifiable

See comment on Assumption 0.4

1.4 Covid restrictions lifted to allow UK-based partner meeting at BAS (Cambridge)

This assumption was incorrect but the meeting was held online and an in-person meeting occurred at Durham University in September 2022.

2.1 Seeds from SG and MSB collections are viable and germinate in sufficient numbers

See comment on Assumption 0.3

2.2 Growth chambers at Durham continue to function well at required climate settings

This assumption, although initially correct for the first half of the climate simulation experiment, was ultimately incorrect, leading to suboptimal data.

3.1 Covid pandemic subsides by field season in year 2, permitting fieldwork

See comment on Assumption 0.1.

3.2 Weather conditions permit safe completion of surveys, and access to field sites

See comment on Assumption 0.2.

3.3 Invertebrate species are identifiable

See comment on Assumption 0.4.

4.1 Evidence base will be successfully obtained from Outputs 1-3

We are confident this assumption will hold for Output 1 and 3 and will try our best to hold it for Output 2.

4.2 Travel to FI for final workshop will be possible in 2024 (Covid and weather permitting)

We are confident that by 2024, covid will not be the barrier it used to be.

5.1 Work in Outputs 1-4 is delivered on time for webinar content

This assumption will only partially hold, because we had to delay creating the first webinar content due to the delay in the first field season and the prioritisation for organising the fieldwork. However, we have replaced some of the webinar activities with superior outreach activities (see section 3.2).

5.2 Webinars are sufficiently advertised to attract a wide audience

See assumption 5.1.

5.3 Tourists will view posters and leaflets, and want to search for more information

This has proven to be true so far as shown by the engagement of some cruise operators and tourist with our citizen science pilot, as well as with our team during a popularization talk onboard NG explorer.

4. Project support to environmental and/or climate outcomes in the UKOTs

As mentioned in the previous annual report, Wayne Dawson contributed insights and ideas to the South Georgia Government's new Non-Native Plant Management Strategy, informed by this project.

Through online and in-person interactions, members of GSGSSI have already been made aware of some of the key preliminary findings of the two field seasons, such as the increase of the distribution of the invasive carabid beetles over the past 15 years (See Annex 3.6). Moreover, our team discovered the presence of a new non-native species of ladybird in January 2023, which we made sure to rapidly communicate to GSGSSI members on the ground. We are planning to

release a scientific description of this species in June 2023 in collaboration with the Environment and Biosecurity Officer and discuss early mitigation measures. Overall, findings from our project and regular interaction with GSGSSI are key to support the strengthening of South Georgia's biosecurity strategy.

5. Gender equality and social inclusion

We ensured that the hiring process of the field assistant for the second field season was broad and unbiased thanks to an early and broad advertisement of the position and a detailed interview. We selected Simon Browning based on his skill, merits and to allow knowledge transfer with local stakeholders in the Falklands.

Please quantify the proportion of women on the Project Board ¹ .	25 %
Please quantify the proportion of project partners that are led by women, or which have a senior leadership team consisting of at least 50% women ² .	25 %

6. Monitoring and evaluation

Project Management Committee meetings every six months are central to the monitoring and evaluation of the project. We have had two such meetings this year (Annex 3.1a and 3.1b), chaired by Dr Colin Clubbe (Kew) to ensure a level of independence in evaluation of project progress. An additional part of the M and E plan is to hold a final meeting of project partners and stakeholders (GSGSSI) at the end of the project workshop in 2024, to identify pathways for project outputs to be implemented into the GSGSSI strategy on biosecurity and invasive species management.

Even before the final workshop and meeting of the project, we will have generated unique data sets on the invertebrate communities of SG as a result of our two field seasons. Invertebrate communities have received less research attention and are therefore less understood than other taxa. We have also established new chronosequences in deglaciated areas, which will enable the GSGSSI to monitor future development of plant and invertebrate communities in these areas.

Our indicators of achievement primarily involve i) generation of datasets from the field seasons establishing the distribution of invasive plants and invertebrates, linked to Outputs 1 and 3; ii) the results of the plant growth experiment assessing the winners and losers of a future climate scenario; iii) the list of plant and invertebrate species posing the highest invasion risk to SG under a future climate; iv) increased awareness of invasive species on SG. Measurement of i) to iii) are simply obtained through the datasets/results outputs. Measurement of iv) is more complex, and will involve recording engagement with the project through Twitter likes and retweets, webpage views and iNaturalist collection project engagement.

There have been no changes to the M and E plan since the start of the project. While the project lead is responsible for ensuring delivery of the M and E plan, all project partners and the stakeholders (GSGSS) contribute through the plan meetings.

7. Lessons learnt

Due to the turnover of staff of GSGSSI, it was important to start the planning of the second field season early and to initiate efficient relationships with the new members of the team.

¹ A Project Board has overall authority for the project, is accountable for its success or failure, and supports the senior project manager to successfully deliver the project.

² Partners that have formal governance role in the project, and a formal relationship with the project that may involve staff costs and/or budget management responsibilities.

Keeping a detailed but flexible survey work plan for the second field season was important to optimise the time and efforts deployed on South Georgia, since some events (poor weather, medical emergency, boat availability) are unpredictable.

Assumption 2.2 that the climate chambers at Durham University would work well was premature, which underlines the absolute necessity to ensure that new equipment is reliable before carrying out a follow-up of the experiment in 2023. This is highly likely to be met, because the chambers will be tested prior to use.

In retrospect, southbound flights for PDRA Pierre Tichit should have been bought earlier, since we did not anticipate that nearly all flights in January 2023 would be fully booked (because of return from winter holiday and many postponed flights in December 2022). However, there was no overall detriment to the project.

Knowledge transfer and mutual support from formal (GSGSSI) and informal (e.g., weed control team) stakeholders can be very beneficial and will be fostered in the following parts of the project (see section 2). We will make sure to publish the raw data from this project entirely and in open access for future stakeholders to use.

8. Actions taken in response to previous reviews (if applicable)

We ensured to update our website more regularly and to acknowledge Darwin plus by adding its logo to all our outreach material and/or by orally stating that the project is financially supported by Darwin PLUS.

After reflection and consultation with all the partners, we appreciated the relevance of having an external chair (Colin Clubbe) during our bi-yearly Project Management Committee Meetings. The Chair is in a unique position of having a good knowledge of South Georgia and the conservations/research/logistical issues at play there, and so he can provide valuable insights and judgement on the project's activities that few others would be capable of doing.

In order to prepare early for the workshop with GSGSSI at the end of the project, we are making sure to engage regularly with GSGSSI (see 2.). A report summarizing our preliminary findings will be written and shared with GSGSSI by the end of summer 2023.

9. Risk Management

We have attached the risk assessment (Annex 3.22) that has been approved by Durham University and GSGSSI prior to the second field season.

10. Other comments on progress not covered elsewhere

The increased costs of boating operations for 2023 originally diminished our ambitions to survey the full geographical extent of the invasive beetles. However, we circumvented this limitation by launching the citizen science project "Beetles vs Stones" that contributes to both scientific Output 3 and awareness-raising Output 5.

11. Sustainability and legacy

The profile of the project has been promoted through the two permit applications (See Annex 3.23 for the approved RAP of the second field season) and through a successful completion of

the two field seasons. As a result of in-depth interactions with most of its members (see sections 2 and 4), the GSGSSI has a clear understanding of the project aims and preliminary findings so far.

Numerous communication activities (See Section 3.2 for a full list) towards local (e.g., FITV) and global (e.g., Neobiota conference) audiences contribute to ensure the legacy of the project. The most important legacy for the project will be the datasets collected, and how the results from data analyses will contribute to future GSGSSI habitat, species and biosecurity management plans.

Following feedback from Darwin PLUS after the first annual report and in order to ensure a good knowledge transfer to stakeholders during and after the project, we have intensified our engagement with GSGSSI (see 2.). A report summarizing our preliminary findings will be written and shared with GSGSSI by the end of summer 2023. We also engaged with other important stakeholders such as the tourism industry and IAATO (engaging with guests onboard the cruise ships NG explorer and Hanseatic Spirit, via an outreach presentation (see section 3.2), the citizen science project, conservation practitioners (GSGSSI weed control team) and media outlets (FITV and SG Newsletter (Annex 3.21)).

12. Darwin Plus identity

We acknowledge Darwin plus by adding its logo to all our outreach material and by verbally stating that the project is funded by Darwin PLUS (in email correspondence, social media, and in conversation).

13. Safeguarding

Has your Safeguarding Policy been updated in the past 12 months?	No
Have any concerns been investigated in the past 12 months	No
Does your project have a Safeguarding focal point?	No
Has the focal point attended any formal training in the last 12 months?	No
What proportion (and number) of project staff have received formal training on Safeguarding?	Past: 100% Planned: 0%
Has there been any lessons learnt or challenges on Safeguarding in the past 12 months? No	
Does the project have any developments or activities planned around Safeguarding in the coming 12 months? No	

14. Project expenditure

Please expand and complete Table 1. If all receipts have not yet been received, please provide indicative figures and clearly mark them as Draft. The Actual claim form will be taken as the final accounting for funds.

Table 1: Project expenditure during the reporting period (1 April 2022 – 31 March 2023)

Project spend (indicative) in this financial year	2022/23 D+ Grant (£)	2022/23 Total actual D+ Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				

Capital items				
Others (Fieldwork survey materials)				
TOTAL			-10.9	The underspend has occurred because i) travel and subsistence costs were brought forward from FY 2023/2024 to 2022/2023 with Darwin agreement. This was done due to genuine concerns about the predicted increases in operating/ T and S costs for the 2023 field season. However, ii) we made significant savings in the second field seasons for reasons stated above, as well as having underspend in staff costs and overheads. Note that the final variance may differ due to some costs being estimated.

Table 2: Project mobilising of matched funding during the reporting period (1 April 2022 – 31 March 2023)

	Matched funding secured to date	Total matched funding expected by end of project
Matched funding leveraged by the partners to deliver the project.		

Total additional finance mobilised by new activities building on evidence, best practices and project (£)	

15. **OPTIONAL: Outstanding achievements or progress of your project so far (300-400 words maximum). This section may be used for publicity purposes**

Annex 1: Report of progress and achievements against logframe for Financial Year 2022-2023 – if applicable

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
<p>Impact</p> <p>South Georgia’s dynamic terrestrial communities are protected from invasion by non-native plants and invertebrates</p>		<p>Early detection of non-native ladybird beetle opening possibilities of monitoring and eradication if necessary</p>	
<p>Outcome</p> <p>South Georgia’s evidence-based management of invasive species will be improved by identifying which non-native species pose the greatest risk to SG (pre- and post-introduction) in a future climate</p>	<p>0.1 Species in early successional communities identified in at least 3 sites by October 2022</p> <p>0.2 ‘Winning’ and ‘Losing’ plants under future climate identified, among at least 14 species (8 invasive and 6 native) by July 2023</p> <p>0.3 Associations between vegetation type and occurrence of invertebrates established by October 2023</p> <p>0.4 Top 10 plant and invertebrate species present on FI that pose a high invasion risk to SG under future climate identified by March 2024</p> <p>0.5 Final workshop on evidence base for future management and biosecurity by June 2024</p>	<p>0.1 Three sites surveyed in April-May 2022. 3 additional inland deglaciation sites surveyed during 2023 field season, leading to a total of 3 tidal glacier + 3 inland glaciers = 6 sites.</p> <p>0.2 Completed the collection of seeds during field season 2023 to reach 7 invasive and 7 native species.</p> <p>0.3 Invertebrate communities surveyed quantitatively during field season 2023 across 10 replicates of 7 habitat types (total 70 locations).</p> <p>0.4 Preliminary list of species present on FI started to be elaborated in February 2023 by Wayne Dawson and Peter Convey.</p> <p>0.5 Work on this objective is due to commence in 2024. Preliminary informal meetings with GSGSSI occurred in 2022-2023.</p>	<p>0.1 Finalize data analysis and write-up of report for GSGSSI and paper for publication</p> <p>0.2 Improved version of climate growth experiment to be designed and executed; data collection and analysis</p> <p>0.3 Identification of invertebrates to be finalised by May 2023. Data analysis and write-up.</p> <p>0.4 Design and perform analysis to determine climate suitability of target species in a future climate</p> <p>0.5 Short report summarizing intermediate key findings to be shared with GSGSSI in 2023. Online meeting to discuss results with GSGSSI representatives.</p>
<p>Output 1. Presence of plant and invertebrate species (including non-</p>	<p>1.1 At least 3 sites suitable for survey located and selected using</p>	<p>Plant and invertebrates at three deglaciated tidal glacier sites were sampled in 2022, processed and analyzed over the summer 2022 (fulfilling 1.2, 1.3 and</p>	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
natives) in areas of glacial retreat and vegetation fronts established	<p>SAERI World View vegetation data by December 2021</p> <p>1.2 At least 3 sites surveyed for plant species present and % cover estimated March 2022</p> <p>1.3 Pitfall traps and soil cores taken, invertebrate species identified for at least 3 sites by March 2022</p> <p>1.4 By December 2022: Colonisation of communities by native versus non-native species (richness and abundance) compared and analysed; diversity and composition of communities among sites analysed</p>	1.4). This data now needs to be combined with data collected in three inland deglaciaded sites from the second field by the end of May 2023.	
1.1 Project Management Group Meeting [PMGM] 1 (online)		Complete	NA
1.2 Recruit PDRA and Field Assistant		Complete	NA
1.3 Draw up Memorandum of Collaboration between Project Partners		Complete	NA
1.4 Select at least 5 sites suitable for plant and invertebrate communities in areas of glacier retreat and vegetation fronts		Complete	NA
1.5 UK-based project partners meet at BAS (Cambridge) for fieldwork planning; PDRA to obtain plant and invertebrate ID information		Online meeting complete	NA
1.6 Produce fieldwork protocols for first field season, including details of survey sites		Complete	NA
1.7 Apply for SG fieldwork permits		Complete	NA

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
1.8 Organise logistics for first field season (PDRA travel to FI, onward transport to SG, SG accommodation, purchase and transport of field kit, on-island boat transport)		Complete	NA
1.9 Project meeting in Stanley, FI prior to first field season (WD, PC and RN to join online, for PMGM 2)		Meeting online/continued organisation via Whatsapp group	NA
1.10 PDRA/Field Assistant first field season on SG: Plant and invertebrate communities surveyed, collection of unidentifiable plant samples, collections of seeds for experiments where possible		Complete	NA
1.11 PDRA and plant samples return to UK: plant samples stored for molecular analysis at Kew		Complete	NA
1.12 Plant DNA extracted and sequenced to verify species ID of unidentified samples (Kew)		No plants were unidentifiable such that DNA extraction was not needed.	No action required.
1.13 Plant and invertebrate community data compilation and analysis after PDRA return to UK		Complete	Combine with data and analysis of 3 newly-surveyed inland glacier sites.
1.14 Project Management Group Meeting 3 (online)		Complete (Annex 3.1a)	NA
1.15 Write up and submit plant and invertebrate community manuscript for peer-reviewed publication		To be completed	Final analysis and write-up will be completed by
Output 2. 'Winners' and 'losers' of competition between non-native plant species and native plant communities under climate change (ex-situ experiment) identified	<p>2.1 By October 2021: 8 invasive and at least 6 native plant species selected for experiment and germination trials; seeds obtained from MSB Kew</p> <p>2.2 Climate experiment conducted; plant growth rate and biomass measured for 14 species by July 2022</p> <p>2.3 Germination trials of at least 6 native species conducted; %</p>	<p>The germination and growth experiments were conducted over the summer and autumn of 2022 (2.2, 2.3) and most of the data was analysed in January 2023 (Annex 3.14a and 3.14b). The reliability of the data is questionable due to malfunctions of the climate chambers. The aim is to perform a higher quality follow-up of the experiment over the summer and autumn of 2023. To allow this, we collected fresh seeds from 7 invasive and 7 native plants during the field season in February 2023. One species- <i>Lobelia pratiana</i> - has been so successfully reduced in abundance by invasive plant management on SG, that we will not be using it in our experiment. Preliminary results are already available in time for 2.4 and 2.5, but higher quality results are to be expected by the end of 2023.</p>	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
	<p>germination data obtained by April 2023</p> <p>2.4 Performance of at least 6 native and 8 invasive plant species under future climate compared to current climate by December 2022</p> <p>2.5 Germination success under future climate change established for at least 6 native species by July 2023</p>		
2.1 Select native and invasive plant species for climate experiment and germination trials		Complete	NA
2.2 Durham and Kew-based project partners meet online, to draw up experiment/trial plans; obtain seeds from Kew if required		Complete	NA
2.3 Order materials required for experiment/germination trials		Complete	Order any extra material needed for follow-up
2.4 Identify current and future (year 2060) climate and light regimes for realistic experimental treatments and germination trial conditions		Complete	Rely on microclimate data collected in early 2023 using TOMST loggers (Annex 3.24) and from BAS historical recordings.
2.5 Durham and Kew: Apply any germination pre-treatments to seeds prior to sowing, as required, and sow		Complete	No treatment applied for follow-up
2.6 Durham: Set up and conduct climate experiment		Complete	Follow-up experiment will be set up in June/July 2023
2.7 Durham: Terminate experiment, harvest biomass, weigh and collate data		Complete except for weighing of biomass	Weigh biomass and add to results. Do for follow-up experiment.
2.8 Kew: Conduct germination trials in incubators at current and future climates		Complete	Coordinate with Kew to identify germination trials that may be

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
			needed. Send seeds and perform if necessary.
2.9 Kew: Terminate germination trials, collate data and publish in Kew's seed information database		To be done	Data to be collated and added to Kew's database
2.10 Durham: Data compilation and analysis from climate experiment		Complete except for biomass	Add biomass to results of first field season. Do analysis for follow-up experiment.
2.11 Write up and submit manuscript for Durham climate experiment and germination trials for peer-reviewed publication		To be done	Manuscript to be prepared in the end of 2023- start of 2024.
2.12 Write up and publish year report online, combining key results and progress for Outputs 1 and 2		To be done	Report to be written and uploaded on to GSGSSI website by end of summer 2023, including Output 1, 2 and 3.
2.13 Project Management Group Meeting 4 (online)		Complete (Annex 3.1b)	NA
2.14 Analyse and write up results of seed germination trials		To be done	Report/publication to be written up in 2023
Output 3. Distribution of invasive carabid beetles, native herbivorous beetles and association with each other and vegetation types established	<p>3.1 At least 10 sites for surveys across vegetation types identified by December 2022</p> <p>3.2 Hand-search surveys conducted, presence and abundance of beetle species recorded at each site by March 2023</p> <p>3.3 Pitfall traps and soil samples taken at each site; invertebrates identified to species level by March 2023</p> <p>3.4 Distribution of invasive carabids updated and relationship to native</p>	<p>Planning of second field season completed in summer and fall of 2023. The field season (including boat crossings) occurred between 14/01 and 04/03. Invertebrate communities were surveyed using pitfall traps and quantitative hand searches across 10 replicates of 7 habitat types (total 70 locations, 3.1), as well as across 10 replicates of elevation gradients (total 100 locations) leading to a total of more than 500 pitfall traps and 150 hand searches (3.2). Given the low productivity of Tullgren funnels during the 2022 season, soil samples were not extracted, but litter and moss samples were used to sample microinvertebrates (3.3). About 80% of invertebrates are identified manually and this will be completed by May 2023 (3.3.). Preliminary data showing an important spread of invasive carabids compared to previous surveys (Annex 3.6, 3.4). Output 3 will be analysed and results written-up during the summer 2023 with a submission goal in September 2023 (3.5).</p>	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
	beetles and vegetation described by July 2023 3.5 Effects of vegetation type and invasive carabid presence on invertebrate community composition identified by October 2023		
3.1 Identify at least 10 sites for invertebrate survey work on SG, across vegetation types		Complete	NA
3.2 UK-based project partners meet at Durham, plan surveys for 2nd SG fieldwork season, and produce fieldwork protocols		Complete (Annex 3.2)	NA
3.3 Reapply/update permits for fieldwork on SG as necessary		Complete (Annex 3.23)	NA
3.4 Purchase materials required for survey fieldwork		Complete	NA
3.5 Organise transport and accommodation logistics for 2nd fieldwork season		Complete	NA
3.6 PDRA travels to FI, and then on to SG for 2nd fieldwork season: survey 10 sites for invasive and native invertebrate species presence and abundance		Complete	NA
3.7 Compilation and analysis of invertebrate survey data		To be continued	Data compilation to be done by mid-May 2023. Data analyses and write up to be done in summer 2023.
3.8 Write up and publish year report on field season and results online		To be done	Report to be written and uploaded on to GSGSSI website by end of summer 2023, including Output 1, 2 and 3.
3.9 Project Management Group Meeting 5 (online)		To be done	In person meeting scheduled for May 2023. Project management meeting scheduled for June/July 2023.

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
3.10 Write up and submit manuscript of analyses assessing relationship between invasive and native vertebrate distributions for peer-reviewed publication		To be done	Submission goal by end of September 2023
Output 4 Non-native terrestrial species from FI that pose greatest invasion risk to SG under a future climate identified	<p>4.1 At least 50 plant and invertebrate species present on FI screened for climate suitability on SG under year 2060 climate scenarios by July 2023</p> <p>4.2 Horizon scanning exercise conducted with project partners and beneficiaries, future climate invaders prioritised from 4.1 according to invasion risk (product of severity of impact and likelihood of arrival and establishment). Top 10 high-risk species identified by March 2024</p> <p>4.3 By June 2024: Information from all 4 outputs synthesised in a final workshop attended by at least 10 beneficiary participants based in Stanley FI/remotely, hosted by SAERI; priorities for FI-GSGSSI discussed</p>	<p>Meeting between P. Convey and W Dawson held in February 2023, to begin building a list of naturalising and invasive invertebrates occurring within the wider region (Chile, Falkland Islands, Antarctica, Sub-Antarctic islands except SG). The preliminary list is provided in Section 3.1. Addition species will be considered and a subset added to the list based on the following recent publications: Antarctic/sub-Antarctic (Leihy et al. 2023, Scientific Data: https://doi.org/10.1038/s41597-023-02113-2); in Chile (Lopez et al. 2023, NeoBiota: https://doi.org/10.3897/neobiota.81.87362).</p> <p>Plant species will be added to the list based on a search of the Leihy et al. (2023) data-set and the Global Naturalized Alien Flora database (www.glonaf.org). The list of at least 50 species will be completed by end of May 2023, and we anticipate climate suitability will be calculated for all species by September 2023.</p>	
4.1 Plan remote horizon-scanning exercise details and invite beneficiaries representatives as well as project partner organisations to participate. Exercise will be done virtually, using Zoom and Slack platforms		To be done	Start planning in first half of 2023
4.2 Identify at least 50 species of plants and invertebrate present on FI but not yet on SG (distinguish whether native or non-native to FI)		To be done	Start building list in first half of 2023

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
4.3 Model species distributions and project resulting models onto SG to quantify and rank climate suitability under year 2060 climate for best, medium and worst-case socioeconomic pathway scenarios		To be done	Design species distribution modelling approach in first half of 2023; run models in second half of 2023.
4.4 Disseminate list of species screened for climate suitability to participants for opinion on the invasion risk of each species focusing on entry, establishment, spread and impact risk		To be done	Dissemination by November 2023
4.5 Gather participant opinions and categorise species according to perceived risk across participants. Present categorised list to stakeholders and elicit feedback		To be done	Information returned by February 2024
4.6 Adjust risk-categorised list of species based on (dis-)agreements until a consensus list is reached, and top-10 high-risk species under a future climate are identified		To be done	Consensus list produced by end March 2024
4.7 Plan final workshop in Stanley, FI: invite attendees from FI-based beneficiaries, organise travel and accommodation, secure venue and organise materials		To be done	Begin planning workshop in November 2023
4.8 Project Management Group Meeting 6 (online)		To be done	Meeting scheduled for January 2024
4.9 Prepare delivery of workshop		To be done	Preparation in late 2023/early 2024
4.10 Write up final year project report, including outcome of horizon-scanning exercise		To be done	Complete report by June 2024
4.11 Hold project final workshop in FI: present findings; discuss horizon-scanning exercise outcome; discuss how project findings can best inform GSGSSI management strategy		To be done	Hold workshop in April-June 2024
4.12 Project Management Group Meeting 7 (online)		To be done	Hold Meeting in June 2024
4.13 Submit analyses of horizon-scanning exercise for peer-reviewed publication		To be done	Publication write-up and submission by June 2024

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
Output 5 Increased awareness of invasive species and climate change impacts on SG	<p>5.1 Project information provided to a global audience via a webpage created by September 2021</p> <p>5.2 Project findings presented to interested audience in webinars held in Dec 2021, Dec 2022, Dec 2023 and July 2024</p> <p>5.3 Awareness raised of invasive species on SG among tourists visiting via a poster, by February 2023</p> <p>5.4 Awareness raised among Antarctic tourists via a digital information leaflet by December 2023</p>	<p>A project webpage (http://www.conservationecology.org/sq_bio_invasion.html) and a project Twitter account (https://twitter.com/SG_bio_invasion) have been created and updated (fulfilling 5.1). A short video describing the work and experiences of the first field season was created in August 2022 (5.2). The pilot citizen science project "Beetle vs Stones" was launched in collaboration with the Polar Collective in October 2022 with online and physical material (Annex 3.16) aimed at tourist cruise guides and guests which contributes to 5.3 and 5.4.. The possibility to continue this citizen science project in future years will be discussed in 2023 with the Polar Collective and GSGSSI and IAATO. Additionally, an i-naturalist project gathering invertebrate records from South Georgia was created in May 2022 (www.inaturalist.org/projects/invertebrates-of-south-georgia-and-the-south-sandwich-islands). Several media and outreach activities towards diverse audiences were performed in 2022-2023 (cf. section 3.2 for a full list), which reinforces indicator 5.1 and 5.2.</p>	
5.1 Create and launch project webpage, promote on Twitter and partner websites		Complete	Continue updating webpage and tweeting with news on project progress
5.2 Advertise 1st project webinar on Twitter/through Scientific Committee on Antarctic Research and its Integrated Science for the Sub-Antarctic sub-group (SCAR/ISSA), IAATO, SGHT; collect registration		Complete	NA
5.3 Hold 1st project webinar, embed recording on project webpage, promote on Twitter		Complete	NA
5.4 Write blog about first field season on project web-page, promote on Twitter		Complete	NA
5.5 Advertise 2nd project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration		To be done	Consider replacing by a short video about second field season to be recorded during the summer 2023

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
5.6 Hold 2nd project webinar, embed recording on project webpage, promote on Twitter		To be done	See 5.5
5.7 Write blog about Output 2 experiments on project web-page, promote on Twitter		To be continued	Add summary of preliminary results on webpage
5.8 Advertise 3rd project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration		To be done	Advertise webinar in November 2023
5.9 Hold 3rd project webinar, embed recording on project webpage, promote on Twitter		To be done	Hold webinar in December 2023
5.10 Write blog about second field season on project web-page, promote on Twitter		To be done	Add blog to webpage in June 2023
5.11 Advertise 4th project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration		To be done	Advertise webinar in June 2024
5.12 Create and display hard-copy poster at Grytviken Museum, SG; make digital version available on webpage		Replaced by Beetles vs Stones	Continue interactions with SGHT to display an information board about invertebrates on South Georgia feeding from the project's results in Fall 2023.
5.13 Create and disseminate digital leaflet to tour operators via IAATO		Replaced by Beetles vs Stones	Update leaflet and material depending on continuation of citizen science pilot
5.14 Hold 4th project webinar, embed recording on project webpage, promote on Twitter 5.15 Write blog about Output 4 and final project workshop on project web-page, promote on Twitter		To be done	Hold webinar in July 2024

Annex 2: Project’s full current logframe as presented in the application form (unless changes have been agreed)

Project summary	SMART Indicators	Means of verification	Important Assumptions
<p>Impact: South Georgia’s dynamic terrestrial communities are protected from invasion by non-native plants and invertebrates</p>			
<p>Outcome: South Georgia’s evidence-based management of invasive species will be improved by identifying which non-native species pose the greatest risk to SG (pre- and post-introduction) in a future climate</p>	<p>0.1 Species in early successional communities identified in at least 3 sites by October 2022</p> <p>0.2 ‘Winning’ and ‘Losing’ plants under future climate identified, among at least 14 species (8 invasive and 6 native) by July 2023</p> <p>0.3 Associations between vegetation type and occurrence of invertebrates established by October 2023</p> <p>0.4 Top 10 plant and invertebrate species present on FI that pose a high invasion risk to SG under future climate identified by March 2024</p> <p>0.5 Final workshop on evidence base for future management and biosecurity by June 2024</p>	<p>0.1 Summary report published on GSGSSI website</p> <p>0.2 Datasets from Outputs 1-3 compiled, analysed and shared with FI government and GSGSSI and publicly available</p> <p>0.3 Articles from Outputs 1-3 submitted as peer-reviewed publications</p> <p>0.4 List of high-risk plant and invertebrate species under climate change resulting from horizon-scanning exercise</p> <p>0.5 Workshop report and proceedings</p>	<p>0.1 Covid pandemic subsides, allowing field work to proceed</p> <p>0.2 Weather conditions allow boat access to SG and access to field sites for surveys</p> <p>0.3 Seeds are viable and germinate in sufficient quantity to allow climate experiment and germination trials to proceed</p> <p>0.4 Species samples from the field are identifiable</p>
<p>Output 1 Presence of plant and invertebrate species (including non-natives) in areas of glacial retreat and vegetation fronts established</p>	<p>1.1 At least 3 sites suitable for survey located and selected using SAERI World View vegetation data by December 2021</p> <p>1.2 At least 3 sites surveyed for plant species present and % cover estimated March 2022</p>	<p>1.1 Datasets compiled on plant and invertebrate species composition in surveyed areas</p> <p>1.2 Datasets analysed</p> <p>1.3 Summary report of field season and preliminary findings published on GSGSSI website and ResearchGate</p>	<p>1.1 Covid pandemic subsides by field season in year 1, permitting fieldwork</p> <p>1.2 Weather conditions permit safe completion of surveys, and access to field sites</p> <p>1.3 Plant and invertebrate species are identifiable</p>

Project summary	SMART Indicators	Means of verification	Important Assumptions
	<p>1.3 Pitfall traps and soil cores taken, invertebrate species identified for at least 3 sites by March 2022</p> <p>1.4 By December 2022: Colonisation of communities by native versus non-native species (richness and abundance) compared and analysed; diversity and composition of communities among sites analysed</p>	<p>1.4 Submitted plant and invertebrate community analyses for peer-reviewed publication, including data deposited at UK Polar Data Centre/SAERI</p>	<p>1.4 Covid restrictions lifted to allow UK-based partner meeting at BAS (Cambridge)</p>
<p>Output 2 'Winners' and 'losers' of competition between non-native plant species and native plant communities under climate change (ex-situ experiment) identified</p>	<p>2.1 By October 2021: 8 invasive and at least 6 native plant species selected for experiment and germination trials; seeds obtained from MSB Kew</p> <p>2.2 Climate experiment conducted; plant growth rate and biomass measured for 14 species by July 2022</p> <p>2.3 Germination trials of at least 6 native species conducted; % germination data obtained by April 2023</p> <p>2.4 Performance of at least 6 native and 8 invasive plant species under future climate compared to current climate by December 2022</p> <p>2.5 Germination success under future climate change established</p>	<p>2.1 Dataset compiled of plant growth rate and biomass under each climate condition</p> <p>2.2 Dataset compiled of native germination % under each temperature regime and deposited in Kew MSB Database</p> <p>2.3 Datasets analysed</p> <p>2.4 Summary report of experiments and preliminary findings published on GSGSSI website and ResearchGate</p> <p>2.5 Submitted climate experiment analyses for peer-reviewed publication</p>	<p>2.1 Seeds from SG and MSB collections are viable and germinate in sufficient numbers</p> <p>2.2 Growth chambers at Durham continue to function well at required climate settings</p>

Project summary	SMART Indicators	Means of verification	Important Assumptions
	for at least 6 native species by July 2023		
Output 3 Distribution of invasive carabid beetles, native herbivorous beetles and association with each other and vegetation types established	<p>3.1 At least 10 sites for surveys across vegetation types identified by December 2022</p> <p>3.2 Hand-search surveys conducted, presence and abundance of beetle species recorded at each site by March 2023</p> <p>3.3 Pitfall traps and soil samples taken at each site; invertebrates identified to species level by March 2023</p> <p>3.4 Distribution of invasive carabids updated and relationship to native beetles and vegetation described by July 2023</p> <p>3.5 Effects of vegetation type and invasive carabid presence on invertebrate community composition identified by October 2023</p>	<p>3.1 Dataset and maps produced, describing current distribution of surveyed beetle species in relation to vegetation types</p> <p>3.2 Database compiled of invertebrate communities</p> <p>3.3 Datasets analysed</p> <p>3.4 Summary report of field season and preliminary findings published on GSGSSI website and Researchgate</p> <p>3.5 Submitted analyses assessing relationship between invasive and native vertebrate distributions, and associations with vegetation type as peer-reviewed publication, and data deposited at UK Polar Data Centre/SAERI</p>	<p>3.1 Covid pandemic subsides by field season in year 2, permitting fieldwork</p> <p>3.2 Weather conditions permit safe completion of surveys, and access to field sites</p> <p>3.3 Invertebrate species are identifiable</p>
Output 4 Non-native terrestrial species from FI that pose greatest invasion risk to SG under a future climate identified	<p>4.1 At least 50 plant and invertebrate species present on FI screened for climate suitability on SG under year 2060 climate scenarios by July 2023</p> <p>4.2 Horizon scanning exercise conducted with project partners and beneficiaries, future climate invaders prioritised from 4.1</p>	<p>4.1 Priority list produced of 10 plant and invertebrate species from FI that pose the highest invasion risk to GSGSSI under future climate</p> <p>4.2 Report of Horizon-Scanning exercise and priority list published on SGSSI and FI governments websites and ResearchGate</p>	<p>4.1 Evidence base will be successfully obtained from Outputs 1-3</p> <p>4.2 Travel to FI for final workshop will be possible in 2024 (Covid and weather permitting)</p>

Project summary	SMART Indicators	Means of verification	Important Assumptions
	<p>according to invasion risk (product of severity of impact and likelihood of arrival and establishment). Top 10 high-risk species identified by March 2024</p> <p>4.3 By June 2024: Information from all 4 outputs synthesised in a final workshop attended by at least 10 beneficiary participants based in Stanley FI/remotely, hosted by SAERI; priorities for FI-GSGSSI discussed</p>	<p>4.3 Final workshop report and priority list of actions for biosecurity and management of invasive species to 2060 published on SGSSI and FI governments websites and ResearchGate</p> <p>4.4 Submitted analyses of Horizon-scanning exercise for peer-reviewed publication, and data deposited at UK Polar Data Centre/SAERI</p>	
<p>Output 5 Increased awareness of invasive species and climate change impacts on SG</p>	<p>5.1 Project information provided to a global audience via a webpage created by September 2021</p> <p>5.2 Project findings presented to interested audience in webinars held in Dec 2021, Dec 2022, Dec 2023 and July 2024</p> <p>5.3 Awareness raised of invasive species on SG among tourists visiting via a poster, by February 2023</p> <p>5.4 Awareness raised among Antarctic tourists via a digital information leaflet by December 2023</p>	<p>5.1 Webpage launched and data on page visits and origins collected</p> <p>5.2 Webpage and webinars advertised on Twitter; number of 'likes', 'retweets' and webinar registrations recorded</p> <p>5.3 Poster created and displayed describing invasive plants and invertebrates of SG in Grytviken museum, with QR codes linked to project webpage and digital poster copy</p> <p>5.4 Digital leaflet disseminated to cruise operators via IAATO. Number of tour operators and tourists reached estimated and recorded. Leaflet linked to project webpage</p>	<p>5.1 Work in Outputs 1-4 is delivered on time for webinar content</p> <p>5.2 Webinars are sufficiently advertised to attract a wide audience</p> <p>5.3 Tourists will view posters and leaflets, and want to search for more information</p>

Project summary	SMART Indicators	Means of verification	Important Assumptions
<p>Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)</p> <p>Output 1</p> <p>1.1 Project Management Group Meeting [PMGM] 1 (online)</p> <p>1.2 Recruit PDRA and Field Assistant</p> <p>1.3 Draw up Memorandum of Collaboration between Project Partners</p> <p>1.4 Select at least 5 sites suitable for plant and invertebrate communities in areas of glacier retreat and vegetation fronts</p> <p>1.5 UK-based project partners meet at BAS (Cambridge) for fieldwork planning; PDRA to obtain plant and invertebrate ID information</p> <p>1.6 Produce fieldwork protocols for first field season, including details of survey sites</p> <p>1.7 Apply for SG fieldwork permits</p> <p>1.8 Organise logistics for first field season (PDRA travel to FI, onward transport to SG, SG accommodation, purchase and transport of field kit, on-island boat transport)</p> <p>1.9 Project meeting in Stanley, FI prior to first field season (WD, PC and RN to join online, for PMGM 2)</p> <p>1.10 PDRA/Field Assistant first field season on SG: Plant and invertebrate communities surveyed, collection of unidentifiable plant samples, collections of seeds for experiments where possible</p> <p>1.11 PDRA and plant samples return to UK: plant samples stored for molecular analysis at Kew</p> <p>1.12 Plant DNA extracted and sequenced to verify species ID of unidentified samples (Kew)</p> <p>1.13 Plant and invertebrate community data compilation and analysis after PDRA return to UK</p> <p>1.14 Project Management Group Meeting 3 (online)</p> <p>1.15 Write up and submit plant and invertebrate community manuscript for peer-reviewed publication</p> <p>Output 2</p> <p>2.1 Select native and invasive plant species for climate experiment and germination trials</p> <p>2.2 Durham and Kew-based project partners meet online, to draw up experiment/trial plans; obtain seeds from Kew if required</p> <p>2.3 Order materials required for experiment/germination trials</p> <p>2.4 Identify current and future (year 2060) climate and light regimes for realistic experimental treatments and germination trial conditions</p> <p>2.5 Durham and Kew: Apply any germination pre-treatments to seeds prior to sowing, as required, and sow</p> <p>2.6 Durham: Set up and conduct climate experiment</p> <p>2.7 Durham: Terminate experiment, harvest biomass, weigh and collate data</p> <p>2.8 Kew: Conduct germination trials in incubators at current and future climates</p> <p>2.9 Kew: Terminate germination trials, collate data and publish in Kew's seed information database</p> <p>2.10 Durham: Data compilation and analysis from climate experiment</p> <p>2.11 Write up and submit manuscript for Durham climate experiment and germination trials for peer-reviewed publication</p> <p>2.12 Write up and publish year report online, combining key results and progress for Outputs 1 and 2</p> <p>2.13 Project Management Group Meeting 4 (online)</p>			

Project summary	SMART Indicators	Means of verification	Important Assumptions
<p>2.14 Analyse and write up results of seed germination trials</p> <p>Output 3</p> <p>3.1 Identify at least 10 sites for invertebrate survey work on SG, across vegetation types</p> <p>3.2 UK-based project partners meet at Durham, plan surveys for 2nd SG fieldwork season, and produce fieldwork protocols</p> <p>3.3 Reapply/update permits for fieldwork on SG as necessary</p> <p>3.4 Purchase materials required for survey fieldwork</p> <p>3.5 Organise transport and accommodation logistics for 2nd fieldwork season</p> <p>3.6 PDRA travels to FI, and then on to SG for 2nd fieldwork season: survey 10 sites for invasive and native invertebrate species presence and abundance</p> <p>3.7 Compilation and analysis of invertebrate survey data</p> <p>3.8 Write up and publish year report on field season and results online</p> <p>3.9 Project Management Group Meeting 5 (online)</p> <p>3.10 Write up and submit manuscript of analyses assessing relationship between invasive and native vertebrate distributions for peer-reviewed publication</p> <p>Output 4</p> <p>4.1 Plan remote horizon-scanning exercise details and invite beneficiaries representatives as well as project partner organisations to participate. Exercise will be done virtually, using Zoom and Slack platforms</p> <p>4.2 Identify at least 50 species of plants and invertebrate present on FI but not yet on SG (distinguish whether native or non-native to FI)</p> <p>4.3 Model species distributions and project resulting models onto SG to quantify and rank climate suitability under year 2060 climate for best, medium and worst-case socioeconomic pathway scenarios</p> <p>4.4 Disseminate list of species screened for climate suitability to participants for opinion on the invasion risk of each species focusing on entry, establishment, spread and impact risk</p> <p>4.5 Gather participant opinions and categorise species according to perceived risk across participants. Present categorised list to stakeholders and elicit feedback</p> <p>4.6 Adjust risk-categorised list of species based on (dis-)agreements until a consensus list is reached, and top-10 high-risk species under a future climate are identified</p> <p>4.7 Plan final workshop in Stanley, FI: invite attendees from FI-based beneficiaries, organise travel and accommodation, secure venue and organise materials</p> <p>4.8 Project Management Group Meeting 6 (online)</p> <p>4.9 Prepare delivery of workshop</p> <p>4.10 Write up final year project report, including outcome of horizon-scanning exercise</p> <p>4.11 Hold project final workshop in FI: present findings; discuss horizon-scanning exercise outcome; discuss how project findings can best inform GSGSSI management strategy</p> <p>4.12 Project Management Group Meeting 7 (online)</p> <p>4.13 Submit analyses of horizon-scanning exercise for peer-reviewed publication</p> <p>Output 5</p> <p>5.1 Create and launch project webpage, promote on Twitter and partner websites</p>			

Project summary	SMART Indicators	Means of verification	Important Assumptions
<p>5.2 Advertise 1st project webinar on Twitter/through Scientific Committee on Antarctic Research and its Integrated Science for the Sub-Antarctic sub-group (SCAR/ISSA), IAATO, SGHT; collect registration</p> <p>5.3 Hold 1st project webinar, embed recording on project webpage, promote on Twitter</p> <p>5.4 Write blog about first field season on project web-page, promote on Twitter</p> <p>5.5 Advertise 2nd project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration</p> <p>5.6 Hold 2nd project webinar, embed recording on project webpage, promote on Twitter</p> <p>5.7 Write blog about Output 2 experiments on project web-page, promote on Twitter</p> <p>5.8 Advertise 3rd project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration</p> <p>5.9 Hold 3rd project webinar, embed recording on project webpage, promote on Twitter</p> <p>5.10 Write blog about second field season on project web-page, promote on Twitter</p> <p>5.11 Advertise 4th project webinar on Twitter/through SCAR/ISSA, IAATO, SGHT; collect registration</p> <p>5.12 Create and display hard-copy poster at Grytviken Museum, SG; make digital version available on webpage</p> <p>5.13 Create and disseminate digital leaflet to tour operators via IAATO</p> <p>5.14 Hold 4th project webinar, embed recording on project webpage, promote on Twitter</p> <p>5.15 Write blog about Output 4 and final project workshop on project web-page, promote on Twitter</p>			

Annex 3: Standard Indicators

Table 1 Project Standard Indicators

DPLUS Indicator number	Name of indicator using original wording	Name of Indicator after adjusting wording to align with DPLUS Standard Indicators	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
DPLUS-A03	Final workshop on evidence base for future management and biosecurity by June 2024	Number of South Georgia /Falkland Island organisations with improved capability and capacity as a result of project	Number	None	0	0		0	2 minimum (Governments of Falkland Islands and South Georgia and South Sandwich Islands)
DPLUS-C01	Species in early successional communities identified in at least 3 sites by October 2022	Number of knowledge products published that catalogue communities in degaciating sites	Number	None	0	0		0	Minimum of 2 (report; publication)
DPLUS-B02	'Winning' and 'Losing' plants under future climate identified, among at least 14 species (8 invasive and 6 native) by July 2023	Number of habitat management plans identified that can be improved with new knowledge	Number	None	0	0		0	Minimum of 1
DPLUS-B02	Associations between vegetation type and occurrence of invertebrates established by October 2023	Number of invasive species management plans identified that can be improved with new knowledge	Number	None	0	0		0	Minimum of 2 (invasive carabid beetles; invasive non-native plants)
DPLUS-D03	Top 10 plant and invertebrate species present on FI that pose a high invasion risk to SG under future climate identified by March 2024	Number of policies with biodiversity provisions that can be amended with new invasion risk information	Number of instruments	Policy typology (Local, National Policy); Typology of biodiversity provisions	0	0		0	Minimum of 1: Biosecurity policy for South Georgia
DPLUS-C17	Increased awareness of invasive species and climate change impacts on SG	Social Media presence (Twitter)	Cumulative number of: Followers Likes	Year Followers Likes	0	Followers: 135 Likes:329		Followers: 135 Likes:329	At least 500 followers; At least 1000 likes

Table 2 Publications

Title	Type (e.g. journals, manual, CDs)	Detail (authors, year)	Gender of Lead Author	Nationality of Lead Author	Publishers (name, city)	Available from (e.g. weblink or publisher if not available online)
NA						



Checklist for submission

	Check
Different reporting templates have different questions, and it is important you use the correct one. Have you checked you have used the correct template (checking fund, type of report (i.e. Annual or Final), and year) and deleted the blue guidance text before submission?	YES
Is the report less than 10MB? If so, please email to BCF-Reports@niras.com putting the project number in the Subject line.	YES
Is your report more than 10MB? If so, please discuss with BCF-Reports@niras.com about the best way to deliver the report, putting the project number in the Subject line.	NO
Have you included means of verification? You should not submit every project document, but the main outputs and a selection of the others would strengthen the report.	YES
Do you have hard copies of material you need to submit with the report? If so, please make this clear in the covering email and ensure all material is marked with the project number. However, we would expect that most material will now be electronic.	NO
If you are submitting photos for publicity purposes, do these meet the outlined requirements (see section 15)?	NA

Have you involved your partners in preparation of the report and named the main contributors	YES
Have you completed the Project Expenditure table fully?	
Do not include claim forms or other communications with this report.	