

## Darwin Plus: Overseas Territories Environment and Climate Fund Annual Report

To be completed with reference to the "Writing a Darwin/IWT Report" Information Note: (<https://dplus.darwininitiative.org.uk/resources/reporting-forms-change-request-forms-and-terms-and-conditions/>). It is expected that this report will be a maximum of 20 pages in length, excluding annexes)

**Submission Deadline: 30<sup>th</sup> April 2021**

### Darwin Plus Project Information

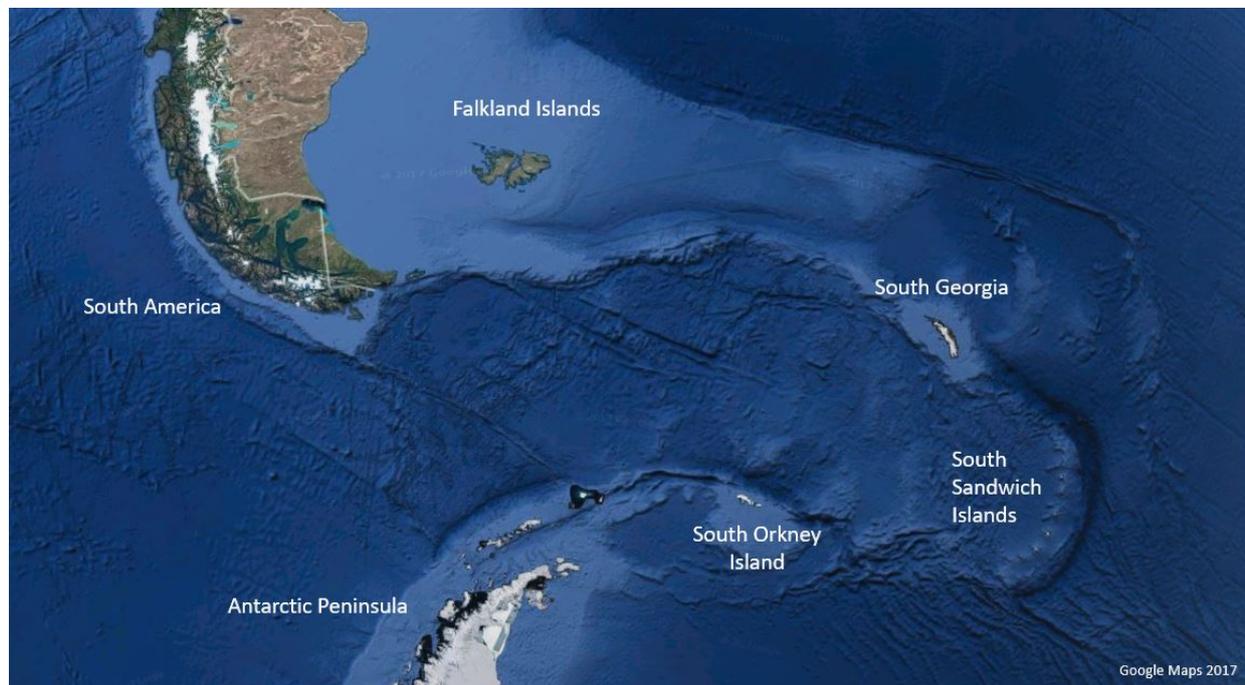
Project reference	DPLUS080
Project title	Securing South Georgia's native habitats following invasive species control
Territory(ies)	South Georgia
Lead organisation	Royal Botanic Gardens, Kew (Kew)
Partner institutions	Indigena Biosecurity International (Indigena) and Durham University
Grant value	£256,544 (Y2 = £65,755)
Start/end dates of project	01 April 2018 – 30 September 2021
Reporting period (e.g. Apr 2020-Mar 2021) and number (e.g. Annual Report 1, 2)	April 2020 – March 2021 AR 3
Project Leader name	Rosemary Newton
Project website/blog/social media	Kew project website: <a href="https://www.kew.org/science/our-science/projects/south-georgias-native-habitats">https://www.kew.org/science/our-science/projects/south-georgias-native-habitats</a> Twitter: Follow @KewUKOTs; Search #KewSouthGeorgia
Report author(s) and date	Rosemary Newton & Colin Clubbe 20 May 2021

### 1. Project summary

The project is focussed on securing native habitats and their constituent native species on South Georgia following non-native species control. South Georgia is an isolated UK Overseas Territory in the Southern Atlantic Ocean. The island is 165 km long and 35 km wide and located around 1300 km south-east of the Falkland Islands (Figure 1).

Invasive non-native species are one of the most important drivers of biodiversity loss, and this impact is particularly severe on islands. South Georgia is a wildlife haven which has, until recently, been significantly impacted by introduced reindeer and rodents. Reindeer have been successfully removed and the island was declared rodent free in May 2018 (DPLUS031; <http://www.sght.org/news/south-georgia-declared-rodent-free/>).

In response to the predicted grazing pressure release following mammal eradication, a Non-Native Plant Management Strategy was developed by the Government of South Georgia & the South Sandwich Islands (GSGSSI; DPLUS015) and is now being implemented, to manage to zero density 33 of the 41 non-native plant species on the island and to control the more widespread invasive plant species (Annex 3). Eradication of non-native plant species is exceedingly difficult because of the formation of a soil seed bank from which plants can regenerate, often for many years.



*Figure 1: Location of the UK Overseas Territory of South Georgia and the South Sandwich Islands.*

This project aims to safeguard South Georgia’s native habitats by monitoring and assessing vegetation changes following invasive non-native species control; estimating from soil seed bank and seed viability studies the risk of non-native plant species persisting beyond 2020 (the end date for the current Non-Native Plant Management Strategy) to inform future management strategy; quantifying the potential for non-native plant species to disperse into new areas following glacial retreat due to climate change; and, securing seed and fern spore collections of native plant species for long-term conservation at Kew’s Millennium Seed Bank (MSB).

The outcomes of the project will inform future management strategies by GSGSSI of non-native plant control and of terrestrial communities in the face of predicted climate change (Needs Assessment: South Georgia and South Sandwich Islands, DFID, July 2012).

## **2. Project stakeholders/partners**

Formal communication by way of Steering Group Meetings was paused during the Covid-19 pandemic as key staff at Kew, including the project manager, were furloughed for a large part of this period. However, there was always at least one Kew staff member working throughout this period and this person was able to maintain communication with partners regarding the project throughout. In this way, support of project partners, Indigena (Bradley Myer, Kelvin Floyd) and Durham University (Wayne Dawson), was maintained throughout the year. This was also reciprocated; for example, Wayne Dawson from Durham University kindly supported MSc student, Calum Sweeney, during periods when his Kew supervisor, Rosemary Newton, was furloughed. A Steering Group meeting was held on 16<sup>th</sup> February 2021, once Kew staff were back at work and were able to properly ascertain project progress and discuss and review project activities with partners, with specific focus on the impacts of the Covid-19 pandemic (Annex 4 and 5). This is a strong partnership of people who know each other well and have worked together for some time. The partnership strengthened over the past year with support offered and received from and by all partners as needed during the challenging year.

Calum Sweeney (Queen Mary and Kew joint MSc student) joined the project in early March 2020 and started work on the thermal gradient plate experiments to assess climate change impacts on native and non-native flora. However, due to the Kew laboratories being closed in mid-March, this was stopped, and Calum's project changed to a desk-based one, analysing MSB germination data of native and non-native plant species found on South Georgia, predicting temperature changes on the island due to climate change, and constructing a DNA "library" from the literature, to enable suitable markers to be identified to distinguish native and non-native South Georgia angiosperm species. Juan Viruel, a Research Leader at Kew, with expertise in conservation genetics, is supporting the molecular work. Calum completed an excellent MSc project (Annex 6) which has laid the foundation for planned molecular work, to enable seeds germinated from South Georgia soil to be identified to species level. Rachel Day, an intern who started on the project in mid-March 2021, will build on Calum's work by characterising the native and non-native angiosperm species on South Georgia from vegetative material obtained from germinating seeds from verified MSB collections, to produce a DNA "library" so that seedlings germinated from South Georgia soil and seed traps can be identified.

The main stakeholder is the Government of South Georgia & the South Sandwich Islands (GSGSSI) who are kept informed of project progress and outputs. We have kept in regular communication with Helen Havercroft, GSGSSI Chief Executive, informing her and her team of progress with the project. Our discussions and thinking helped inform the development of the GSGSSI's new 5-year stewardship framework for SGSSI [Protect, Sustain, Inspire](#) (2021-2025), particularly the Biosecurity section, which was published in January 2021. Current discussions include input into developing a new science strategy and an updated non-native plant management plan to replace the existing one, which we were part of developing for DPLUS015: Strategic Management of Invasive Alien Plants of South Georgia. The results from the current project will provide a key input into the renewed non-native plant management plan.

### **3. Project progress**

Limited progress was possible during this reporting period due to the impacts of Covid-19 on the project. All Kew's science buildings at both sites (Kew and Wakehurst) were closed from 18 March to 27 August 2020. No laboratory-based project activities were possible during this period, and as the current phase of the project is completely laboratory-based this meant no project activity was possible, resulting in a pause to the project.

In addition, MSc and intern help arranged for the project for 2020 and 2021 has been severely impacted: MSc student Calum Sweeney was unable to do the laboratory work originally planned and Rachel Day's internship, originally planned for a year, has been reduced to less than 6 months. This work must now be completed by Rosemary Newton and Marcella Corcoran.

A formal change request was made to Darwin on 18 December 2020 for a no-cost extension to the project for a period of six months and an accompanying extension of all deadlines from mid-March 2020 onwards by six months, to make up for time lost when the laboratories were closed (Annex 7). Approval for this request was received from Darwin on 29 January 2021 (Annex 8).

During September 2020 through January 2021, although Rosemary Newton and Marcella Corcoran were able to resume laboratory-based work, they were still partly furloughed. The laboratory was opened in a limited capacity to select staff on a part-time basis, and processes and restrictions put in place to ensure staff safety reduced the speed at which laboratory work could proceed. Full laboratory access and consequently full resumption of laboratory work was only possible from February 2021.

Many of the activities are now back on track as listed below, but we have some remaining concern about the tight revised timescale for project completion.

#### **3.1 Progress in carrying out project Activities**

##### Output 1 activities

Activities 1.1 – 1.5 have been completed and are detailed in previous reports.

Activities 1.6-1.9: Vegetation data from the different field sites have been mostly analysed and changes in vegetation composition, plant height and cover of target non-native and native plant species in herbicide plots determined. Once this analysis is complete a summary report on non-native species distribution will be produced and a paper for submission to a peer-reviewed journal prepared.

#### Output 2 activities

Activities 2.1 – 2.4 have been completed and are detailed in previous reports.

Activities 2.5 – 2.8 now have a modified protocol based on experience gained during analysis of samples from the first field season. Seeds are no longer being directly extracted from soil samples; instead, a thin layer of a subsample of South Georgia soil is being spread on top of sterilized potting soil and then moistening and incubating under quarantine conditions at temperatures most likely to stimulate seed germination (25°C, 12 h day / 10°C, 12 h night, with a corresponding 12 h / 12 h photoperiod). This was found to be an effective method for obtaining seedlings: from the first replicate of soil samples collected from all 26 sites in 2018-2019, 482 seedlings were obtained, identified (where possible), harvested, dried and stored in silica gel for identification (using molecular methods) to be completed over the summer of 2021 by intern Rachel Day. Trays containing soil from the second and third replicates have been sown and are currently in growth chambers, with seedlings being collected weekly for DNA analysis. Trays for the remaining replicates for the 2018-2019 soil samples should be completed by the end of June 2021.

Activities 2.9 – 2.11, which include analysing the data and producing a summary report, will commence once molecular identification of species is complete.

#### Output 3 activities

Activities 3.1 – 3.5 have been completed and are detailed in previous reports.

Activities 3.6 – 3.8: In the 2018-2019 field season, the 30 seed traps collected 748 seeds, of which 218 were empty seed husks. The remaining 530 seeds appeared full. Seeds were identified, where possible, from seed morphology: 5% were native, 62% non-native and 33% could not be identified (so remain unknown). Seeds of Poaceae species, *Taraxacum officinale* and *Cerastium fontanum*, the latter two both Class 3 non-native plant species, were most abundant in the traps. These are being sown on agar over the next few months to assess viability and any unknown seedlings will be identified using molecular methods by intern Rachel Day. The lost time on the project during 2020-2021 due to Covid-19 mean that we may have insufficient time and personnel to fully analyse the contents of all 30 seed traps collected in the 2019-2020 field season. This will have some impact on our ability to fully understand the movement of seeds across South Georgia. However, we anticipate strong results from the first set of seed traps, which should enable us to make practical recommendations.

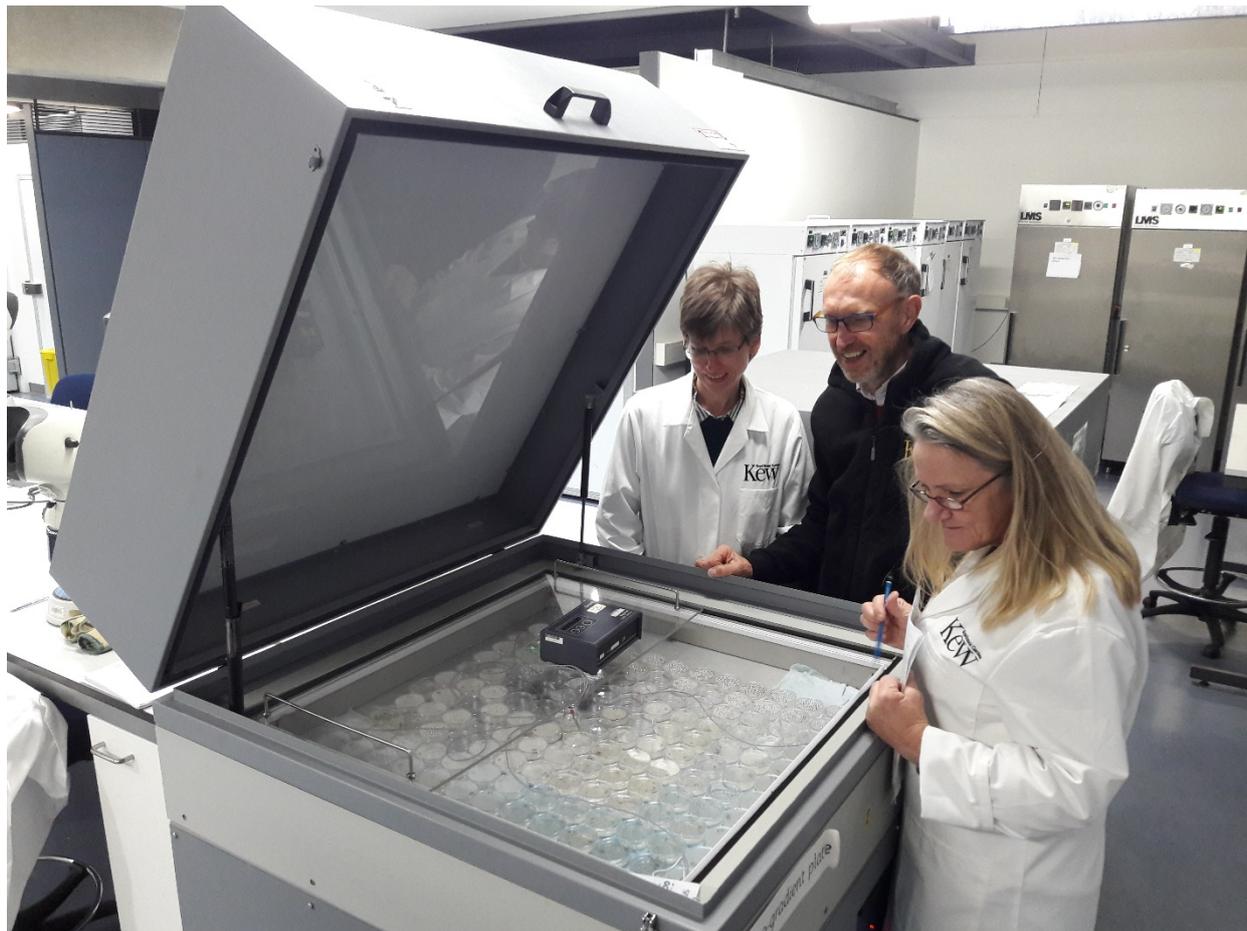
Activities 3.9 – 3.11: We will endeavour to complete the analysis for both field seasons as part of our exit strategy post-project and the results will be used in publications being planned post-project, which will be shared with GSGSSI as part of our regular updates.

#### Output 4 activities

Activities 4.1 – 4.3 have been completed and are detailed in previous reports.

Activity 4.4: Thermal gradient plate experiments are being run to determine the likelihood of non-native seed germination success compared with native species (Figure 2). Germination testing of the native and non-native *Poa* species pair is virtually complete, with only a few germination test plates remaining in the cold section of the thermal gradient plate. Good germination was observed in both species; initial indications are that germination occurs over a wider temperature range and more rapidly in the non-native *Poa annua* compared with the native *Poa flabellata*, although detailed analysis of these data is required to confirm this. The native and non-native *Festuca* species pair was set up at the end of March 2021, with germination of non-native *Festuca rubra* occurring more rapidly than native *Festuca contracta*. The *Deschampsia* species pair has been in cold stratification treatment at 0°C since early March; this will be moved to the thermal gradient plate mid- to late May 2021 to monitor germination.

Activities 4.5 – 4.6 include analysing the data to determine germination characteristics and preparing a paper for submission to a peer-reviewed journal prepared, which will commence when data collection is complete.



*Figure 2: Rosemary Newton, Colin Clubbe and Marcella Corcoran viewing the thermal gradient plate experimental setup for native and non-native congeneric species pairs comparison of seed germination requirements.*

### Output 5 activities

Activities 5.1 – 5.4 have been completed.

Activities 5.5 – 5.6: Seed germination tests at different conditions (e.g., constant and alternating temperatures), and with pre-treatments (such as chipping or cold stratification) on South Georgian seed collections, and also seed collections of species that occur on South Georgia, have been analysed and used to produce seed germination protocols. From these results an understanding of seed dormancy characteristics, and consequently the conditions required to break dormancy, have been determined for most of the native and non-native angiosperm species on South Georgia.

Activities 5.7 and 5.9: Germinated seeds have been grown on for imaging. Most species have photographs of seeds and three stages of seedlings, and the Seed and Seedling Identification Field Guide is currently being prepared.

Activity 5.8: Once all the germination tests are complete, germination protocols will be entered onto the internal Seed Bank Database (SBD) and this will then be updated to the external Seed Information Database (SID).

## **3.2 Progress towards project Outputs**

Output 1: All data required to analyse changes in numbers and frequency of native and non-native plants from established vegetation monitoring plots and invaded sites have been collected, and variation in community composition among seasons, changes in plant height for

individual species and changes in cover of target non-native and native plant species in herbicide plots have been determined for various field sites. This will give us an insight into the success of the non-native plant control programme on South Georgia.

Output 2: Sufficient soil samples were collected on field trips for analysis. Despite the original methodology of extracting seeds from soil samples having to be changed as this process was too time-consuming, the second method of assessing seed viability, by watering soil samples to encourage germination, was then successfully trialled. This methodology is suitable for processing larger quantities of soil. However, identification of some species, especially in the Poaceae (grass family), is difficult because of the lack of characteristic morphological features of seedlings, and soil quarantine restrictions have prevented plants being grown on to a reproductive stage at which identification could be confirmed. Vegetative material of seedlings is being identified where possible, and then collected to enable confirmation of identification to species level using molecular methods (enabled by additional funding secured specifically for this work), by comparison against a DNA library of the angiosperm species on South Georgia. This is being undertaken by intern Rachel Day over the summer of 2021.

Output 3: Sufficient seed samples were collected on field trips from seed traps for analysis. Seed trap contents from the first field season have been extracted from traps and identified where possible. Germination tests have commenced to determine viability and confirm species identification for unidentified seeds.

Output 4: Germination testing of the native and non-native *Poa* species pair is virtually complete, germination testing of the *Festuca* species pair should be finished by the end of June, and the *Deschampsia* species pair, currently in cold stratification treatment at 0°C since early March, will be moved to the thermal gradient plate mid- to late May 2021 to monitor germination. This third species pair should be finished by the end of August 2021.

Output 5: In total, 52 collections of seeds and spores from 21 species (comprising seven ferns, one club moss, six native and seven non-native angiosperm species) as well as a hybrid between two native species (*Acaena tenera* and *A. magellanica*) have been collected in both field seasons. This exceeds the target of at least three fern species to be banked. Most seed dormancy syndromes have been identified and seed germination protocols determined, for both native and non-native species. Seedling images have also been captured for most species. The Guide to the Seeds and Seedlings of the Plants of South Georgia is being prepared. This output target has largely already been met and is expected to be exceeded.

### 3.3 Progress towards the project Outcome

There have been some challenges, largely the Covid-19 pandemic, that have delayed progress in Outputs 2 – 4. A time extension of 6 months has been granted; nevertheless, getting the laboratory work completed during this period will be challenging. If there are no further unforeseen delays, completing the laboratory work by the end of the funding should still be possible.

Despite these delays and the challenge of completing all activities within the compressed timetable we remain confident of achieving our overall Outcome by the end of the project: 'South Georgia's native habitats protected by identifying non-native species most likely to persist, determining potential climate change effects on native and non-native species survival and banking seeds of native species'. Our indicators remain adequate, and we have already seen substantial progress towards a successful outcome with the commitment of GSGSSI to continue their non-native plant management programme for a further 5-years, informed by inputs from this project. We have also secured all native plant species (as detailed in "A Field Guide to the Flora of South Georgia" by Deirdre Galbraith, published by the South Georgia Heritage Trust in 2011) as *ex-situ* collections at the MSB. Seed collections from 12 non-native plant species have been collected from South Georgia, although some seed collections still need to be tested for viability.

### 3.4 Monitoring of assumptions

- Weather conditions and transport problems did not significantly hamper project activities in either field season. The field team received full support from the British Antarctic Survey (BAS) and GSGSSI on-island support teams, enabling them to get to all field sites for both year one and year two activities. The second field season was cut short due to having to

leave the island early because of the Covid-19 pandemic; however, all planned samples were still collected, so these are no longer risks (Assumptions 0.1, 1.1, 1.2).

- Seeds or spores from all target species were collected in the first field season (Annex 9). Six of these collections, following processing, had to be discarded as they did not contain fully developed seeds or few spores, indicating that they had been collected too early in their development (or too late, in the case of fern spores). Missing species were included in the 2019-2020 target list for collection and were recollected (Annex 10). Again, some seeds (5 collections) were collected too early in the field season (this was unavoidable as the team had to leave the island early due to the Covid-19 pandemic threat). The remaining 2019-2020 seed collections still need to be germination tested and so there remains a risk that collection numbers, quality and viability will be insufficient to count towards the target as safely stored for conservation at the MSB. Although *Festuca rubra* collected on South Georgia were not viable, a MSB collection from Europe has been identified as suitable for use in the thermal gradient plate germination work, and so obtaining adequate seed for these germination experiments is no longer a risk; although whether seeds of the native and non-native *Deschampsia* species pair (that are currently in cold stratification to alleviate seed dormancy prior to setting up the thermal gradient plate experiment) will germinate under test conditions remains a risk. These risks continue to be monitored (Assumptions 0.2; 4.1, 4.2, 5.1).
- The success of the non-native plant control programme remains at risk from new non-native species being discovered or introduced to South Georgia. The field team have identified four species requiring further research (*Gaultheria pumila*, *Gunnera magellanica*, a likely hybrid between *Poa annua* and *P. flabellata*, and *Rumex acetosa*). Additionally, *Lobelia pratiana* has been reclassified as a Class 2 species from Class 1, and *Poa trivialis* as a Class 1 species from a Historic species). Herbarium specimens and DNA material have been collected for investigation at Kew. The biosecurity measures implemented on South Georgia are amongst the most rigorous in the world and are regularly reviewed and strongly enforced (<http://www.gov.gs/biosecurity/>). Consequently, these occasional new discoveries are more likely to represent over-looked species rather than genuine new recent introductions to South Georgia. However, appearance of new non-native plant species remains a threat to native South Georgia plant species, and this is being carefully monitored during each field season (Assumption 1.3).
- Sufficient soil samples from a variety of sites have been collected and germination from these soil samples has been good. Having insufficient seeds in samples is therefore no longer a risk (Assumption 2.1).
- Seed and seedling imaging of native and non-native plant species that occur on South Georgia has shown that identification of some species with a reasonable level of certainty is impossible. DNA barcoding will be used to identify unknown species from soil samples and seed traps. Although this work is proceeding well, this risk continues to be monitored (Assumptions 2.2, 3.3).
- Dispersal traps were robust and were not disturbed whilst they were *in-situ* in either field season. Assumption 3.1 is therefore no longer a risk.
- The number of full seeds extracted from seed dispersal traps from the 2018-2019 field season was 530. These are currently being tested for viability and identified. Seed traps from the 2019-2020 field season have not yet been analysed; however, it is likely that a similar number of seeds would have been collected this field season. The field teams observed in the first field season that dispersal traps had to be collected before seed dispersal from some plant species had finished in the 2018-2019 field season. To ensure that later dispersing species would also be collected, the plan was to stay on the island for a several weeks longer during the 2019-2020 field season. Frustratingly, the Covid-19 outbreak necessitated an early departure from the island, so the risk remains that a representative sample of seed dispersing over the late summer months on South Georgia was not collected. However, other monitoring methods (e.g. surveys of plants establishing in recently exposed areas due to glacial retreat) should gather similar information about plant establishment; thus answering the question on which plant species are likely to establish on new ground exposed to retreating glaciers should still be possible. Assumption 3.2 is therefore no longer a serious risk.

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

Despite the challenges of Covid-19 and the limited project activity this reporting period, we have made some progress in supporting SGSSI strategic goals for the natural environment of South Georgia. The annual SGSSI Stakeholder event that we hosted at Kew in 2019 had to move online in 2020, but was nevertheless a successful event which we participated in. An active area of discussion was biosecurity and terrestrial habitat protection and results from the current project provide valuable information and insights into these topics. GSGSSI's major focus has been on their new 5-year strategic framework and through our strengthened partnership during this project we have had the opportunity to feed into this process and comment on early drafts, especially regarding the Biosecurity section, one of the seven priority areas of the framework. Their new 5-year stewardship framework, [Protect, Sustain, Inspire](#) (2021-2025) was published in January 2021. It has been well received by the wider community and is being implemented. This will be an exemplar of good environmental stewardship which can be used as part of the UK's reporting for both CBD and Climate COPs planned for 2021.

#### **5. OPTIONAL: Consideration of gender equality issues**

South Georgia is uninhabited apart from the research scientists that are based there seasonally, at either King Edward Point or Bird Island. The research teams are recruited via their institutional recruitment schemes which incorporate processes to promote diversity. The collaborating partners for this project have processes in place to promote diversity and inclusion. These partners came together to implement this project, but individuals were already on staff and not recruited specifically for this project. The Kew Team consists of three staff members (1 male, 2 female) with 1 female and 1 male Masters student supporting the project in 2019 and 2020, respectively, a female intern working on the project in 2021 and a female volunteer helping with the project one day a week from the beginning of 2021. The gender-balance of our partners is skewed (6 male : 2 female), but in 2018-2019 a locally-based Chilean female was included in the field team. In 2020-2021 there were 2 females and 1 male in the field team.

#### **6. Monitoring and evaluation**

This was a year disrupted by the Covid-19 pandemic and formal communication by way of Steering Group Meetings was paused during the pandemic as key staff were furloughed for a large part of this period. However, there was always at least one Kew staff member working throughout this period and this person was able to maintain communication with partners regarding the project, ensuring that information was shared amongst partners and stakeholders. A steering group meeting between Colin Clubbe, Rosemary Newton and Marcella Corcoran (Kew), Bradley Myer (Indigena) and Wayne Dawson (Durham University) was held on 16 February 2021 (Annex 4 and 5) to monitor project progress and to discuss and review project activities, with specific focus on the impacts of the Covid-19 pandemic.

Due to the project leader and other Kew project members being furloughed for a significant period during 2020, extensions on the submission of the Darwin annual and half-year reports were granted and these were submitted on 21 September and 18 December 2020, respectively. Feedback on these was welcomed and acted upon. Following return to work, regular discussions (at least weekly and more frequently when needed) between Rosemary Newton and Colin Clubbe about project progress and between Rosemary Newton and the project partners, have taken place. This has proved an efficient and effective way to monitor progress.

The GSGSSI have committed to continue with the South Georgia non-native plant management plan; evidence that our activities are contributing to the project outcome.

## **7. Lessons learnt**

This year has been over-shadowed by the Covid-19 pandemic and our major lessons learnt are around how project management copes in the face of this unprecedented derailment. Good communication remained essential, and we maintained good virtual contact (email, MS Teams, Skype, phone) with all partners throughout the period of project pause and as we got the project started again as soon as was practicable. We held a full Steering Group meeting as soon as possible after the project was fully up and running again (Annex 4 and 5). We drafted a new implementation plan and have modified some laboratory protocols to account for slightly changed timelines. The laboratory team have worked additional hours to try and get the project back to a manageable timetable for completion.

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

We were very pleased to read the comments from the Reviewer of AR2 and thank the Reviewer for their overall positive assessment and complementary remarks. As noted there, we did need to request a 6-month no-cost extension to the project to make up for lost laboratory time due to the closure of the labs because of the Covid-19 pandemic. We have done this via the change request process and Darwin approved this extension (Annex 7 and 8).

The Reviewer commented that although discussions with GSGSSI representatives on how the findings from the current project might inform non-native plant management and control when the period covered by the current Management Plan ends in 2021 were positive, the outcome was not clear and requested clarification in this annual report. We can clarify that GSGSSI has continued to fund the non-native species eradication programme for another year whilst they finalised their new 5-year stewardship framework [Protect, Sustain, Inspire](#). The Biosecurity section, which our discussions and project results fed into, makes the specific commitment to 'continue to fund a comprehensive invasive plant management programme to drive down prevalence of key invasive species, building on the success of the last 5 years'. We are delighted to see this commitment from GSGSSI and are gratified by the role the outputs of this project have played in supporting this. The new framework was published in January 2021 and is being implemented. We continue to discuss implementation with GSGSSI as well as the development of a specific Science Strategy for South Georgia.

## **9. Other comments on progress not covered elsewhere**

None.

## **10. Sustainability and legacy**

The final year of the project was always a UK lab-based one, processing the samples collected during the two South Georgia field seasons during years 1 and 2 of the project, and so there have been fewer opportunities to directly promote the project in territory. Nevertheless, regular communication with GSGSSI has ensured that the project profile remains high, and tweets on laboratory and field work have promoted the project throughout, as detailed in Section 11. We have been in active discussions during the development of new 5-year stewardship framework [Protect, Sustain, Inspire](#) and the legacy of the project is ensured by GSGSSI commitment to 'continue to fund a comprehensive invasive plant management programme to drive down prevalence of key invasive species, building on the success of the last 5 years'. The outputs of the research component of the project, which will outlast the project end date, will help to provide further evidence through the peer-reviewed papers that are planned once all these data are compiled and analysed. The Seed and Seedling Field Guide, which is in preparation, will provide an excellent complement to the earlier publication we produced as an output of DPLUS015 (Upton, R., Myer, B., Floyd, K., Lee, J. & Clubbe, C. 2017. Field Guide to the Introduced Flora of South Georgia. Royal Botanic Gardens Kew, Richmond) and will provide a valuable resource for the field teams who will implement the new 5-year invasive plant control programme.

## 11. Darwin identity

The Darwin Initiative has been identified as the funder of the project in all communications, including in all the presentations mentioned in the answer to Q10 above, on the Kew website (<https://www.kew.org/science/our-science/projects/south-georgias-native-habitats>) and frequently on our Twitter feed, by using the @Darwin\_Defra tag; search: #KewSouthGeorgia (Annex 11).

The Darwin Initiative funding has always been recognised as a distinct project with a clear identity. The Darwin Initiative is well known by researchers on South Georgia and has received good exposure in the Falkland Islands, the closest inhabited territory to South Georgia. Local radio interviews and the article in the Penguin News (detailed in AR1) clearly identified the project as a Darwin project and the Darwin Initiative as the project funder.

Twitter is an effective way of promoting the project, @Darwin\_Defra is always tagged along with @GovSGSSI, @KewScience and @KewUKOTs, who have many followers, and usually retweet about the project. The blogs at Kew also have a large readership. We were also delighted to have an update on our project included in the [Alien Invasions](#) edition of the March 2021 Darwin Newsletter, including the Newsletter lead image (Annex 12).

## 12. Impact of COVID-19 on project delivery

The global pandemic and restrictions primarily imposed by the UK government, resulted in Kew not being able to operate as normal, with activities temporarily ceased for a significant period. Laboratory work detailed in Activities 2.5 - 2.8; 3.6 – 3.8; 4.4 and 5.5 – 5.7 could not be completed within the scheduled time which had the impact of delaying progress on subsequent activities (see detail in section 3).

Kew project staff were furloughed for varying periods and percentages of time from April 2020 through March 2021 under the UK Government's Job Retention Scheme and had limited access to offices and labs leading to home working (when not furloughed) for most of the period between April and August 2020, with necessary postponement of planned laboratory work. During this period, no-cost administrative tasks and email communication about the status of project staff, working arrangements and national restrictions and options for project delivery were discussed. A change request for the project was submitted in December 2020 (Annex 7) and a formal Steering Group meeting was held in February 2021 (Annex 4 and 5).

Additional impacts included the loss of assistance from a Kew MSc student with thermal plate laboratory work, and the loss of more than 6 months' help from an intern student with the soil processing work, as her contract was delayed by more than 6 months and the end date not extended, both of which were due to provide significant data and results for the project. This work has had to be picked up primarily by Marcella Corcoran and project leader, Rosemary Newton.

A formal change request was made to Darwin to postpone the funded elements of the project for 6 months with no alteration to the log frame and partial budget transfer to the new financial year with a revised project end date of 30 September 2021, which was approved by Darwin in January 2021 (Annex 7 and 8).

Kew made significant investment to ensure that all our staff remained safe and supported during the pandemic. All buildings and workspaces have been fully tested and passed as Covid-19 secure for safe working, but with a much lower capacity to ensure safe working and adequate social distancing. All staff had to undertake a full Covid briefing and risk assessment before resuming work and limited access was prioritised for critical activities, such as the laboratory work required to get this project re-started. Kew also invested heavily in virtual platforms to ensure that staff could remain connected whilst working from home and ensured that staff had appropriate computer facilities at home to work effectively. As documented here, that enabled members of the Steering Group and project partners to keep in touch and work efficiently towards project goals. The success of this will likely influence future decisions about travel and what types of meetings/activities need to happen face to face and what can remain virtual, with potentially positive impacts on travel and carbon emissions. Kew has just published its new Sustainability Strategy with the aspiration to be Climate Positive by 2030, and some of the learning from the pandemic around scientific-related travel informed this. The Strategy is due to be published on 25 May 2021.

### 13. Safeguarding

Please tick this box if any safeguarding violations have occurred during this financial year.

If you have ticked the box, please ensure these are reported to [ODA.safeguarding@defra.gov.uk](mailto:ODA.safeguarding@defra.gov.uk) as indicated in the T&Cs.

Details of safeguarding policies of Kew, the lead organisation for this project, as well as for project partners, Durham University and Indigena, are detailed in AR2. All staff working on the project are aware of these policies and these policies are still active.

South Georgia is not permanently inhabited. The project work on the island does not include any interaction with vulnerable people. The project has not encountered any safeguarding issues nor have any concerns been raised during this reporting year.

### 14. Project expenditure

Please note that all values in the table below are the current amounts which incorporate changes approved via our December change request. The original budget for Y3 (2020/21) was £[REDACTED]. This increased to £[REDACTED] with our approved March 2020 change request for £[REDACTED] (Other costs, which were shipping costs) to be transferred into Y3 from Y2 (Annex 13). The extension of the project into Y4 was approved with the December 2020 change request, along with a transfer of £[REDACTED] out of Y3 and into Y4 (Annex 7). The total for Y3 after change requests is therefore £[REDACTED]. The total amount carried over to Y4 with the most recent change request is £[REDACTED]. The sum of these latter two figures matches the original budget for Y3.

**Table 1: Project expenditure during the reporting period (1 April 2020 – 31 March 2021)**

Project spend (indicative) in this financial year	2020/21 D+ Grant (£)	2020/21 Total actual D+ Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items				
Others (Please specify)				
<b>TOTAL</b>				

The large underspend in travel and subsistence resulted from an underspend by our partner organisation, Durham University, which was realised on their reconciliation of their expenditure to enable calculation of the final grant amount to be paid by Kew to Durham University. This underspend was a result of no accommodation or subsistence being claimed by Wayne Dawson in Y1 and Y2 when he attended meetings, as he was able to reside with family. In Y3, no travel took place at all due to the Covid-19 pandemic, and so the full amount of £[REDACTED] remained unspent as meetings took place online. Thus, overall, only £[REDACTED] out of the budgeted £1950 was spent, which comprised exclusively of train travel expenses.

## Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2020-2021 – if applicable

Project summary	Measurable Indicators	Progress and Achievements April 2020 - March 2021	Actions required/planned for next period
<p><b>Impact</b></p> <p>South Georgia's native habitats and plant species diversity are protected through the eradication of non-native species, conservation of native species, rehabilitation and maintenance of native habitats and improved biosecurity</p>		<p>Eradication efforts on South Georgia by Indigena team members continued during the 2020-2021 South Georgia field season. GSGSSI's new 5-year stewardship framework for SGSSI, published in January 2021, includes a strong commitment to biosecurity, one of the seven pillars of the Framework.</p>	
<p><b>Outcome</b></p> <p>South Georgia's native habitats protected by identifying non-native species most likely to persist, determining potential climate change effects on native and non-native species survival and banking seeds of native species</p>	<p>0.1 The number of non-native species predicted to persist post-2020 determined</p> <p>0.2 Native and non-native species likely to colonise new habitats identified</p> <p>0.3 Spores of at least three fern species and all native seed plants of South Georgia securely banked at the MSB</p>	<p>0.1 All data and samples required were collected during field seasons 2018-2019 (AR1) and 2019-2020 (AR2) and the analysis of field and laboratory soil sample data is ongoing.</p> <p>0.2 All data and samples required were collected during field seasons 2018-2019 (AR1) and 2019-2020 (AR2) the analysis of field seed trap data is ongoing.</p> <p>0.3 This target has been exceeded with spores of more than three fern species, at least one (and frequently multiple) collections of seeds of all native plants of South Georgia and several collections of seeds of non-native plant species securely banked at the MSB (Annex 9 and 10).</p>	<p>Analyses to be completed and results to be prepared for publication.</p> <p>Remaining spore and seed collections from the 2019-2020 field season to be viability / germination tested.</p>
<p><b>Output 1.</b></p> <p>Vegetation changes following reindeer removal from established vegetation monitoring plots quantified and success of the control programme of non-native plants on South Georgia evaluated</p>	<p>1.1 Data from 2 established vegetation monitoring plots analysed in year 1 and year 2 and across the monitoring period to demonstrate change in numbers and frequency of native and non-native plant species</p> <p>1.2 Data from at least 2 invaded sites (4 plots per site) analysed in year 1 and year 2 and across the monitoring period to demonstrate change in numbers and frequency of native and non-native plant species</p>	<p>1.1 Analysis of data from both field seasons now complete; interpretation of results in progress.</p> <p>1.2 Analysis of data from both field seasons now complete; interpretation of results in progress.</p>	
<p><b>Activities 1.</b></p>			

Project summary	Measurable Indicators	Progress and Achievements April 2020 - March 2021	Actions required/planned for next period
<ul style="list-style-type: none"> <li>1.1 Agree a Memorandum of Collaboration with GSGSSI, Indigena, Durham University and Kew</li> <li>1.2 Review and finalise current methodology, including sites and plots for sampling, in light of planned South Georgia activities and data analyses</li> <li>1.3 Project launch and workshop in the Falkland Islands</li> <li>1.4 Discuss and finalise field data protocols at Falkland Islands workshop</li> <li>1.5 Collect data on non-native species distribution at field sites visited in year 1 and year 2</li> <li>1.6 Analyse data to quantify the success of control methods in year 1 and year 2</li> <li>1.7 Update excel database and produce a summary report on non-native species distribution</li> <li>1.8 Upload summary report onto GSGSSI and Kew websites and Research Gate</li> <li>1.9 Prepare scientific paper for open access publication in an international peer-reviewed journal</li> </ul>		<ul style="list-style-type: none"> <li>1.1 Memorandum of Collaboration agreed and signed by all parties (AR1).</li> <li>1.2 Methodology, sites and plots agreed at Falkland Islands workshop (AR1).</li> <li>1.3 Project launched and successful workshop held in the Falkland Islands in December 2018 (AR1).</li> <li>1.4 Field data protocols finalised (AR1).</li> <li>1.5 Data collected by field team during 2018-2019 and 2019-2020 field seasons (AR1, AR2).</li> <li>1.6 Analysis of both field seasons almost complete; interpretation of results in progress.</li> <li>1.7 Excel database updated. Summary report to be written once interpretation complete.</li> <li>1.8 - 1.9 N/A for this reporting period.</li> </ul>	<p>Summary report to be written and a manuscript prepared for open access publication.</p>
<p><b>Output 2.</b> The risk of non-native plant species persisting past 2020 estimated</p>	<p>2.1 Viability of seeds from at least 20 invaded sites with a minimum of 5 soil samples of 200 cm<sup>3</sup> per site determined</p>	<p>2.1 Subsamples from three of five replicates from soil samples collected from 26 sites during the 2018-2019 field season have been sown and seedlings identified where possible.</p>	
<p><b>Activities 2.</b></p> <ul style="list-style-type: none"> <li>2.1 Develop soil sampling protocols</li> <li>2.2 Discuss and finalise field data protocols at Falkland Islands workshop</li> <li>2.3 Collect soil samples from field sites in South Georgia</li> <li>2.4 Transport samples to the MSB for analysis</li> <li>2.5 Process samples in the laboratory by sieving soil and removing seeds</li> <li>2.6 Identify species where possible from seeds</li> <li>2.7 Seed germination and tetrazolium tests to quantify seed viability</li> </ul>		<ul style="list-style-type: none"> <li>2.1 - 2.2 Soil sampling protocols finalised and agreed at the Falkland Islands workshop. Laboratory Standard Operating Procedure developed and agreed by Defra enabling a soil licence to be obtained for the work to be conducted at the MSB (AR1).</li> <li>2.3 Five reps from 26 sites (130 soil samples in total) collected from South Georgia field sites during 2018-2019 and five reps from 20 sites (100 soil samples in total) collected from South Georgia during 2019-2020 (AR1, AR2).</li> </ul>	<p>Soil samples from replicates 4-5 collected in the 2018-2019 field season to be moistened and monitored and seedlings harvested for DNA analysis where visual identification is not possible. Data to be added to the excel</p>

Project summary	Measurable Indicators	Progress and Achievements April 2020 - March 2021	Actions required/planned for next period
<p>2.8 Grow on seedlings in a glasshouse at Kew for plant species identification</p> <p>2.9 Analyse data to estimate the proportion of viable non-native seeds in soil samples</p> <p>2.10 Update excel database and produce a summary report on soil sample analysis and the risk of non-native plant species persisting past 2020</p> <p>2.11 Upload summary report onto GSGSSI and Kew websites and Research Gate</p>		<p>2.4 - 2.8 Soil samples collected on South Georgia during the 2018-2019 field season have been processed using two different methods (AR2):</p> <p>a) Seed extracted from subsamples of soil (5 reps x 4 sites = 20 samples); extracted seed checked for viability using germination and tetrazolium testing.</p> <p>b) Subsamples of soil moistened, and seed germination being monitored (3 reps x 26 sites = 78 samples).</p> <p>Seeds and seedlings identified where possible, and seedlings collected for identification by molecular methods.</p> <p>2.9 Preliminary analysis completed (AR2).</p> <p>2.10 Excel database updated. Summary report to be completed when soil sample processing is complete.</p> <p>2.11 N/A for this reporting period.</p>	<p>database and a summary report produced and uploaded onto Research Gate, Kew and GSGSSI websites.</p>
<p><b>Output 3.</b> The potential for non-native species to spread quantified</p>	<p>3.1 The number of species and number of seeds per species dispersed into at least 5 traps per site each placed in a minimum of 2 invaded sites, 2 native sites and 2 sites recently exposed by retreating glaciers identified</p> <p>3.2 Likelihood of new areas recently exposed by retreating glaciers being colonised by non-native species, over native species, quantified</p>	<p>3.1 Seed trap contents (5 replicates from 6 sites) collected on South Georgia during the 2018-2019 field season have been processed and identified where possible. Seed trap contents are being sown to check viability. Seed trap contents (5 replicates from 6 sites) from the 2019-2020 field season are still to be processed.</p> <p>3.2 Plant surveys in deglaciated areas in the 2019-2020 field season completed. These data are being analysed.</p>	
<p><b>Activities 3.</b></p> <p>3.1 Develop and test seed trap design</p> <p>3.2 Agree seed trap sites and set-up protocols at Falkland Islands workshop</p> <p>3.3 Set seed traps at the beginning of the field season to catch dispersed seeds</p> <p>3.4 Collect seed from seed traps before the end of the field season</p> <p>3.5 Transport samples to the Millennium Seed Bank (MSB) for analysis</p> <p>3.6 Identify species where possible from seeds</p>		<p>3.1 - 3.2 Seed trap design researched and developed, and seed trap sites agreed at the Falkland Islands workshop (AR1).</p> <p>3.3 - 3.4 Thirty seed traps installed at six different locations on South Georgia at the beginning and retrieved at the end of the 2018-2019 field season. The same traps installed and retrieved at the end of the 2019-2020 field season (AR1, AR2).</p> <p>3.5 Seed traps from 2018-2019 field season processed.</p> <p>3.6 Seeds extracted and identified where possible from 2018-2019 field season (AR2).</p>	<p>Remaining seeds from 2018-2019 field season to be viability-tested and identified from seedling material using molecular methods. Seed trap contents for 2019-2020 field season to be documented, and</p>

Project summary	Measurable Indicators	Progress and Achievements April 2020 - March 2021	Actions required/planned for next period
<p>3.7 Seed germination and tetrazolium tests to quantify seed viability</p> <p>3.8 Grow on seedlings in a glasshouse at Kew for plant species identification</p> <p>3.9 Analyse data to quantify potential native and non-native species spread</p> <p>3.10 Update excel database and produce a summary report on the potential for non-native species to spread</p> <p>3.11 Upload summary report onto GSGSSI and Kew websites and Research Gate</p>		<p>3.7 - 3.9 Seed germination and tetrazolium tests to quantify seed viability and identify unknown seeds is in progress for the 2018-2019 field season traps and is still to be completed for the 2019-2020 field season traps.</p> <p>3.10 Excel database updated. Summary report to be completed following processing of 2019-2020 field samples.</p> <p>3.11 N/A for this reporting period.</p>	<p>seeds removed and identified. Seed viability to be determined by germination and tetrazolium tests, and seedlings grown on for identification where needed.</p>
<p><b>Output 4.</b> Impact of climate change on selected native and non-native plant species in South Georgia estimated</p>	<p>4.1 Germination characteristics of 3 native and 3 non-native plant species at current and warmer temperatures of seeds determined (as a proxy of establishment success)</p> <p>4.2 Likelihood of non-native success over native species under climate change quantified</p>	<p>4.1 Germination characteristics of native <i>Poa flabellata</i> and non-native <i>Poa annua</i> seeds have been determined. The experiment to determine the germination characteristics of native <i>Festuca contracta</i> and non-native <i>Festuca rubra</i> is still running, but due to complete in the next couple of months. The final species pair, consisting of native <i>Deschampsia antarctica</i> and non-native <i>Deschampsia parvula</i>, is currently in cold stratification and will be moved onto the thermal gradient plate next month, to enable germination of these two species to be characterised.</p> <p>4.2 Likelihood of non-native success over native plant species will be determined when all thermal gradient plate results have been collected and analysed.</p>	
<p><b>Activities 4.</b></p> <p>4.1 Identify non-native and closely-related native species to research the impact of climate change on seed germination and subsequent recruitment in South Georgia</p> <p>4.2 Determine germination requirements for paired native and non-native plant species from SBD or the literature</p> <p>4.3 Collect target non-native seed from populations in South Georgia or the Falklands if not available from MSB collections</p> <p>4.4 Seed germination tests on a thermal gradient plate at the MSB on three closely related species pairs, where one species is native and the other is non-native</p> <p>4.5 Analyse data to determine germination characteristics (e.g. temperature thresholds)</p> <p>4.6 Prepare scientific paper for open access publication in an international peer-reviewed journal</p>		<p>4.1 - 4.2 Suitable pairs of native and non-native congeneric plant species selected, and germination requirements checked on SBD (AR1).</p> <p>4.3 Seed from both native and non-native target species were collected in field season 2018-2019 (AR1).</p> <p>4.4 Thermal gradient plate germination completed for native <i>Poa flabellata</i> and non-native <i>Poa annua</i>; almost complete for native <i>Festuca contracta</i> and non-native <i>Festuca rubra</i> and cold stratification virtually complete for native <i>Deschampsia antarctica</i> and non-native <i>Deschampsia parvula</i>, with thermal gradient plate germination testing to be set up on removal from cold stratification conditions.</p> <p>4.5 Analyses will commence when germination tests are complete as these are comparative.</p> <p>4.6 N/A for this reporting period.</p>	<p>Thermal gradient plate germination tests to be completed for native <i>Festuca contracta</i> and non-native <i>Festuca rubra</i>; native <i>Deschampsia antarctica</i> and non-native <i>Deschampsia parvula</i>. Results to be analysed and a manuscript prepared for open access publication on the three species pairs.</p>

Project summary	Measurable Indicators	Progress and Achievements April 2020 - March 2021	Actions required/planned for next period
<p><b>Output 5.</b> Seeds and fern spores of native plant species of South Georgia collected and stored at the Millennium Seed Bank for ex-situ conservation and seed germination protocols determined</p>	<p>5.1 Spores of at least three fern species and all native seed plants of South Georgia securely banked and at least two thirds (i.e. 17 species) with multiple collections for genetic diversity at the Millennium Seed Bank</p> <p>5.2 Seed dispersal and dormancy syndromes identified and seed germination protocols determined for all native species</p> <p>5.3 Seedling images captured for all native plant species</p>	<p>5.1 In both field seasons, 52 collections comprising 21 species plus a native seed plant hybrid were collected. At least 13 spore collections of 7 native fern species, 6 seed collections from 3 native plant species; and 4 seed collections of 3 non-native plant species have been viability-tested and banked. All native seed plants of South Georgia are now represented in the MSB. This exceeds the target of at least three fern species to be conserved at the MSB.</p> <p>5.2 Germination tests for native and non-native plant species that occur on South Georgia have been conducted and data analysed to determine germination requirements (AR1, AR2). Dormancy syndromes are being determined from these analyses.</p> <p>5.3 Germinated seeds have been grown on to produce seedlings which have been imaged in three different distinct stages for the field guide: emergence (1-2 leaves), seedling (3-8 leaves) and young plant. Virtually all emergence images (&gt;95%), most seedling images (&gt;75%) and almost half (&gt;40%) of young plant images have been captured with for both native and non-native species.</p>	
<p><b>Activities 5.</b></p> <p>5.1 Identify suitable populations for seed and fern spore collection</p> <p>5.2 Collect seeds and fern spores of native plant species of South Georgia for ex-situ conservation at the MSB</p> <p>5.3 Transport collections to the MSB for processing and banking</p> <p>5.4 Produce blog on South Georgia collecting trip for GSGSSI and Kew websites</p> <p>5.5 Process seed and fern spore collections and produce germination protocols</p> <p>5.6 Identify seed dispersal and dormancy syndromes</p> <p>5.7 Photograph seedlings from germination tests and make images available online</p> <p>5.8 Upload germination protocols onto the Seed Information Database (SID)</p> <p>5.9 Publish a Guide to Seeds and Seedlings of the Plants of South Georgia</p>		<p>5.1 - 5.2 Suitable populations were identified, and seed and fern spores collected during both field seasons (see details above).</p> <p>5.3 Seed and fern spore collections from both field seasons arrived at the MSB (AR1, AR2).</p> <p>5.4 Blog on Kew website: <a href="https://www.kew.org/read-and-watch/invasive-species-south-georgia">https://www.kew.org/read-and-watch/invasive-species-south-georgia</a> (AR2)</p> <p>5.5 Seed and fern spore collections from both field seasons have been processed and banked.</p> <p>5.6 Seed germination requirements for South Georgia native and non-native plant species collated; these data are being analysed to determine dormancy syndromes.</p> <p>5.7 Seedlings for most species produced and photographed (see details above).</p> <p>5.8 - 5.9 N/A for this reporting period.</p>	<p>Seed dormancy syndromes to be completed and uploaded onto SBD and SID, remaining seedling photographs to be captured and made available online and the Guide to Seeds and Seedlings of the Plants of South Georgia to be published.</p>

## Annex 2: Project's full current logframe as presented in the application form (unless changes have been agreed) - if applicable

*N.B. if your application's logframe is presented in a different format in your application, please transpose into the below template. Please feel free to contact [Darwin-Projects@ltsi.co.uk](mailto:Darwin-Projects@ltsi.co.uk) if you have any questions regarding this.*

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<b>Impact:</b>			
South Georgia's native habitats and plant species diversity are protected through the eradication of non-native species, conservation of native species, rehabilitation and maintenance of native habitats and improved biosecurity			
<b>Outcome:</b> South Georgia's native habitats protected by identifying non-native species most likely to persist, determining potential climate change effects on native and non-native species survival and banking seeds of native species	0.1 The number of non-native species predicted to persist post-2020 determined  0.2 Native and non-native species likely to colonise new habitats identified  0.3 Spores of at least three fern species and all native seed plants of South Georgia securely banked at the Millennium Seed Bank	0.1 Summary report published on GSGSSI and Kew websites and Research Gate  0.2 Seed Bank Database (SBD) for seed collected and excel database of results	0.1 Weather conditions allow boats to access South Georgia and field work to be completed  0.2 All target species produce sufficient seeds or spores during the lifetime of the project to allow safe collection for storage and not impact the future of native populations
<b>Output 1</b> Vegetation changes following reindeer removal from established vegetation monitoring plots quantified and success of the control programme of non-native plants on South Georgia evaluated	1.1 Data from 2 established vegetation monitoring plots analysed in year 1 and year 2 and across the monitoring period to demonstrate change in numbers and frequency of native and non-native plant species  1.2 Data from at least 2 invaded sites (4 plots per site) analysed in year 1 and year 2 and across the monitoring period to demonstrate change in numbers and frequency	1.1 Excel database and report on vegetation changes in established monitoring plots and in non-native species distribution in invaded sites where control is taking place  1.2 Summary report published on GSGSSI and Kew websites and Research Gate  1.3 Scientific paper on vegetation changes following non-native species control submitted to open	1.1 Team able to visit all sites every year to collect data unhampered by weather conditions  1.2 GSGSSI boat operational and able to transport team from the Falkland Islands to South Georgia and to field sites  1.3 No new non-native species introduced to South Georgia

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	of native and non-native plant species	access journal for publication end of year 3	
<b>Output 2</b> The risk of non-native plant species persisting past 2020 estimated	2.1 Viability of seeds from at least 20 invaded sites with a minimum of 5 soil samples of 200 cm <sup>3</sup> per site determined	2.1 Excel database on seeds found in soil seed bank  2.2 Summary report on potential for non-native species to spread into new areas published on GSGSSI and Kew websites and Research Gate	2.1 Soil samples contain sufficient seeds  2.2 Reliable identification of species is possible from seeds or young plants
<b>Output 3</b> The potential for non-native species to spread quantified	3.1 The number of species and number of seeds per species dispersed into at least 5 traps per site each placed in a minimum of 2 invaded sites, 2 native sites and 2 sites recently exposed by retreating glaciers identified  3.2 Likelihood of new areas recently exposed by retreating glaciers being colonised by non-native species, over native species, quantified	3.1 Excel database on seeds caught in dispersal traps  3.2 Summary report on potential for non-native species to spread into new areas published on GSGSSI and Kew websites and Research Gate	3.1 Dispersal traps are robust enough to survive the field season and are not disturbed  3.2 Dispersal traps collect sufficient seeds  3.3 Reliable identification of species is possible from seeds or young plants
<b>Output 4</b> Impact of climate change on selected native and non-native plant species in South Georgia estimated	4.1 Germination characteristics of 3 native and 3 non-native plant species at current and warmer temperatures of seeds determined (as a proxy of establishment success)	4.1 Scientific paper on the thermal germination niche of three closely related pairs of native and non-native species and associated predictions of a changing climate on seed germination behaviour submitted to open access journal for publication by the end of year 3	4.1 Adequate seed can be sourced for germination experiments  4.2 Seeds germinate under tested conditions

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	4.2 Likelihood of non-native success over native species under climate change quantified		
<b>Output 5</b> Seeds and fern spores of native plant species of South Georgia collected and stored at the Millennium Seed Bank for <i>ex-situ</i> conservation and seed germination protocols determined	5.1 Spores of at least three fern species and all native seed plants of South Georgia securely banked and at least two thirds (i.e. 17 species) with multiple collections for genetic diversity at the Millennium Seed Bank  5.2 Seed dispersal and dormancy syndromes identified and seed germination protocols determined for all native species  5.3 Seedling images captured for all native plant species	5.1 Kew's internal Seed Bank Database at the Millennium Seed Bank  5.2 Blog detailing seeds banked at end of year 3 on GSGSSI and Kew websites  5.3 Germination protocols on Kew's open access Seed Information Database: <a href="http://data.kew.org/sid/">http://data.kew.org/sid/</a>  5.4 Seedling images for native plant species to South Georgia available online  5.5 Publish a Guide to Seeds and Seedlings of the Plants of South Georgia	5.1 Populations of target native plant species produce seeds which are mature and in sufficient quantities for collection (no more than 20% of available seed to be collected to ensure native populations are not harmed) at the time the sites are visited
<b>Activities</b>  1.1 Agree a Memorandum of Collaboration with GSGSSI, Indigena, University of Durham and Kew 1.2 Review and finalise current methodology, including sites and plots for sampling, in light of planned South Georgia activities and data analyses 1.3 Project launch and workshop in the Falkland Islands 1.4 Discuss and finalise field data protocols at Falkland Islands workshop 1.5 Collect data on non-native species distribution at field sites visited in year 1 and year 2 1.6 Analyse data to quantify the success of control methods in year 1 and year 2 1.7 Update excel database and produce a summary report on non-native species distribution 1.8 Upload summary report onto GSGSSI and Kew websites and Research Gate 1.9 Prepare scientific paper for open access publication in an international peer-reviewed journal			

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<ul style="list-style-type: none"> <li>2.1 Develop soil sampling protocols</li> <li>2.2 Discuss and finalise field data protocols at Falkland Islands workshop</li> <li>2.3 Collect soil samples from field sites in South Georgia</li> <li>2.4 Transport samples to the MSB for analysis</li> <li>2.5 Process samples in the laboratory by sieving soil and removing seeds</li> <li>2.6 Identify species where possible from seeds</li> <li>2.7 Seed germination and tetrazolium tests to quantify seed viability</li> <li>2.8 Grow on seedlings in a glasshouse at Kew for plant species identification</li> <li>2.9 Analyse data to estimate the proportion of viable non-native seeds in soil samples</li> <li>2.10 Update excel database and produce a summary report on soil sample analysis and the risk of non-native plant species persisting past 2020</li> <li>2.11 Upload summary report onto GSGSSI and Kew websites and Research Gate</li> </ul>			
<ul style="list-style-type: none"> <li>3.1 Develop and test seed trap design</li> <li>3.2 Agree seed trap sites and set-up protocols at Falkland Islands workshop</li> <li>3.3 Set seed traps at the beginning of the field season to catch dispersed seeds</li> <li>3.4 Collect seed from seed traps before the end of the field season</li> <li>3.5 Transport samples to the Millennium Seed Bank (MSB) for analysis</li> <li>3.6 Identify species where possible from seeds</li> <li>3.7 Seed germination and tetrazolium tests to quantify seed viability</li> <li>3.8 Grow on seedlings in a glasshouse at Kew for plant species identification</li> <li>3.9 Analyse data to quantify potential native and non-native species spread</li> <li>3.10 Update excel database and produce a summary report on the potential for non-native species to spread</li> <li>3.11 Upload summary report onto GSGSSI and Kew websites and Research Gate</li> </ul>			
<ul style="list-style-type: none"> <li>4.1 Identify non-native and closely-related native species to research the impact of climate change on seed germination and subsequent recruitment in South Georgia</li> <li>4.2 Determine germination requirements for paired native and non-native plant species from SBD or the literature</li> <li>4.3 Collect target non-native seed from populations in South Georgia or the Falklands if not available from MSB collections</li> <li>4.4 Seed germination tests on a thermal gradient plate at the MSB on three closely related species pairs, where one species is native and the other is non-native</li> <li>4.5 Analyse data to determine germination characteristics (e.g. temperature thresholds)</li> <li>4.6 Prepare scientific paper for open access publication in an international peer-reviewed journal</li> </ul>			
<ul style="list-style-type: none"> <li>5.1 Identify suitable populations for seed and fern spore collection</li> </ul>			

Project summary	Measurable Indicators	Means of verification	Important Assumptions
5.2	Collect seeds and fern spores of native plant species of South Georgia for <i>ex-situ</i> conservation at the MSB		
5.3	Transport collections to the MSB for processing and banking		
5.4	Produce blog on South Georgia collecting trip for GSGSSI and Kew websites		
5.5	Process seed and fern spore collections and produce germination protocols		
5.6	Identify seed dispersal and dormancy syndromes		
5.7	Photograph seedlings from germination tests and make images available online		
5.8	Upload germination protocols onto the Seed Information Database (SID)		
5.9	Publish a Guide to Seeds and Seedlings of the Plants of South Georgia		

### **Annex 3 Onwards – supplementary material (optional but encouraged as evidence of project achievement)**

Annex 3: South Georgia Non-Native Plant Strategy 2016-2020

Annex 4: Agenda for SG meeting 2021-02-16

Annex 5: Minutes for SG meeting 2021-02-16

Annex 6: Sweeney MSc Conserving South Georgia's native plants

Annex 7: Seeds and spores collected 2018-2019 South Georgia

Annex 8: Seeds and spores collected 2019-2020 South Georgia

Annex 9: Change request DPLUS080 December 2020\_final

Annex 10: Change request DPLUS080 December 2020 outcome

Annex 11: Twitter record 2021-04

Annex 12: Darwin-Newsletter-Alien-Invasions-FINAL-March-2021

Annex 13: Change request DPLUS080 March 2020\_final

Annex 14: South Georgia Non Native Plants Season Report 2019\_20