

BIODIVERSITY DUTY REPORT 2018-2020



Royal Botanic Garden Edinburgh



SECTION 1: INTRODUCTORY INFORMATION ABOUT YOUR PUBLIC BODY

Please describe your organisation’s role and purpose, including any particular environmental responsibilities

<p>Guidance on completing this section</p>	<p>Summarise your organisation’s role and purpose, including a brief outline of governance and management structures.</p> <p>Summarise any relevance and impacts of biodiversity to your organisation, including your role in:</p> <ul style="list-style-type: none"> • Land and estate management; • Regulation of land use and development; • Providing public information, community learning and education around nature and the environment; • Any key environmental impacts from your operations.
<p>Text Field</p>	<p>Role and purpose, governance and management structures</p> <p>The Royal Botanic Garden Edinburgh (RBGE) was founded in 1670, and is one of the world’s leading scientific botanic gardens. RBGE is a registered charity (SC007983) and a non-departmental public body sponsored by the Scottish Government’s Environment and Forestry Directorate. Our remit is defined by the National Heritage (Scotland) Act 1985, and includes research and dissemination of plant science, and maintenance and development of our national living and preserved collections. Our contributions to the steps of the Scottish Biodiversity Strategy and to the Aichi Biodiversity Targets are highlighted throughout this report as “SBS x.x” and “Aichi x,” respectively.</p> <p>Our Mission is “to explore, conserve and explain the world of plants for a better future,” and our Vision is: “a world that increasingly values, protects and benefits from plants.”</p> <p>Our research has a strong focus on Scotland’s own unique flora alongside a renowned international programme with active projects in more than 35 countries. We work collaboratively to strengthen global capacity in plant science and conservation, having strong and well-established partnerships with individuals, institutions, governments and organisations across the world, particularly in tropical South America, South East Asia, the Middle East, Nepal and China.</p> <p>RBGE is also the custodian of globally important scientific collections including an herbarium of three million preserved plant specimens, an extensive botanical library and archive and a living collection of 13,750 plant species. Our horticulture and horticultural training are a particular strength, and our education programmes range from primary school level to</p>



PhDs, as well as recreational courses. We are a major tourist destination, with four Gardens across Scotland together attracting over one million visitors per year.

Our work is articulated via five-year strategic plans, supported by annual operational delivery plans, and is aligned around three strategic pillars:

Pillar 1: Unlocking knowledge and understanding of plants and fungi to benefit society.

Pillar 2: Protecting and developing the National Botanical Collections as a global resource.

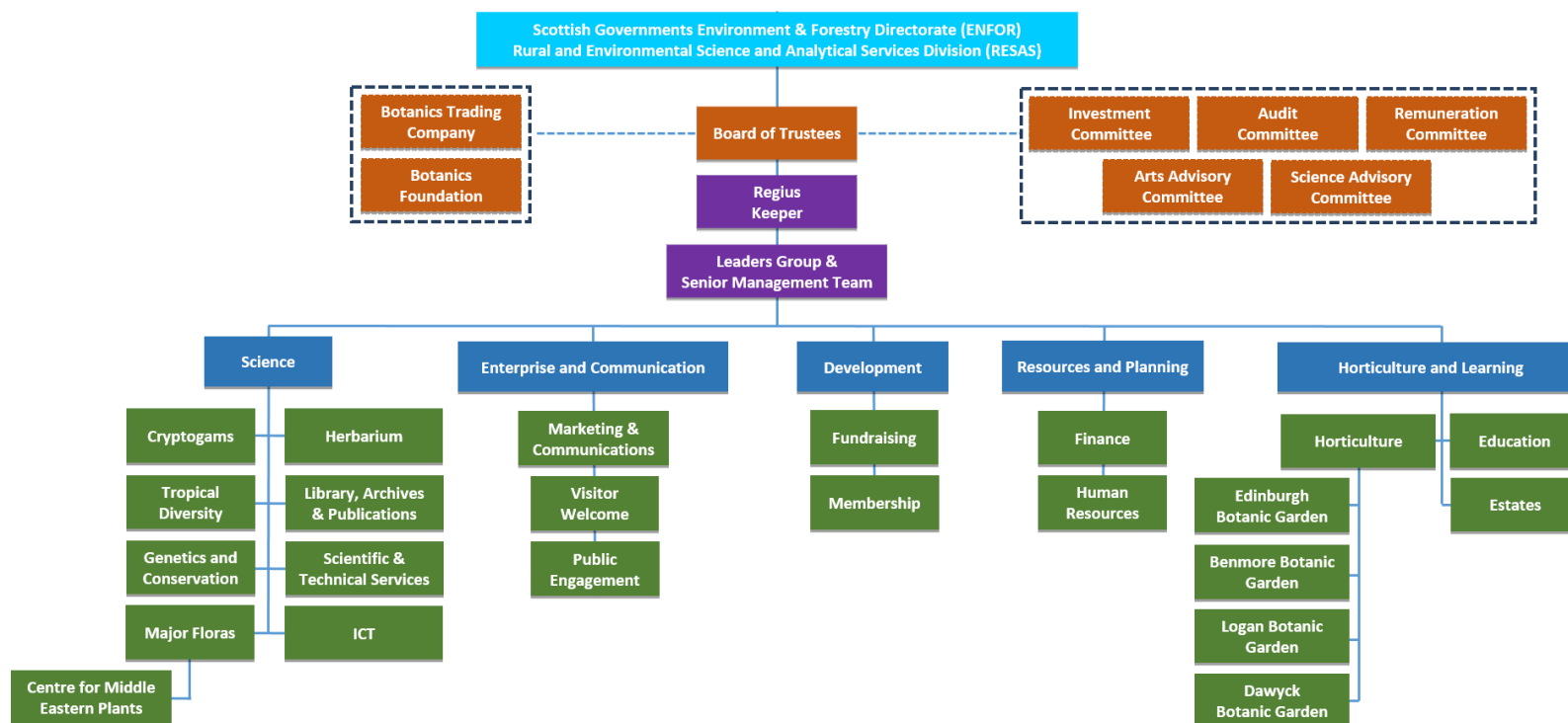
Pillar 3: Enrichment and empowerment of individuals and communities through learning and engagement with plants and fungi.

Our primary source of funding is Grant-in-Aid and capital support from the Scottish Government. In addition, RBGE receives financial support from trusts, foundations, corporate supporters, donations from the public, income from admission charges, our membership programme, research grants, retail sales, education courses, events and exhibitions, investments and consultancy.

RBGE is governed by a board of nine trustees appointed by Scottish Ministers. The Regius Keeper and Chief Accountable Officer is Professor Simon Milne, who reports directly to the Scottish Government and the Board of Trustees. Formal reporting is via quarterly board meetings with reports to the board and government, along with the statutory annual report and accounts. RBGE is managed by a Leadership Group comprising the Regius Keeper and the leaders of our five divisions: Science; Horticulture and Learning; Development; Enterprise and Communications; and Resources and Planning. Our governance structure is outlined overleaf.

Land and estate management

The RBGE estate includes approximately 270 acres of land, across four Gardens in Edinburgh, Dawyck, Benmore and Logan. The RBGE property portfolio comprises nearly 30,000 m² of built environment over 100 assets, and includes administrative offices, education facilities, visitor centres and heritage glasshouses. This land and built environment allow us not only to understand better the natural world, but also to conserve and restore rare and threatened species. Our living collection contains 13,750 species from over 160 countries, including the vast majority of rare and threatened Scottish vascular plant species. Our Edinburgh glasshouses contain thousands of species from around the world, many of which are new to science, threatened, or even extinct in the wild.



Governance structure of the Royal Botanic Garden Edinburgh

Regulation of land use and development

We assess the environmental impacts of how we use and develop our estate. This includes (a) adopting management strategies to protect the biodiversity in our collections, and to support the wider habitat value of RBGE for wildlife, and (b) incorporating environmental sustainability as a central priority in our capital works programme.



Public information, community learning and education around nature and the environment

Our education and engagement programmes provide learning opportunities focusing on biodiversity loss and climate change to a wide range of audiences. Our current education provision includes school sessions from early years to secondary, tertiary provision in partnership with SRUC and University of Edinburgh on HND, BSc and MSc level programmes, RBGE certified programmes including herbology and botanical illustration, delivery of RHS qualifications and a range of short courses and online programmes. Public engagement occurs both through formal events and exhibitions, and use of self-guided tours and interpretation materials. Community learning takes place both on-site and off-site through a wide range of activities and events (See Section 5: Public Engagement).

Key environmental impacts

We recognise that carrying out the vital work of maintaining our living collections and our built estate has an impact on the natural environment. This impact—which is measured and submitted to the Scottish Government every year as part of our accounting procedures—occurs largely through the energy, water and other resources required to run our buildings and cultivate our world class plant collections, as well as the air travel required to share our expertise internationally. Our greenhouse gas emissions contribute to climate change, which in turn impacts upon global biodiversity. In 2019-2020, our emissions were estimated at 3,006 tCO₂e, and we will continue to reduce this through our policies, which already strongly discourage domestic flights and promote public transport use, including a staff ‘cycle-to-work’ scheme and flexible working. We also generated and exported the equivalent of 10 tCO₂e through our renewables (solar PVs and hydro-electric scheme) bringing our net output to 2,996 tCO₂e.

We work continuously to embed sustainability and low carbon practices into every aspect of our decision-making. The upcoming ‘Edinburgh Biomes’ project will allow us directly to reduce our biggest source of GHG emissions—heating the glasshouses—while safeguarding the national botanical collection and improving the efficiency of multiple listed buildings within our historic estate. We are currently working on a Carbon Management Plan 2021-2030, which will outline and prioritise projects to improve energy efficiency and increase our use of renewables, allowing us to decarbonise further our built environment and define our path to net zero emissions by 2040, ahead of Scottish Government targets.



SECTION 2: ACTIONS TO PROTECT BIODIVERSITY AND CONNECT PEOPLE WITH NATURE

Please describe and explain any actions that your organisation has undertaken alone or as part of a partnership to benefit biodiversity directly, to tackle the main drivers of biodiversity loss, or to achieve wider outcomes for nature and people

<p>Guidance on completing this section</p>	<p>As a Level One reporting organisation, you may wish to report on activities across your organisation, including any actions that you have undertaken on the ground on land that you manage alone or with others.</p> <p>Please explain how these actions have benefited biodiversity, noting successes and challenges, and any plans for future or follow-up work. These might include:</p> <p>The creation, enhancement and protection of wildlife and natural habitat. Please include quantitative measures where possible (e.g., ha of raised bog restored, ha of new woodland planted, areas managed to enhance biodiversity).</p> <p>Involvement in key partnerships such as the Local Biodiversity Action Plan Partnership, relevant Community Planning groups, running a Local Records Centre.</p> <p>Addressing the key drivers of biodiversity loss, which might include work or projects to tackle:</p> <ul style="list-style-type: none"> • Land use change; • Exploitation; • Invasive Non Native Species; • Pollution. <p>Enhancing biodiversity at your premises through actions in and around offices such as:</p> <ul style="list-style-type: none"> • providing bird boxes / feeders; • creating a habitat for wildlife, such as wildflower areas; • installing green roofs; • organising staff volunteering days.
<p>Links to related resources</p>	<ul style="list-style-type: none"> • Guidance on the Key pressures on biodiversity. • Guidance for Planners and developers on legally Protected Areas and Protected Species. • Guidance for all bodies on highest priority species and habitats for targeted conservation action



	<ul style="list-style-type: none">• Guidance on biodiversity and the Planning system including creating, enhancing and protecting wildlife and natural habitats through Habitat management and Habitat networks.• Guidance on Buildings and biodiversity - how to make space for nature in the built environment.• Information on Local Biodiversity Action Plan Partnerships (LBAPs).• Collecting and managing biodiversity data, including from Local Records Centres Biodiversity - where to find data.• Information on Placemaking, open space and green infrastructure.• Case studies:<ul style="list-style-type: none">○ Greening parks and creating urban meadows in Edinburgh.○ Scottish Water Volunteering Programme• Guidance on Managing freshwater, including pollution and on Coastal development and marine pollution.• Examples of smaller actions that can be enacted in the office or staff homes - Biodiversity - what can you do?
Text Field	<p>Our actions to protect biodiversity extend from our own sites to the city of Edinburgh, across Scotland and around the world, in partnership with numerous other organisations. Our living collection is of global conservation importance, safeguarding hundreds of threatened taxa, including hundreds of Endangered or Critically Endangered species and six species Extinct in the Wild; we continue to identify additional threatened species year on year. We are world leaders in conservation horticulture, managing genetically diverse and representative collections of threatened species to support active <i>in situ</i> conservation programmes, with a particular focus on Scottish native species and conifers globally, while we also manage the Global Conservation Consortium for Rhododendron, established by Botanic Gardens Conservation International, which brings together scientists, horticulturists and conservationists to prioritise and facilitate <i>in situ</i> and <i>ex situ</i> conservation of these iconic and often threatened species.</p> <p>Protecting Scottish biodiversity</p> <p>(SBS 4.1) On our own sites we maintain two 25 m² 'living lawn' plots sown with a mix of low-growing, native, perennial wildflowers, providing a functional 'lawn' rich in both plant and insect species and inspiring to visitors to consider making similar changes for biodiversity in their own lawns (Aichi 1). For more information see https://www.rbge.org.uk/news/articles/growing-biodiversity-in-living-lawns. In 2020 we sowed a large, annual 'pictorial meadow' providing food for pollinators and a restorative space for visitors alike. At Logan Botanic Garden we maintain a specialised area focused on conserving local coastal plant species.</p>



RBGE is an active partner in the Edinburgh Biodiversity Action Plan (EBAP) (Aichi 2, 10, 14, 15, 17), with a commitment to multiple EBAP targets. These include:

- restoration of coastal species-rich grassland (through our Shoreline Project, see Section 5) using species coherent with the Pollinator Strategy for Scotland;
- creation and promotion of urban biodiversity through green roofs both on- and off-site;
- green walls;
- a demonstration raingarden (see Section 4);
- 'square metres for butterflies' providing pollinator food and habitat across the city;
- planting endangered conifers at 'conifer safe sites' across the Lothians and beyond (we now cultivate 14,000 genetically-diverse individuals of 285 conifer species from across the globe at more than 200 UK sites, dramatically broadening the genetic base and range of these economically and ecologically important plants in the British Isles); and
- targeted conservation work on multiple other species including many rare bryophytes.

(SBS 4.1, Aichi 15) Since June 2019, our Biodiversity Challenge Fund project, 'Wild Line,' has delivered multiple interventions to create important habitat in the Cramond to Granton area of the Edinburgh coastline. We are on track to deliver 8 500 m² of perennial wildflower meadows by Spring 2021, providing important habitat for pollinators. In late summer 2020, 50 concrete tiles, designed to provide habitat for rocky shore invertebrates, were cast and erected on hard sea defences in the area, improving the biodiversity of otherwise uninhabited coastal defensive structures.

(SBS 4.4) Elsewhere across the nation, our Scottish Rare Plants Programme (Highly Commended in the 2019 Nature of Scotland Awards) draws upon our wide expertise in genetics, horticulture and plant health and works closely with local landowners and conservation organisations such as NatureScot. This programme aims to:

- generate evidence-based management strategies for species facing extinction in the UK (i.e., rare, nationally threatened, and/or listed on the UK Biodiversity Action Plan, the Wildlife and Countryside Act, or the Scottish Biodiversity List);
- protect rare plant species *in situ*;
- study the requirements of rare species and the threats facing them;
- cultivate the rarest species *ex situ* in our Gardens;
- translocate genetically diverse, disease-free stock into existing and new wild populations; and
- educate and engage the public around Scotland's beautiful native flora.

By these actions we ensure Scotland meets Target 8 of the Global Strategy for Plant Conservation (*At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes*).



One of our success stories is *Cicerbita alpina*, the alpine-blue sowthistle, one of the UK's rarest and most striking species (SBS 4.4, Aichi 12). Threatened by grazing and climate change, the sowthistle's 1.5 m, bright blue flowering spikes persist at only four small sites in the UK, all in the Cairngorms National Park. Natural regeneration is at a standstill: neither young plants nor seedlings have been found. We discovered that Scotland's alpine-blue sowthistle populations lack diversity—comprising fewer than 50 genetically-distinct individuals across all sites—and our pollination experiments showed that the species can set seed, but germination rates are low without crossing between populations, which is unlikely to occur in the wild. By controlled pollination, we cultivated over 1,000 individuals with maximised genetic diversity, which were reintroduced to carefully selected sites in the Cairngorms. Thanks to strict quarantine measures, they established healthy populations with potential not only to be self-sustaining and naturally-regenerating, but to adapt to future climate change. We have now tripled the number of wild populations in the UK, providing a degree of insurance against geological instability, grazing and extreme weather events. The populations are carefully managed and monitored—using drone technology for the most inaccessible sites—in partnership with NatureScot and local landowners. New interpretation materials on Clunie Bridge, Braemar, raise awareness of the restoration programme and other threatened Scottish species. Our sowthistle programme is complemented by experimental translocations of internationally rare rainforest epiphytes into sites recovered from *Rhododendron* invasion, working with Forest and Land Scotland and the Loch Lomond and Trossachs National Park.

We hold *ex situ* collections representing all UK populations of *Woodsia ilvensis* (oblong woodsia) and *Sorbus arranensis* (Arran whitebeam), as well as genetically diverse collections of other species. These collections safeguard species in case of extinction in the wild, can be bulked-up for population translocations/reintroductions, provide material for studies supporting effective ecosystem restoration, and are used for training, teaching and raising awareness. We continue to monitor our long-term reintroduction projects for *Oxytropis halleri* (mountain milk-vetch) around the Cromarty Firth, *Polygonatum verticillatum* (whorled Solomon's seal) in Perthshire, *Salix lanata* (woolly willow) at Corrie Fee National Nature Reserve, and *Woodsia ilvensis* across Scotland and Cumbria.

We also made genetically diverse collections of seed of 14 Scottish native tree species and 29 conservation-priority herbs, for long-term preservation in the UK Millennium Seed Bank. Our programme of 'conservation hedges' enables cultivation of multiple genotypes of threatened species in a small space. Over the last five years we planted nine conservation hedges across the UK, featuring many rare species including native heritage yews (Aichi 12, 13).

Protecting biodiversity across the world

In Bhutan, we developed an intensive programme to protect Bhutan's sacred national tree, the Himalayan cypress (tsenden), *Cupressus torulosa*, from unsustainable logging. With the Royal Botanic Garden Serbithang, Botanic Gardens Conservation International and local people, we surveyed tsenden populations, collected seed from a wide range of



individuals, and established a community tree nursery to create a sustainable timber supply, relieving pressure on natural forests while still delivering material for local community housing and religious buildings. In one year, an astounding 41,000 seedlings were planted out across the Dangchu Valley, where they are now protected and monitored (Aichi 2, 4, 10, 12, 14, 19).

We used DNA-based identification tools to protect threatened species including the heavily exploited and Critically Endangered jatamansi (*Nardostachys grandiflora*) in Nepal. More than 15,000 people in the Himalayas rely on income from jatamansi harvesting for medicinal uses, but are increasingly undercut by largescale illegal exporters. Our Darwin Initiative project with TRAFFIC International and others used jatamansi as a model to develop monitoring and certification mechanisms supporting better-regulated, sustainable trade and livelihoods (Aichi 2, 4, 10, 12).

In Tanzania, our Darwin Initiative project is developing rigorously evidenced community-based approaches to forest management, enhancing sustainability, equity and gender-balance (Aichi 4, 5, 10, 19). In Chile—where only 11% of remaining temperate rainforest has any form of protection—our International Conifer Conservation Programme established the 1,200-hectare ‘Reserva Nasampulli,’ with Rainforest Concern, to conserve ancient primary *Araucaria* forest (Aichi 2, 5, 10, 11). In Laos we launched the first restoration programme for the Critically Endangered conifer mai hing sam (*Glyptostrobus pensilis*), in collaboration with the University of San Francisco, Nakai Nam Theun Watershed Management Protection Authority and Nam Theun Power Company (Aichi 10, 15).





On Soqotra (Yemen), our Centre for Middle Eastern Plants developed a British Council Cultural Protection Fund project to integrate cultural heritage and biodiversity into conservation and development planning. In the face of little in-depth documentation of Soqotri cultural heritage, our team of local experts working with the Freie Universitat, Berlin, the Senckenberg Research Institute, Frankfurt, UNESCO, Friends of Soqotra and Soqotra Environmental Protection Agency, recorded more than 400 significant heritage sites and a wide range of cultural traditions and practices, many relying on the islands' endemic plants. Around 5,000 people engaged with the project through traditional poetry, music, dance and theatre events (Aichi 2, 11, 16).

Back in Edinburgh Our new DART (Direct Analysis in Real Time) mass spectrometer, installed in collaboration with Edinburgh's Roslin Institute and supported by the players of the People's Postcode Lottery, is being used to develop assays to determine the provenance of wild-collected threatened cycads, and track timber products to their source forests, combating illegal logging and forest degradation across the globe (Aichi 4, 7, 10).

Knowledge and skills transfer, and capacity building, is central to our biodiversity conservation work in countries with low incomes and rich floras. With our long, global history of research, we have a responsibility not only to share our knowledge and skills with these countries, but also to repatriate resources and expertise. For example, in Tajikistan, funding from the UK Foreign and Commonwealth Office helped us train staff of Kulob Botanic Garden in all aspects of propagation and cultivation, supporting conservation of the country's valuable heritage fruit trees, threatened by unsustainable planting of European cultivars. Our new, three-year Darwin Initiative project is now extending this capacity, increasing income for local farmers and improving access to local produce. In Iraq, with the Darwin Initiative and Nature-Iraq, we transferred skills and equipment to survey and manage biodiverse areas and improved in-country availability of botanical data, supporting protected area management and community-level conservation. We recently repatriated 40 rooted cuttings of the Near Threatened catkin yew, *Amentotaxus argotaenia*, to boost populations in Hong Kong.

Please note that further reporting on 'Connecting People with Nature' is contained in Section 5: Public Engagement and Workforce Development.



SECTION 3: MAINSTREAMING BIODIVERSITY

Please outline any steps your organisation has taken to incorporate biodiversity measures into its wider policies, plans or strategies. This should include decision-making structures and staff and organisational roles and responsibilities.

<p>Guidance on completing this section</p>	<p>Describe and explain any of your own body’s policies, plans and strategies that refer to biodiversity or may affect biodiversity positively or negatively, and how these are reflected in the structure of your organisation.</p> <p>These may include policies on managing green spaces, Open Space Strategies, Supplementary Planning Guidance, consideration of biodiversity in estate management, procurement policies and purchasing decisions, use of an Environmental Management System, Sustainability and Climate Change commitments or actions such as installing a Sustainable Urban Drainage System (SuDS).</p> <p>Detail any areas in which your organisation has most successfully implemented mainstreaming of biodiversity, or has demonstrated leadership in a local or national context, including through working with others, raising awareness, or delivering landmark projects or activities.</p>
<p>Links to related resources</p>	<ul style="list-style-type: none"> • Information on Green Infrastructure, placemaking, and open space strategies. • Guidance on Buildings and biodiversity and SuDs - how to make space for nature in the built environment. • Guidance on Buildings, Highways and Infrastructure - Maintenance & biodiversity, • Research on Maximising the benefits of green infrastructure in social housing. • The Place Standard tool and associated Strategic Plan 2020-2023 provides a simple framework to structure conversations about place. • Guidance on managing Local Nature Conservation Sites systems. • Case study - Procurement by the Scottish Courts and Tribunal (SCTS) Services. • The Forest Stewardship Council global forest certification system. • Guidance on Scotland's Pollinator Strategy, projects, resources • Case studies: <ul style="list-style-type: none"> ○ Local Nature Conservation Sites systems in North Lanarkshire and Aberdeenshire. ○ A Pollinator Action Plan in Aberdeenshire



Text Field

Policies, plans and strategies

RBGE has aligned its work to assist in meeting the targets of the Climate Change (Scotland) Act, and contributing to the Greening Government strategy. We are committed to the Scottish Biodiversity Strategy and have a Delivery Agreement with the 2020 Challenge for Scotland's Biodiversity (<https://www.nature.scot/sites/default/files/2018-01/SBS%20Delivery%20Agreements%20-%202020%20Challenge%20for%20Scotland%20-%20RBGE%20-%20January%202016.pdf>) (Aichi 2, 17). Internally, we have developed a comprehensive, high-level Environmental Policy (<https://www.rbge.org.uk/media/4267/environmental-policy-june-2018.pdf>), resonating with three of the five Scottish Government Strategic Objectives (*Smarter, Safer & Stronger* and *Greener*) and contributing to five of the National Outcomes. We also have a Sustainable Development Policy (<https://www.rbge.org.uk/media/7103/sustainable-development-policy-march-2014-2.pdf>), and Sustainable Procurement Action Plan (<https://www.rbge.org.uk/media/6138/rbge-sustainable-procurement-action-plan.docx>) in line with Scottish Government strategies. Three of our four Gardens are members of the Green Tourism Scheme and have achieved its highest (Gold) award. Our wider biodiversity impact is also reduced through a new Ethical Investment Policy (<https://www.rbge.org.uk/media/5686/ethical-investment-policy.pdf>) (Aichi 2, 3, 10).

We are currently undergoing a shift to a new strategic plan for 2020-2025, which will be informed by the outcome of international negotiations towards a post-2020 biodiversity framework. As such, we are currently following a Transition Plan 2019-2020. Our new Biodiversity Strategy, which will be published in early 2021, focuses our Science and Conservation activities around our three pillars (outlined in Section 1: Introductory Information) and within that, five strategic strands:

- Discovery Science: Understanding plant and fungal diversity.
- Global Environmental Change: Understanding biodiversity and ecosystem change.
- Conservation and Sustainability: Delivering science to enable the conservation and sustainable use of biodiversity.
- Collections Custodians: Curating and enriching the botanical collections held at RBGE, and supporting the wider global network of botanical collections.
- Building global capacity in plant biodiversity science, conservation and horticulture.

Implementation and leadership

Our biggest existing environmental impacts are from waste, energy use and travel. We minimise our environmental impacts from waste by having recycling facilities available in all Gardens for visitors and staff alike. Food waste is collected and sent to a local anaerobic digestion plant. Our ambitious Edinburgh Biomes plan, supported by investment from the Scottish Government's Low Carbon fund, will be realised over the next seven years. It includes replacing our old



heating system with a sustainable energy centre featuring ground-source heat pumps, and renovating or replacing our heritage glasshouses to minimise heat losses and maximise energy efficiency. Our Dawyck Botanic Garden, in the Scottish Borders, became the first carbon-neutral botanic garden in the UK through an innovative combination of green roofing, a hydro-electric energy scheme, biomass heating, and electric vehicle charging points, which are now installed at all four of our sites. At Logan Botanic Garden, we built the first UK public glasshouse heated exclusively by green energy, including solar photovoltaic panels and air source heat pumps. Although we cannot entirely avoid making long-haul flights in our work to protect biodiversity around the world, we have a 'no domestic flights policy' within the UK and, where possible, Europe.

Our Horticulture team have integrated biodiversity into their working in several ways (Aichi 2): we have a policy of retaining deadwood from shed branches, dead and dying trees within our Gardens, providing habitats initially for fungi, bacteria and wood boring insects and, as the wood breaks down, for spiders, millipedes, mites, and birds and bats. Our 'no peat' policy has been in place for thirty years, demonstrating our commitment to protecting Scotland's globally important peat bog ecosystems, their unique biodiversity, and their important role in carbon storage. Instead of peat as a growing medium, our Gardens use milled pine bark, a widely available by-product of the local forestry industry, which has very similar qualities to peat. We work hard to reduce chemical inputs—and their associated biodiversity and climate change impacts—across our Gardens. Artificial fertiliser use is minimised by composting all green waste: in Edinburgh alone, we return 750 tonnes of material to the soil each year, adding nutrients, preventing desiccation and improving soil health. Our display glasshouses are now completely pesticide-free, with plants protected via a combination of physical pest removal and biological control. Our practices aim to trigger an increase in a diverse range of natural, native predators which would be unwanted victims of broad-spectrum pesticides (Aichi 4).

Sustainable, wildlife-friendly food production is mainstreamed via our certified organic market garden, supplying both visitor catering outlets and the staff canteen. Food production has a huge impact upon biodiversity, and organic food not only has fewer direct impacts upon biodiversity, due to the lack of pesticides used, but also reduces impacts on climate change by cutting out chemical fertilisers. Working with both our previous (Sodexo) and new caterers (Heritage Portfolio) our market garden demonstrates that we are what we eat (Aichi 4).

Our Education team integrate an awareness of biodiversity into every course. For example, our Schools Gardening Project takes a long-term approach, working regularly with six local primary, secondary and special schools from the local community. Participants are supported to grow plants in their own grounds, through outreach visits by a range of RBGE tutors and volunteers, and through hosting teachers at RBGE. Bringing together three key principles—'earth care, people care and fair share'—the project provides inter-generational learning opportunities and teaches a hands-on approach to biodiversity management (Aichi 1).



SECTION 4: NATURE-BASED SOLUTIONS, CLIMATE CHANGE AND BIODIVERSITY

How has your organisation integrated biodiversity into nature-based solutions to the climate emergency and other socio-economic outcomes?

<p>Guidance on completing this section</p>	<p>Climate change is a direct driver of biodiversity loss. Some species are dying out while others are being displaced due to warmer air temperatures, extreme weather patterns, and higher sea levels. As well as being a direct driver of biodiversity loss, climate change also worsens the other drivers. For example it enables quicker spread of non-native invasive species. Combined action for biodiversity loss and climate change can be achieved through nature-based solutions.</p> <p>This reporting section provides the opportunity for your organisation to provide details on how you are supporting the positive contribution biodiversity can make to building resilience, and helping nature to mitigate and adapt to climate change.</p> <p>Nature-based solutions can play a vital role in helping us to protect and enhance biodiversity, achieve net zero targets, and improve quality of life.</p> <p>You may wish to report on a range of specific processes or activities that your organisation has undertaken, including on land you own or manage, within your buildings and workforce, and projects that you have delivered.</p> <p>Integration might include incorporating biodiversity into nature-based solutions to:</p> <ul style="list-style-type: none"> • The climate emergency, for example by developing climate change strategies that include nature, investing in green infrastructure, and taking action for pollinators. • Inclusive economic growth, for example by growing nature-based industries, or investing in key natural visitor attractions. • Health and wellbeing, for example by improving access to nature for all.
<p>Links to related resources</p>	<ul style="list-style-type: none"> • Information on how urban nature-based solutions can help Scotland's towns and cities mitigate and adapt to climate change providing guidance and examples. • The Helping nature to adapt webpage contains useful information on making use of nature's capacity to adapt to change as one of our best tools for managing climate change impacts, including through managing native woodlands and restoring peatlands.



	<ul style="list-style-type: none">The publication People, Place and the Climate Emergency includes examples and information on local nature-based solutions to deliver a range of socio-economic outcomes.
Text Field	<p>Nature-based solutions to the climate emergency</p> <p>In all its activities, RBGE promotes a biodiversity-rich environment crucial to carbon sequestration and ecosystem and human resilience, and as a major centre of public engagement we support individuals and businesses to reduce their carbon emissions (Aichi 1, 2, 10).</p> <p>Understanding the impact of the climate emergency is fundamental to instigating positive change. We work to establish the status of plant and fungal species in our most climate-threatened landscapes, such as the snow-beds of the Cairngorms National Park (Aichi 14). This enables us to monitor changes as the environment heats up and habitats shrink, and to identify focal areas for protection. A particular focus is on cryptogams. ‘Cryptogamic crusts’ of bryophytes and lichens account for a substantial proportion of carbon capture and more than 50% of terrestrial nitrogen fixation, and Scotland is a hotspot for these vulnerable species. Our cryptogam research includes long-term monitoring, field sampling, translocation experiments and statistical modelling, to understand how climate change is affecting their ability to survive, grow, and reproduce. Elsewhere, our forest plot data accumulated over decades in central Africa was integral to a recent <i>Nature</i> paper (https://www.nature.com/articles/s41586-020-2035-0) estimating that tropical forests may by 2035 become sources, rather than sinks, of carbon—a crucial climate tipping point.</p> <p>We document the identity, distribution, and conservation status of plant species in biodiverse and economically-important groups including forest trees, conifers, gingers, begonias, the potato family, and grasses, to monitor threats and identify priorities for conservation. For example, our analysis of location data from herbarium specimens found that the elevation at which iconic Himalayan poppies (<i>Meconopsis spp.</i>) are found has shifted upwards by an average of over 300 m since 1970 (https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.5034). In Colombia, we are studying how climate change might impact upon coffee yields and therefore on the livelihoods of local farmers (SBS 4.1, Aichi 4). In Afghanistan we helped communities adopt efficient stove technologies, leading to a more than 30% decrease in woody plant extraction, simultaneously reducing both biodiversity losses and carbon emissions, and in Nepal, we built local capacity to convert waste material of invasive non-native species to biochar, a more sustainable form of fuel (SBS 4.1, Aichi 4, 9, 10, 14, 15). Our influential work also explores the pros and cons of large-scale afforestation in resolving the climate crisis, demonstrating—contrary to popular opinion—that African grasslands are not a deforested and degraded biome suitable for tree-planting (Aichi 14).</p> <p>The climate emergency poses a growing threat from emerging pests and diseases. Our Plant Health programme—one of the most rigorous in the world—helps protect Scotland’s natural environment, horticultural and agricultural sectors</p>



from potentially devastating pathogens through an early-warning network, strict plant quarantine procedures, and investigation of disease resistant plant varieties (Aichi 14). We recently built new isolation houses at all four Gardens to minimise disease transmission during introductions to the collection or reintroductions to the wild. As Horticulture and Environment lead for Scotland's Centre of Expertise in Plant Health, we disseminate plant health information to stakeholders across the nation. At the same time, our research into wild relatives of crop plants supports the development of cultivated species and varieties, such as drought-tolerant cacao and heirloom potatoes, best able to withstand the effects of climate change and pests, and minimise food shortages (Aichi 4, 13, 16).

Our work to protect, cultivate, reinforce and reintroduce rare Scottish mountain species, increasing both their numbers and genetic diversity (see Section 2: Actions to Protect Biodiversity), will improve their resilience to future climate change. Increasing the number of wild populations of the beautiful alpine-blue sowthistle (*Cicerbita alpina*) in the Cairngorms helps to offset potential losses due to more frequent extreme weather events (Aichi 12, 15).

We work with landowners and conservation organisations to manage Scotland's globally important ecosystems, including Europe's best examples of internationally rare temperate rainforest. We provide data and toolkits, now used in several National Nature Reserves, to identify the best management strategies for a changing climate (SBS 1.2, 1.4, 4.2, 5.5, 5.7, Aichi 10, 14, 15). On our coastlines, our Shoreline Project (see also Section 5) works with local communities to deliver adaptation and mitigation activities, including physical intervention to encourage inter-tidal and marine diversity on coastal defences around Edinburgh (Aichi 15). We support nature to become more resilient to sea level rise by removing non-native invasive species and translocating natives in their place, with funding from the Heritage Lottery Fund, European Green Infrastructure Programme and NatureScot's Biodiversity Challenge Fund. As part of 'Edinburgh Living Landscape,' we pioneer green infrastructure projects to support climate resilience in the city (Aichi 15), such as 'depaving' to protect urban communities from inundation, and green roofs to provide extra urban habitat for pollinating insects and other invertebrates (SBS 3.2). Many of our own buildings have green roofs, such as the Dawyck Botanic Garden Visitor Centre, where plants help insulate the building and regulate the temperature throughout the year.

Our Edinburgh demonstration raingarden, created in 2019 in partnership with The Water Academy at Heriot-Watt University as part of 'Edinburgh Adapts—Driving Adaptation Actions for the Capital,' showcases plants as a tool for flood mitigation, whilst also providing benefits to biodiversity, ecology, greenspace, recreation and educational value. In addition to providing resilience to the extremes of weather likely to result from future climate change, the mix of plants grown in the raingarden is designed to encourage and attract a greater diversity of wildlife to the area: the diversity of flowers provides nectar sources for insects, and leaving stems of the perennials and grasses standing over winter will provide a habitat for many invertebrates, as well as food for seed eating birds.



The raingarden is just one example of our work to engage our many visitors with the issues facing the natural world, and empower them to make a difference in their own lives (SBS 4.1, Aichi 1). Hands-on involvement is key to full engagement, and our volunteer phenology programme, regular 'Bioblitzes' and citizen science events bring people face to face with our climate science. In 2019, our acclaimed immersive art experience, 'Below the Blanket', celebrated the Flow Country, Scotland's most important terrestrial carbon sink. Across the world, anyone can access our expert teaching on climate-related issues such as pollinator security via our online learning facility, PropaGate. Our latest, free online course is a comprehensive introduction to 'Plants and Climate Change' (<https://www.rbge.org.uk/learn/online-courses/plants-and-climate-change-course/>).

Nature-based contributions to health and wellbeing

(SBS 3.1, 3.3, 4.1) We generate physical, emotional and social benefits by fostering connections between people, plants and each other. Our Edinburgh Garden provides 70 acres of free-to-enter, fully accessible greenspace in the heart of the city. All four of our gardens offer a Silent Space, an area open to all for quiet enjoyment of nature. Visitors to a Silent Space are invited to switch off all technology and sit or stroll among the plants and wildlife in quiet contemplation. Without distractions or expectations, this experience allows visitors to tune in to nature and enjoy the calm of simply being in a green space. Both on- and off-site, we run projects which bring people together through plants to build inclusive and friendly communities, an appreciation for nature, and an awareness of local and global issues such as food security and climate change.

(SBS 3.1, 3.3) Edinburgh's Botanic Cottage is our public learning and engagement hub hosting a range of activities enjoyed by over 5,000 people each year. These include a fortnightly cook club and monthly Friday 'Botanic Cottage Garden Socials.' Adjacent to the Botanic Cottage is our Edible Gardening Project (Aichi 4), where over 7,000 people each year from a wide variety of community groups attend weekly meets with our community gardeners and volunteers, both to develop their gardening skills and to cultivate a sense of achievement. Every group tends their own plot, planting and caring for their own fruit and vegetables throughout the seasons, and cooking together once their harvest is ready. Groups delight in spending time working outside with the soil and plants, and connecting with each other every week over the growing season, forming friendships as they pick up tips





and techniques for growing their own produce. The project runs almost 100 'Meet the Gardener' sessions each year, where anyone can ask our community gardeners and volunteers for growing advice. Sessions are themed around topics such as zero waste, soil health, organic gardening and gardening for health and wellbeing (Aichi 1).

(SBS 3.1, 3.3) In 2020 we opened our new Garden of Tranquillity, a calming and engaging space for those living with dementia and their families. Intricately created by a graduate of our Garden Design Diploma, the garden is an inclusive, sensory-based greenspace with non-slip, non-reflective surfaces, using natural boundaries to reduce anxiety. Plants in this garden have been specifically selected for their lively appearances, exciting aromas and interesting textures to provide a stimulating sensory experience. Nostalgic planting creates a welcoming environment and can also help invigorate memories. The Garden of Tranquillity is designed to inspire visitors to make their own gardens more dementia friendly. Medicinal plantings exemplify how important plants are to our general health and wellbeing, while interpretation boards raise awareness of the prevalence of dementia, and of the world-leading dementia research carried out at the University of Edinburgh.

Our diverse Short Courses programme offers multiple opportunities for learning and connecting with others with similar interests in friendly and inclusive environments. Many of our courses are directly aimed at enhancing health and wellbeing. For example, Nordic Walking classes focus on the use of two poles while walking to engage the upper body, which is particularly beneficial for those with knee or back problems; 'Slow Art for Fast Lives' combines mindfulness techniques with learning new painting styles. We also arrange collaborative learning programmes for schools, facilitating active outdoor learning and engaging young people with the benefits of spending time in nature.

(SBS 3.1, 3.2, 3.3) Off-site, RBGE staff and volunteers coordinate collaborative, nature-based wellbeing projects across the city of Edinburgh and beyond (many described elsewhere in this report), including the many facets of the Edinburgh Living Landscape, promoting the wide-ranging benefits of urban greening, including natural filtering of air and noise pollution, and mental health benefits. We enhanced our offer to local communities during 2020's pandemic, supplying hundreds of kilos of fresh organic produce as food parcels and through a fortnightly on-site Open Pantry. Botanic Cottage programmes such as the Community Cook Club moved online, and a new online programme—Marley's School of Garden Magic—was developed to support home-schooling and encourage children to continue to interact with nature. Over 1,000 'Expedition Dandelion' activity packs were provided, via local foodbanks, to local children who may not have internet access.



What steps has your organisation taken to incorporate biodiversity outcomes into partnership initiatives, wider strategies or initiatives of relevance to climate change?

<p>Guidance on completing this section</p>	<p>Strategies or initiatives might include:</p> <ul style="list-style-type: none"> • a Green Infrastructure Strategy; • a Pollinator Strategy; • Maintaining a Local Nature Conservation Sites system; • Participating in the Local Biodiversity Action Plan Partnership; • Developing a soil management strategy; • Co-operating in collecting, managing and using biodiversity data.
<p>Links to related resources</p>	<ul style="list-style-type: none"> • NatureScot’s overview of Green Infrastructure. • Information on Pollinator strategies, managing Local Nature Conservation Sites systems, and on Local Biodiversity Action Plan Partnerships (LBAPs). • Guidance on Soil Management including soil carbon management. • Information on biodiversity data, including obtaining and sharing data from Local Records Centres Biodiversity - where to find data. • NatureScot provides various ideas and case studies on partnership approaches.
<p>Text Field</p>	<p>RBGE is a delivery partner to the Biodiversity 2020 Route Map, which provides the pathway to achieving Scotland’s Biodiversity Strategy. Our plant translocation work has contributed to and reports under Priority Project 2 (Restoration of Native Woodland) and Priority Project 9 (Conservation of Priority Species), while our public-facing work is broadly relevant across many Route Map projects (e.g., Priority Project 5, 6 and 7). Further, we contribute wider strategic leadership, chairing the Habitats and Species Working Group of the Scottish Biodiversity Strategy (also linking to NatureScot’s <i>Species at Risk</i> assessment), and hosting the annual Scottish Biodiversity Strategy science conference.</p> <p>Our habitat restoration work aligns with the Pollinator Strategy for Scotland, through the creation of coastal wildflower meadows with invertebrate food plants, and providing food plants into the green roof ‘Square Metres for Butterflies’ project (in collaboration with Butterfly Conservation), specifically for the rare Northern Brown Argus (<i>Aricia artaxerxes</i>). We are currently investing in a major review of our own green roof resource, to understand how we might improve its management for invertebrates and wider ecosystem functions.</p> <p>We are a board member of the Edinburgh Living Landscape Project, contributing to the city-wide vision of benefitting ‘local people and wildlife with an aim to make the city one of the most sustainable in Europe by 2050.’ We are currently</p>



working with local schools to understand how Edinburgh children experience and utilise their local city green space, a project that has been brought into sharp focus by the covid-19 pandemic. We have partnered with NatureScot on green infrastructure projects targeted to removal of invasive species (*Rosa rugosa*) for improved resilience of coastal habitats. With NatureScot and other partners we developed a world first 'genetic scorecard' for assessing conservation risk in wild species (Aichi 13).



We are members of the Edinburgh Biodiversity Partnership, responsible for the EBAP, and are currently chairing this group (Aichi 2, 17). We are a partner to the Cairngorm's Nature Action Plan, with responsibility for the recovery of rare plant and lichen species, and to Scotland's Rainforest Alliance, where we provide evidence and advice on landscape interventions by partners (NatureScot, Forest and Land Scotland, Woodland Trust, Scottish Wildlife Trust, and others) to improve rainforest habitat for biodiversity. We also contribute to the Scottish Biodiversity Information Forum, aiming to improve Scotland's infrastructure for recording, managing, sharing and using wildlife data, and fully aligned with the National Biodiversity Network.

Our Education team deliver CPD sessions for teachers through the ENFOR partnership in conjunction with Education Scotland, and with City of Edinburgh Council and the Edinburgh Outdoor Learning Network.

We also bring our expertise to the international policy conversation, working with institutes across the world to develop meaningful, achievable goals for sustainable development, protection of natural capital, and to minimise the impact of the climate emergency, particularly as we move towards a global post-2020 framework for biodiversity. Most recently, in 2020, we contributed to the 'Edinburgh Process for Subnational and Local Governments on the development of the Post 2020 Global Biodiversity Framework' (Aichi 2, 3, 10).



(Aichi 1, 19) Our biodiversity data is published in the most useful and usable formats to enable further research and conservation on the ground. We co-ordinate data for 17 plant families, covering around 17,600 species, for the World Flora Online, an essential first step towards meeting the targets of the Global Strategy for Plant Conservation. We published the first verified checklist of seed plants of the lowland Amazon rainforest—more than 14,000 species—a sound basis for research and conservation in one of the world’s most important biodiversity hotspots. Our unique online resource *Endemic Plants of Chile*, detailing all known ferns, conifers and flowering plants unique to Chile and its oceanic islands, helps guide action to protect species in their native habitats. *Plants and You*, our series of bespoke guides to the plants of Nepal, translates the authoritative knowledge in the *Flora of Nepal* into tailored identification tools for local communities, facilitating informed choices around native plants and invasive non-native species, and has proven very popular with users from foresters to tourists.

One key facet of making our biodiversity data available and accessible to partners and others has been the digitisation of our herbarium. Over one-sixth of our collection (around 500,000 specimens) can now be viewed in full, and images downloaded in high resolution, via our catalogue. In just one year, more than two million records and 180,000 digitised images were downloaded. We have prioritised digitising the specimens with greatest research potential: ‘type specimens’ (those to which the name and description of a species is tied) and our focal research groups *Begonia*, Gesneriaceae, Sapotaceae and Zingiberaceae. We have fully digitised our temperate South America and Australian collections, and to support responsive research, we also offer ‘digitisation on demand.’ We work with other institutions to digitise conservation-priority groups. For instance, in a mass digitisation project funded by UK Official Development Assistance, we collaborated with the Royal Botanic Gardens, Kew, and the Natural History Museum, London, to harness information on the world’s most widely traded illegal wildlife product, tropical rosewood (*Dalbergia*), a leguminous tree in great demand on the burgeoning Chinese luxury furniture market. Many rosewoods are now threatened with extinction, while illegal logging for their timber, particularly in biodiversity hotspots such as Madagascar, puts whole ecosystems at risk. Using high-throughput workflows and with the help of volunteers, we fully imaged, transcribed and georeferenced all our *Dalbergia* (alongside related *Pterocarpus*, *Inga*, and Phaseolinae) specimens. Taken together, we digitised and databased 37,000 specimens, opening taxonomic, ecological and geographic data to those unable to visit the UK, and protecting delicate plant material from the risks of being sent overseas. The data and images can be used to determine species’ past and present ranges and carry out conservation risk assessments for these poorly understood and threatened plants (Aichi 12, 19).



Looking ahead, what do you think will be the main climate change related challenges for biodiversity over the next three years?

<p>Guidance on completing this section</p>	<p>You may wish to detail any arrangements that your organisation has in place to review or monitor the implications from modelling biodiversity on land that you own or manage under future climate scenarios.</p>
<p>Text Field</p>	<p>Our strategic and organisational foci for the next decade are the biodiversity crisis and the climate emergency—and these themes are central to all our future activities. Thus, we will deliver research to provide evidence to understand global change, and to guide conservation interventions. We will help estimate and understand these impacts through our significant contributions to <i>State of Nature</i> reports in Scotland, and globally via the <i>State of the Worlds Plants and Fungi</i>. We also focus on practical actions to restore biodiversity in the face of pressures from climate. RBGE’s Education programme has a key role to play in raising awareness around biodiversity loss and climate change, and is currently developing a new and updated learning offer to meet these needs (Aichi 1, 10). Likewise, our public engagement and outreach activities are critically important for raising general awareness of the challenges and guiding positive behavioural change.</p> <p>Key climate-related challenges to biodiversity at RBGE include direct loss of plants in the living collection due to changing climate or extreme weather events. The impacts of the latter are becoming increasingly evident, and loss of individual trees can lead to cascading impacts such as loss of shelter/windbreaks. Already, we have had to carry out extensive work to mitigate the impact of climate change upon the collection, particularly at Benmore Botanic Garden, which is experiencing more frequent and intense rainstorms. This included access, drainage and infrastructure improvements, and a programme to reduce soil compaction and waterlogging in the iconic Redwood Avenue.</p> <p>Indirect impacts include changes in the dynamics and effects of pests and pathogens in response to climate change and climate stresses. In the coming years, we are increasing (a) the use of phenological data from our gardens to directly monitor climate impacts on biodiversity, via the generation of a ‘Botanics spring index,’ (b) the use of modelling approaches to predict impacts on the plant biodiversity held at RBGE, in relation to projected climate change, and (c) expanded plant health and biosecurity monitoring to manage threats from emerging pests and diseases.</p>



SECTION 5: PUBLIC ENGAGEMENT AND WORKFORCE DEVELOPMENT

Public Engagement

<p>Guidance on completing this section</p>	<p>Detail communications and education activities have you undertaken to inform or engage directly or indirectly with communities, young people and the public. This might include actions to raise staff, customer and public enjoyment and understanding of, and connection with, biodiversity and nature, such as:</p> <ul style="list-style-type: none"> • Supporting volunteering; • Exhibitions and events; • School outreach; • Outdoor learning; • Citizen Science initiatives; • Provision of ranger services or public education programmes; • Information hosted on your webpage; • Blogs and press releases.
<p>Links to related resources</p>	<ul style="list-style-type: none"> • Ideas on volunteering outdoors. • Stats, stories, activities and inspiration to help bring nature and landscapes to life for young people and learners through education, including Beyond your boundary: easy steps to learning in local greenspace, and the Outdoor Learning Directory is a useful source of information and resources. • Ideas on citizen science activities that can increase public enjoyment, understanding and connection with nature. • Information on how to make more use of Scotland’s outdoors as ‘Our Natural Health Service’
<p>Text Field</p>	<p>Supporting volunteering</p> <p>RBGE has approximately as many volunteers as it does staff, and they provide a vital and respected contribution to our work, playing a central role in the welcome and experience of our visitors, including as our popular Garden Guides. Volunteers—many of whom have been volunteering for a decade or more—contribute to a variety of departments including Horticulture, Science Communication, Phenology, Events, Exhibitions, and our Herbarium and Library. They are supported by a Volunteer Coordinator to develop their career and personal prospects, and are recognised as valued members of our team, for instance by attending staff conferences. Our dedicated team of phenology volunteers, working in the Genetics and Conservation Section of our Science Division, monitor annual changes in the development of over</p>



500 plants across our Gardens, providing vital evidence of plants' responses to changing climate. In our Edible Gardening Project (see Section 4: Nature-based Solutions), a cohort of around 30 volunteers carry out a weekly demonstration, enabling visitors to see horticulturalists in action, ask questions and get advice and ideas for their own vegetable plots.

Exhibitions and events

RBGE arts and culture events are unique within the Scottish cultural and heritage sector in linking scientific research, art and community engagement (Aichi 1, 19). Our exhibitions and events are designed to spark the imagination, nurture a culture of interest in the natural environment, inspire connections among a wide variety of audiences, and as a catalyst for action. Inverleith House, our leading gallery, has hosted several high-profile exhibitions over the past three years with a biodiversity theme running throughout. These include:

- *The Lost Words* (2018): a unique collaborative project between renowned writer Robert Macfarlane and artist Jackie Morris, combining their considerable creative talents to celebrate the relationship between language and the living world, and nature's power to spark the imagination. The exhibition was a response to Macfarlane and Morris's belief that nature is in retreat from our stories and imaginations and aimed, in Morris's words, to "send children to sleep dreaming of wild things."
- *Natural Selection* (2018): the culmination of a five-year collaboration between artist Andy Holden and his father, the ornithologist Peter Holden, following their journey through the lives of birds, from the building of nests to the past practice of collecting of eggs, and celebrating the diversity of natural forms and the diversity of viewpoints attached to the same object.
- *Microsculpture* (2019): the remarkable insect photography of Levon Biss drew a record 46,000 visitors, and was extended due to its popularity.
- *Florilegium: A Gathering of Flowers* (2020): work by over forty contemporary and botanical artists from across the globe brought together to celebrate the power of flowers and shed light on both the RBGE living collections and human behaviour. Alongside a set of beautiful new plant portraits, four contemporary artists brought their take on botany to the exhibition, ranging from drawings to cinema and private recitals, aiming to provoke new response to the biodiversity of the Garden and the globe.
- *Golden Monkey* (2020): Lisa Roet's hand-painted, 10 m golden snub-nosed monkey sculpture adorned the exterior of the gallery, highlighting the threatened plight of all snub-nosed monkey species and their forest habitats, serving to communicate the severity and impacts of the global biodiversity crisis.

Our John Hope Gateway building has also hosted a series of biodiversity-themed exhibitions including *Food Forever*, *Weird Plants*, and *Think Plastic*.



Popular Biodiversity-themed events included our *Seaweed for Health* symposia, the popular Apple Day events, hugely successful Bioblitzes—recently heralding identification of the Edinburgh Garden’s 1,000th wild species—and regular offerings as part of the Edinburgh International Science Festival, which in 2018 was themed around bees and pollination and in 2019 around biodiversity and sustainable agriculture.

Our famous titan arum, *Amorphophallus titanum*, flowered for the third time in 2019. We extended our opening hours for the spectacle, and volunteer staff ensured that maximum numbers of people could experience this spectacular species and learn about the threats facing its natural habitat in Java and Sumatra.

In 2020, we were awarded a major Outset Transformation Grant in conjunction with the Serpentine Galleries to transform Inverleith House Gallery into ‘Climate House,’ promoting a synergy between art and science as we face the twin challenges of the 21st Century: biodiversity loss and the climate emergency.

Schools outreach and outdoor learning

(SBS 3.4, Aichi 1, 19) RBGE Education plays a key role in supporting teachers in the delivery of outdoor learning. We provide almost 20,000 hours of tuition for children and teachers each year, mapped to the Curriculum for Excellence and supporting the Campaign for Outdoor Learning. From early years to secondary, key messages include biodiversity loss, the climate emergency, conserving key species, and reducing habitat degradation (Aichi 5, 10). Over 10,000 nursery and school children participated in our hands-on active learning programmes each year, prior to the 2020 pandemic (SBS 3.1).

(SBS 3.4) Since March 2020, our face-to-face sessions have been converted and delivered online. We also responded to the additional need for home-schooling materials by creating online learning resources for primary school aged learners, made available via our virtual learning environment, PropaGate (<https://propagatelearning.rbge.ac.uk/course/view.php?id=210>). All activities included an ‘expedition’ element, which learners were encouraged to complete outdoors with their households during daily walks. Aware of digital inequality, RBGE also partnered with a local foodbank to issue over 1,000 paper copies to learners receiving food parcels. This ensured greater inclusivity for all learners, particularly those without access to the relevant technology which became essential during lockdown.

With the support of the players of the People’s Postcode Lottery, we offer regular, free Schools’ Weeks at our regional Gardens Benmore, Dawyck and Logan, focusing on similar themes and often reaching disadvantaged children who may not otherwise get the opportunity to visit a botanic garden (SBS 3.1, 3.4).



(Aichi 19) We also offer tertiary provision in partnership with SRUC and the University of Edinburgh on HND, BSc, MSc and PhD level programmes. RBGE certified programmes include herbology and botanical illustration, and we deliver the RHS Level 2 and 3 qualifications as well as a range of short courses and online programmes. The specific objectives of these programmes are many, however they all focus on reconnecting people with nature and encouraging participants to think about how individual behaviour change can impact on global issues such as the climate emergency and biodiversity loss. Our MSc course has led the world in plant biodiversity and taxonomy tuition for over a quarter of a century. More than 350 students from around 50 countries have passed the course, 85% of whom are studying further or now employed, often in decision-making roles in plant science and conservation. During 2020, we offered discounted access to two online courses; RHS Level 2 and 'Getting Started with Botany,' both of which encourage learners to increase their knowledge of horticulture and botany and engage with practical outdoor activities, relating these activities to biodiversity loss and management.

Citizen Science initiatives

Our herbarium team regularly run citizen science projects—either stand-alone or as part of wide initiatives—to help harness the vast quantities of data held in herbarium specimens, whilst engaging the public with our historic botanical collections. These include 'virtual expeditions'—which may take the participant anywhere from the UK to Australia and Myanmar!—through our collections hosted on the Digivol citizen science platform.

Public education programmes

(SBS 3.1, Aichi 1, 19) We run an array of public education programmes both on- and off-site. At our Edinburgh Garden, several areas are particularly designed with engagement in mind, including an Ecological Garden, Demonstration Garden and Experimental Garden. Interpretation panels guide visitors to learn more about the plants on display and the biodiversity science taking place at RBGE. In 2019 we held a well-attended and successful celebration of the new Edinburgh Biodiversity Action Plan. At Logan we maintain a Scottish native plant area, while at Benmore extensive plantings showcase the unique biodiversity of, and conservation projects taking place in, Chile and elsewhere. At Edinburgh, Logan and Benmore our self-guided 'Lichen Safari' trails introduce people to the incredible diversity of these tiny, oft-overlooked organisms, and their global importance in carbon cycling and as important indicators of environmental health. Seasonal trails (e.g., Easter, Halloween) link our collections and science programmes through enticing themes.

(SBS 3.1) RBGE Logan runs a series of public engagement events, including an annual summer guided walk at the Mull of Galloway observing and discussing local wildflowers, in conjunction with the RSPB. Working with the Solway Firth



Partnership we are developing a new programme, 'Making the most of the coast,' including a booklet highlighting the native species of the newly formed South Rhins Coastal Footpath and an exhibition on coastal wildflowers.

One of our biggest off-site engagement projects has been the 'Edinburgh Shoreline' (SBS 1.1, 3.1, 3.2, 6.3, 6.8, Aichi 1, 6). Between 2018 and 2020, the project successfully connected people with nature along 27 km of the Firth of Forth, running a wide range of activities with local schools, community groups, researchers and artists. A programme of public engagement events enabled over 2,000 participants to explore and discover more about climate change and sea level rise, the Edinburgh shoreline as a SSSI and SPA, and the biodiversity to which it is home. These included walks and bioblitzes on winter wading birds, mudflat invertebrates, fish, seaweeds, and native wildflowers, to name a few. Biodiversity conservation activities included developing a wildflower nursery at Granton Hub, where a community of volunteers grow native plants for planting into underutilised coastal green spaces, wildflower planting days along the coast, removal of invasive species *Rosa rugosa* from sand dune habitats (SBS 6.6, Aichi 9, 15), beach cleans and workshops. A successful exhibition raising awareness of the biodiversity and habitats of the city's shoreline was held at RBGE in summer 2018, receiving 43,065 visits. A project documentary highlighting the important habitats of the Firth of Forth and the need to protect these has been viewed over 1,000 times on YouTube. The Shoreline project's dedicated website and blog has received over 6,500 visits, and a community engagement pack with ideas of activities and interventions that the public could undertake has reached over 2,000 people. Edinburgh Shoreline has not only been a successful public engagement project, but has also brought together people from a range of ages and occupations and renewed and strengthened the sense of community along the coastline.

Web-based engagement

In 2018 we launched our new website (www.rbge.org.uk), viewed over two million times each year by over 625,000 people, and covering all aspects of our biodiversity science, horticulture and visitor information. Our 'Learning' and 'Collections' pages are particularly popular, with over 41,000 and 29,000 views, respectively. We recently added new 'Climate Emergency' and 'Health and Wellbeing' pages, providing a launchpad to activities across the full scope of our work. We have over 91,000 followers on Facebook, over 76,000 on Instagram and over 30,000 on Twitter, many of whom engaged strongly with our 'virtual spring' and 'virtual summer' content during the covid-19 pandemic (Aichi 1).

Blogs and press releases

Our blog, *Botanics Stories* (<https://stories.rbge.org.uk/>), has a rapidly growing audience and features news from all departments including Science, Horticulture and Learning. Monthly 'Garden Wildlife Reports' showcase the changing native biodiversity of our Gardens with the seasons, while 'Garden Highlights' guide the reader through the plants of the world which may be giving the most spectacular displays at any given time. Press releases covering all aspects of our



	work including collaborative biodiversity conservation projects can be found in our Media Centre (https://www.rbge.org.uk/media-centre/press-releases/) (Aichi 1).
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Workforce skills and training

<p>Guidance on completing this section</p>	<p>Detail activities that have been undertaken to support the development of your workforce, particularly in relation to skills relevant to biodiversity, nature, outdoor learning and community engagement in the natural environment.</p> <p>Activities might include:</p> <ul style="list-style-type: none"> • Staff training, education and capacity building; • Hosting conferences, exhibitions and events; • Ranger services; • Collaborative working with other organisations and sharing best practice.
<p>Text Field</p>	<p>All staff are encouraged to benefit from personal and professional development and have access to a wide range of courses and resources. Our living collection is an active training resource, hosting approximately 50 horticulture students from around the world each year. Our reinvigorated apprenticeship scheme, at both Edinburgh and Benmore, provides training, mentorship and the opportunity to study for an SVQ Level 2 in Horticulture and Landscaping.</p> <p>When covid-19 restrictions allow, a regular ‘Science Journal Club’ discusses recent advances in biodiversity science. Seminars by in-house and visiting speakers take place in person or online as appropriate. Our Education Department is part of several networks which ensure opportunities for sharing best practice, including the Heritage Environment Forum, Scottish Science Centre Educators Group, Edinburgh Outdoor Learning Network Working Group and ENFOR Education Group. Science staff attend networking and learning events with organisations such as Edinburgh Plant Science (which has a particular focus on early career researchers), Edinburgh Conservation Science (ECOS), the Systematics Association and Linnean Society.</p> <p>We regularly host public conferences, seminars and workshops, to which staff and students alike are welcome (Aichi 1, 19). These have included the Scottish Botanists Conference, a hugely educational knowledge-sharing event covering aspects of biodiversity, conservation, community engagement and education across the British Isles (jointly organised with the Botanical Society of Britain and Ireland’s (BSBI) and the Botanical Society of Scotland (BSS)); BSBI evening lectures; the 2019 Scottish Biodiversity Conference; and 2020’s successful online conference, ‘Promoting Excellence in Horticulture,’ organised jointly by our own journal <i>Sibbaldia—The International Journal of Botanic Garden Horticulture</i>, PlantNetwork and RBGE. Staff also attend external events such as the University of Edinburgh ‘Learning for</p>



	<p>Sustainability Annual Conference and Networking Day’ and ‘Nature Connectedness Workshop’ at the University of Derby.</p> <p>During the 2020 pandemic, all staff and volunteers were offered free access to online courses ‘Getting Started with Botany’ and the RHS Level 2 Horticulture course. Education staff took part in training webinars including ‘Maths Outdoors with Early Years,’ CEH’s ladybird identification course and an identification workshop on skulls and bones.</p> <p>We share best practice on gender equality with other organisations through the Athena SWAN initiative, and recently ran a series of joint seminars with the Royal Botanic Gardens, Kew, tackling the important issue of racism and anti-racism in botany and horticulture, featuring high-profile figures such as Angela Saini and James Wong. Our staff support each other through a mental health first aid network, and encourage each other through a mentoring programme.</p>
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Identify any opportunities that are available to your staff to take part in practical actions

<p>Guidance on completing this section</p>	<p>Activities might include:</p> <ul style="list-style-type: none"> • Volunteering days, for example with environmental Non-Governmental Organisations; • Participation in staff networks that aim to deliver on or promote biodiversity objectives; • Opportunities for secondments to other organisations working on biodiversity and conservation.
<p>Text Field</p>	<p>As the work of RBGE is so heavily focused on biodiversity conservation, the day-to-day work of our staff is fully aligned with practical action. Beyond this, one example of encouraging wider participation in practical actions, is encouraging a wide diversity of staff to participate in field work for conservation projects (e.g., in the past this has included staff from Finance, Publications, and Governance teams, working alongside the Science and Horticulture teams on biodiversity conservation field work in both Nepal and China).</p> 



SECTION 6: RESEARCH AND MONITORING

Describe any research activities that your organisation has undertaken to help develop understanding and awareness of biodiversity

<p>Guidance on completing this section</p>	<p>Detail relevant research activities undertaken to raise awareness and understanding of nature and biodiversity both internally and externally, either alone or in partnership with others. Where relevant, summarise the key changes that this research has supported within your public body.</p> <p>This might include research papers, surveys or reports undertaken by your organisation.</p>
<p>Text Field</p>	<p>Research and monitoring in Scotland</p> <p>We carry out a huge range of collaborative discovery science and biodiversity research at varying scales from our Garden sites to globally (Aichi 19).</p> <p>We have carried out public ‘Bioblitzes’ of all four RBGE Gardens to record native biodiversity over a short period, providing comprehensive species lists (over 1,000 species for Edinburgh, including many rare species and species previously unrecorded in Scotland) which are a sound basis for continued biodiversity monitoring. Following these comprehensive surveys, we are now targeting our urban wildlife research more closely, particularly linking diversity to ecological resilience provided by our green and blue infrastructure, and on key elements such as wildlife corridors. Recent research has targeted our Edinburgh pond and associated areas, which has been identified as a biodiversity hotspot for a range of plant and animal taxa. We found that sustainable urban drainage systems (SUDS) such as this have multiple benefits for biodiversity and ecosystem services, and identified several uncommon species at SUDS across Edinburgh. Green roofs are another priority habitat, for which we are currently making species inventories.</p> <p>Our Education and Science teams are collaborating on an Edinburgh-based project, ‘The Good City,’ an awareness-raising programme in which school children generate and contribute data to help determine how evenly nature is distributed throughout the city, whether young people select encounters with nature on their routes to school, whether access to nature impacts on the resilience of urban neighbourhoods, and how this bottom-up approach can compare with comparable top-down approaches to mapping nature and resilience throughout the city, such as the Edinburgh Ecological Coherency Plan.</p>



(SBS 4.4, Aichi 12, 13) Across Scotland, we carry out monitoring and genetic analysis of the status of populations of rare, threatened, and conservation target species. We determined the rate of clonal reproduction and number of genetic individuals in species including *Cicerbita alpina*, *Salix lanata* and *Woodsia ilvensis*, and the genetic diversity present in others including *Saxifraga cespitosa* and *Sorbus pseudomeinichii*, informing future management decisions. For example, for *Melampyrum sylvaticum* we demonstrated that low genetic diversity in UK populations may constrain the species' ability to adapt to changing conditions, and indicated a need for human-mediated seed dispersal among selected populations; for *Saxifraga hirculus*, we found that clonal reproduction in Scottish populations renders absolute population size a poor proxy for genotype diversity, and identified highly diverse small populations that may have been overlooked.

We also empirically test the benefits of increased genetic diversity and connectivity for long-term survival. Our cross-pollination experiments determine whether fitness can be enhanced by increased opportunities for gene-flow between populations, such as in *Cicerbita alpina*, which fails to reproduce in the wild. This work laid a foundation for using cross-pollination to maximise genetic diversity in reintroduced *C. alpina*, increasing the likelihood of establishing self-sustaining, naturally-regenerating populations that are best able to adapt to environmental change (see also Section 2: Actions to Protect Biodiversity) (Aichi 13, 15).

Our research has helped determine rare species' ecological requirements: for *Oxytropis halleri* we found that natural regeneration from dormant seed, sometimes up to fifty years old, is encouraged by scrub-clearance. We have also focused on the habitat requirements and dispersal capacity of rare epiphytic lichens such as *Nephroma parile*, *N. laevigatum*, *Pannaria conoplea*, *Pannaria rubiginosa*, and *Pectenaria atlantica*, for which Scotland's Atlantic rainforests are a crucial global stronghold. Our detailed distribution models were used to develop an evidence-based tool for managers to explore how species might respond to landscape-scale conservation measures, which is now employed at Glen Creran NNR/SSSI, Argyll & Bute (SBS 4.2, 4.3). In addition, growth experiments identified potential climate change impacts on specialist species such as *Lobaria pulmonaria* (an ancient woodland indicator), uncovering sensitivities to climate and thus how the effectiveness of management techniques depends on variables such as proximity to water sources. We developed risk analyses for Scotland's unique forest epiphytes and defined biological indicators of ecosystem health in the Cairngorms National Park, supporting the UK climate change adaptation programmes.

Our genetic studies revealed high levels of hybridisation between the UK's wild and cultivated apples, identifying the 'last bastions' of pure wild apples in Scotland's southern highlands. This will facilitate protection of the wild genotype through conservation horticulture in remote sites, to bolster populations of this native species (Aichi 11, 12).

We are pioneers of the 'DNA barcoding' approach to distinguishing species which is crucial to accelerating species discovery in the face of unprecedented extinction rates. This work has led to the discovery of many new species—for instance at least six species of *Aneura* (liverworts), for which previously only one was known in the UK—and clarified the



conservation status of others. In collaboration with the Cairngorms National Park and University of the Highlands and Islands, we are using DNA meta-barcoding to investigate the impact of grazing feral reindeer on mountain plant communities through faecal analysis to determine the components of reindeer diet.

2020 saw the first year of the Darwin Tree of Life Project, led by the Wellcome Sanger Institute, an ambitious plan to sequence the genomes of all known species of animals, plants, fungi and protists in Britain and Ireland, with implications for biodiversity conservation and sustainable use of species, and potential to be scaled up to the flora and fauna of the world. Although a challenging year due to restrictions imposed during the covid-19 pandemic, RBGE's arm of the project—which includes all bryophytes and rare Scottish native plants—benefited from access to our rich living collections and also took the opportunity to collect samples for DNA extraction from bryophyte-rich woodland and moorland sites in the Scottish Borders.

Research and monitoring around the world

(SBS 4.4, Aichi 10, 11, 12, 14) Elsewhere around the world our work helps reduce and reverse biodiversity loss. We describe more than one species unknown to science every week, dramatically increasing their chance of survival by rendering them visible to conservation efforts (Aichi 12). Recent fieldwork in Papua New Guinea uncovered a huge variety of *Begonia* species, which may result from one of the fastest observed diversifications in flowering plants. Work is ongoing to confirm this and uncover the genomic changes underlying such a massive burst of speciation. Our 'Red List' conservation assessments facilitate targeted action to protect threatened species and improve sustainable use of plant resources. For example, as chairs of the IUCN Species Survival Commission Conifer Specialist Group we monitor all the world's conifers, over one-third of which are threatened with extinction, while our Centre for Middle Eastern Plants recently assessed over 95% of the endemic and regionally important plants of Arabia (Aichi 12).

Our botanical data helps ensure that economic development is sustainable and focused only on the most resilient landscapes. In the neotropics, we coordinate a network, 'Dryflor' of over fifty partners pooling biodiversity data and using it to support conservation projects in seasonally dry tropical forests, the world's most threatened tropical forests (Aichi 5, 14). In Oman, our Centre for Middle Eastern Plants identified 43 Important Plant Areas which are now incorporated and protected in the government's twenty-year National Spatial Strategy (Aichi 4, 11, 14, 19), and in China and South-East Asia our analyses of forest cover helped identify areas where plantation agriculture, such as rubber, would not be economically-viable, thus discouraging the unsustainable deforestation of these sites. Working with in-country partners and the World Agroforestry Centre ensures our results reach local policymakers, land managers and small-scale farmers (Aichi 4, 5, 14, 19). In Africa, our economic analyses shed light on the long-term sustainability of large-scale afforestation schemes for carbon-capture, suggesting alternative solutions that might be more effective (Aichi 5, 14, 15).




What follow-up actions or monitoring have you undertaken to assess the impacts of the actions you have taken? How have you measured this? If you do not carry out any monitoring activities, please explain why.

<p>Guidance on completing this section</p>	<p>Where appropriate, you may wish to report on monitoring of:</p> <ul style="list-style-type: none"> • Activities relating to recording biodiversity on land you own or manage; • Your contribution in meeting national and international biodiversity targets; • Biodiversity programmes or projects that you have delivered either alone or in partnership with others; • Implementation of relevant strategies or policies; • Relevant physical conditions, such as soil and water; • Organisational capability or development in relation to biodiversity.
<p>Links to related resources</p>	<ul style="list-style-type: none"> • Information on biodiversity data, including obtaining and sharing data from Local Records Centres Biodiversity - where to find data. • The State of Scotland's Nature report provides a useful overview. • The National Biodiversity Network provides a single hub for biodiversity data management in the UK. • Biological Recording in Scotland is a useful source of information on surveys and biodiversity data management in Scotland.
<p>Text Field</p>	<p>At our Garden sites, daily records are made of many vertebrate and invertebrate sightings including birds, butterflies and moths, contributing to management plans and visitor engagement. New monitoring schemes are being established for our green roofs. Our phenological recording also provides long-term records of species' changing responses to climate change.</p> <p>Our species reintroduction and management programmes across Scotland are all monitored long-term by ourselves, or partners including NatureScot and local landowners, to ensure that populations of rare and target species remain healthy and are not impacted by factors such as disease or grazing (SBS 1.3). We have monitored reintroduction sites in the Cairngorms (montane willows) for more than a decade, and we have a commitment to monitor our habitat restoration sites in Edinburgh over at least the next 10 years. These provide excellent training opportunities for students, and opportunities for engagement with volunteers and citizen scientists.</p> <p>Long-term relationships with in-country partners ensure that the legacy of our international programmes is monitored and assessed. Often, one project follows another to build upon past successes. This is particularly true of our Darwin Initiative programmes such as in Nepal and Tajikistan.</p>



Does your monitoring show any significant trends or highlight any areas of concern?

<p>Guidance on completing this section</p>	<p>Trends or areas of concern might include those related to:</p> <ul style="list-style-type: none"> • The conservation status of habitats that you manage or deliver programmes to protect; • The ecological health of land that you own or manage; • Adverse recordings of water or soil quality; • Increases or decreases in species present.
<p>Text Field</p>	<p>Working with NatureScot, our analysis of trend data for bryophytes in Scottish snowbeds has shown a decline in these species, especially for snowbeds in western mountain ranges. This monitoring is ongoing, and also includes lichen-rich montane heath, which represents another of the key habitats for tracking climate change impacts on Scotland’s natural systems.</p> <p>Our monitoring established for lichen epiphytes (growing on trees) as indicators of environmental change has been used to assess the response of Scotland’s internationally important rainforest diversity to climate change. This work demonstrated a strong link between the growth of rainforest species and climate, including climate change. Monitoring suggests that key rainforest species will be negatively affected by drier summers and wetter winters in the future. However, by extending the monitoring across our garden sites, and using their topography to our advantage, we were also able to show that certain landscape positions, such as closer to watercourses, can act as microrefugia that could protect these rainforest species under climate change. This helps to inform afforestation targets, such as under the Scottish Forestry Strategy, highlighting the need for spatial targeting to landscape positions that provide future climate change resilience, including riparian woodlands.</p>  <p>Monitoring of translocated plant species such as <i>Cicerbita alpina</i> has been used to guide future translocation success, but also to provide information about the existing constraints to success. Our results suggest that across many Scottish sites, grazing levels remain too high for the establishment of translocated populations, with not only deer as a problem, but also potentially voles. This points to the need to control herbivore populations through human action or ecosystem coherency, alongside the requirement to create translocated populations that are large enough to withstand extant grazing pressures.</p>



Have you added any data collected to the National Biodiversity Network or your Local Records Centre?

Text Field	RBGE is a member of the National Biodiversity Network. All databased UK collections in our herbarium (around 120,000 records) are represented in the NBN Gateway, and we provide data on Scotland's 1,947 conservation priority species to the National Biodiversity Atlas. In addition, all databased collections are accessible on GBIF, where our data are recognised as a 'colossal database.'
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SECTION 7: BIODIVERSITY HIGHLIGHTS AND CHALLENGES

Describe your organisation’s main achievements for biodiversity over the reporting period and what you are most proud of (this can include processes, plans, projects, partnerships, events and actions).

<p>Guidance on completing this section</p>	<p>As a Level One reporting organisation, it is likely that you will own or manage land, regulate land use, or have biodiversity as one of your main responsibilities. Examples of key achievements in this context might include:</p> <ul style="list-style-type: none"> • Leading or contributing to programmes or projects that directly support the key steps in the Scottish Biodiversity Strategy, or contribute to international Biodiversity targets; • Demonstrating national or international leadership or expertise in relation to biodiversity; • Meeting your strategic aims in relation to biodiversity; • Improvement in habitat or ecological status; • Notable species present or recorded; • Completion of key projects; • Funding achieved or delivered; • Volunteering days or time invested; • Provision of successful education or public engagement activities.
<p>Text Field</p>	<p>We are justly proud of our work to protect, restore and enhance biodiversity across Scotland and worldwide, which is integrated across all our strategic aims. A few example highlights are listed below.</p> <ul style="list-style-type: none"> • Launched in 2018, our collaborative Edinburgh Shoreline project has been a hugely successful programme addressing the Scottish Biodiversity Strategy Steps 1.1, 3.1, 3.2, 6.3 and 6.8 and Aichi Targets 1 and 6. The project has enhanced coastal biodiversity through planting coastal meadows of native species, restored and improved coastal resilience by removal of invasive non-native species, provided new habitats on essential coastal marine defences, and connected the people of Edinburgh’s shoreline with each other and with nature through activities, events and an exhibition. More information about the project can be found at https://edinburghshoreline.org.uk/. • Our International Conifer Conservation Project is an innovative, world-leading programme securing genetically diverse populations of rare and threatened conifers through scientific research, creation of new protected areas, development of an extensive network of ‘safe sites’ across the UK and Ireland, and repatriation of material to boost populations elsewhere in the world. Responsible for maintaining the authoritative International ‘Red List’ of conifers, the project has made a significant global impact upon conifer conservation and awareness. • Our work with the iconic Scottish rarity <i>Cicerbita alpina</i> has made a direct and discernible impact upon the species’ status and prospect. Over the period covered by this report, ecological and genetic research has supported a



flagship reintroduction programme that has tripled the number of UK wild populations in the UK and raised public awareness, not only of this species, but of the plight of many other Scottish species facing challenges from climate change and habitat degradation.

- Plant Health is an area of increasing concern for our natural environment, horticultural and agricultural sectors. We have greatly enhanced our approach to plant health over the past years, developing one of the most rigorous systems in the world at our Gardens and in our reintroduction programmes. We completed new isolation houses at all four Gardens and, as Horticulture and Environment lead for Scotland's new Centre of Expertise in Plant Health, we now disseminate plant health information to stakeholders across the nation.
- We were pleased to see our collaborative development of the first 'genetic scorecard' for assessing conservation risk in wild species, which brings Scotland closer to meeting Aichi Target 13 (Genetic Diversity Maintained), receive the 2020 Nature of Scotland Innovation Award. Our Garden was also accredited an Advanced Conservation Practitioner status by Botanic Gardens Conservation International, recognising our significant conservation impact.
- Across the world, we lead and coordinate major projects to characterise biodiversity and establish monitoring programmes in species-rich, highly threatened ecosystems, providing science-based guidance for conservation interventions. Our work has considerable impact in neotropical dry forests, African savannas, and the mega-diverse flora of Nepal.
- We are proud that RBGE continues to provide leadership and collaboration in major transformative global projects using genomics to characterise biodiversity. These including the International Barcode of Life Project (using DNA to tell species apart), and the Darwin Tree of Life Project (complete genome sequencing of all multicellular species in Britain and Ireland, with implications for our understanding, use, and conservation of biodiversity).
- Finally, we are honoured to have been able to help our community through the tough times 2020 has brought. Our response to the covid-19 pandemic included donating over 750 kg of fresh organic produce as hundreds of daily hot meal provisions per week and through a fortnightly on-site 'open pantry'. We quickly adapted our education programme to reach schools and families through a combination of online learning and hard copy activity packs, distributed via an Edinburgh foodbank to those with least access to technology. Our Virtual gardening workshops have reached nearly 500 participants, and Botanic Cottage Programmes have such as the Community Cook Club and dementia friendly Garden Social have been moved to fortnightly online blogs and monthly retrospectives, alongside ongoing communications with a personal touch via phone and post. We even donated and loaned our lab supplies, from disposable gloves to PCR machines, to the Western General Hospital's fight against the pandemic. We are committed to ensuring that RBGE continues to be a safe and welcoming haven for visitors, and a global leader in fighting the planet's other key challenges: the biodiversity crisis and climate emergency.



Looking ahead, what do you think will be the main challenges over the next three years?

<p>Guidance on completing this section</p>	<p>Challenges might include:</p> <ul style="list-style-type: none"> • Economic and resource pressures; • Delivery of cross-cutting actions; • Preventing further loss of habitats and species; • Effective management of invasive non-native species; • Pressures for space; • Need to meet targets; • Encouraging enhanced partnership working.
<p>Text Field</p>	<p>As we move into 2021, our new Strategic Plan and Biodiversity Strategy identify the biodiversity crisis and climate emergency, alongside supporting the nation’s health and wellbeing, as the most important challenges facing us. RBGE is well-placed to meet these challenges, focusing on our three pillars: Unlocking knowledge and understanding of plants and fungi to benefit society; Protecting and developing the National Botanical Collections as a global resource; and Enrichment and empowerment of individuals and communities through learning and engagement with plants and fungi. Emerging from the covid-19 pandemic, we will inevitably face challenges around new ways of working, particularly with respect to our extensive overseas activities, which are essential to prevent losses of habitats and species and to support sustainable development. However, the pandemic also presents an opportunity and impetus to reconnect people with nature, both locally and globally. Brexit may pose challenges to the engagement and retention of scientists from Europe.</p> <p>As noted above, our local research priorities are evolving from a general approach of recording biodiversity at our sites, to a targeted effort to explore the benefits of green and blue infrastructure for biodiversity and citizens, in agreement with Edinburgh City’s Ecological Coherence Plan. We will continue our work to study, protect and promote resilience amongst Scotland’s rarest species, as far as restrictions on fieldwork allow. We will have a major role in the technically challenging and ground-breaking ‘Darwin Tree of Life’ programme to sequence the genomes of all 60,000 species of complex life in Britain and Ireland. As a ‘genome acquisition lab,’ we will collect, cultivate and sequence DNA from our specialist groups ferns, bryophytes, lichens and Scottish flowering plants, generating unprecedented knowledge of their evolution, ecology, conservation and potential uses. We will also contribute to two multi-million-pound UK Research and Innovation Global Challenges Research Fund Research Hubs focusing on global challenges. The South Asian Nitrogen Hub brings together organisations across the UK and south Asia to build a coherent picture of the nitrogen cycle and nitrogen pollution, and to improve nitrogen management in agriculture. The Trade, Development and Environment Hub brings scientists, businesses, UN bodies and NGOs together to make trade a driver of positive change, protecting biodiversity and lifting people permanently out of poverty.</p>



For our Education department, the biggest challenge ahead will be to sustain the new interest in nature-connection achieved in 2020, and maximise its potential, embedding positive behaviours and attitudes before 'normality' resumes and this opportunity to leverage positive change could be lost. Time is of the essence and investment in continuing to develop interactive educational resources, appropriately trained staff and learning technology, is crucial to enable us to deliver on this ongoing commitment. This may be particularly challenging against a backdrop of economic hardship as the result of both the pandemic and Brexit. However, both also offer opportunities as people reassess priorities. We can provide support in continually uncertain times, as people may need to adapt and be facilitated to acquire new skills in the green economy. Evaluating the long-term impact of our education programmes on behaviour change in relation to biodiversity loss and the climate emergency is one of the biggest challenges for those involved in environmental education. Current feedback on the effectiveness of taught sessions and learning programmes provides details of what has been learned but not what the outcome of this learning is. This is particularly difficult when working with schools, where one off visits are the norm, however it is something that RBGE is committed to tackling in the coming years with plans for multiple points of contact in our engagement with learners and long-term tracking of behaviours, including increased engagement with alumni.

As we enter 2021, RBGE embarks upon arguably the most ambitious capital project in its history, Edinburgh Biomes. Edinburgh Biomes will protect RBGE's unique and globally important plant collection for the future, securing the Garden's biodiversity work for future generations and providing a spectacular new visitor experience for public engagement (SBS 3.1, 3.5, Aichi 1). It will bring together RBGE's research, horticulture, education and infrastructure facilities and significantly restore and rebuild our heritage glasshouses. The success of Edinburgh Biomes is essential to avoid the catastrophic loss of material of thousands of species in the public and research glasshouses, and to deliver world-leading facilities that will protect the work of this national institution for the future. Taking shape over the next seven years and generating over a hundred new jobs per year, with a strong focus on socially inclusive employment opportunities for those from disadvantaged backgrounds, apprentices and the long-term unemployed, Edinburgh Biomes includes the construction of new research facilities dedicated to combating plant pathogens damaging the environment, affecting commerce and impacting gardens big and small. There will be new education facilities to engage with students from primary school through to PhD, locally and around the world. Central to these improvements will be an efficient, cost effective energy centre, significantly reducing the Garden's carbon emissions, and a new plant health suite which will provide a safe bio-secure propagation environment.