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Biodiversity Research at SCRI

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Executive Summary

- *SCRI is Scotland's major plant research centre, with a wealth of expertise in ecosystem function, plant pathology, genomics and other disciplines.*

- *Globally, the loss of biodiversity is accelerating. This loss not only affects the inventory of biological diversity itself, but may also irreversibly damage ecosystems with consequences for the provision and regulation of nutrient flow, water resources, air quality and the planet's climate.*

- *Internationally, the recognition of a potential sixth global mass extinction induced by human activities has led to political commitments to stem this loss of biodiversity.*

- *Scotland is rich in natural biodiversity, with a number of iconic species and internationally important communities of bryophytes, arctic-alpine species and birds. SCRI's expertise is helping deliver the tools for both knowledge-based conservation of plant biodiversity, and also sustainable exploitation of these resources where appropriate.*

- *The biodiversity in arable and other human-dominated ecosystems maintains production and delivery systems for high-quality food, water, timber and biofuels. Research at SCRI delivers understanding of the functioning of the arable system so that its resilience can be maintained.*

- *SCRI also preserves internationally important* ex situ *biodiversity in the form of crop germplasm. This is an international obligation and an essential resource for the development of new crop cultivars for sustainable production in a changing world.*

- *SCRI will continue its research to aid the preservation and sustainable exploitation of biodiversity, in line with international commitments.*

Background

Since the evolution of advanced life on Earth over 500 million years ago, five major extinction events have each roughly halved the number of genera living at the time. The unsustainable approach to the exploitation of natural resources by the people of the Earth has increased the current rate of extinction up to 1,000 fold higher than the mean of the fossil record, with the proportion of species at risk rising towards that seen in previous mass extinctions. This already dramatic loss of biodiversity is predicted to accelerate by a further one or two orders of magnitude as global climate change further damages ecosystems (Living Beyond Our Means, Millenium Ecosystem Assessment, 2005).

Species loss is not just a heritage issue. Natural and managed ecosystems contribute greatly to the well being of people by furnishing food, fibre, fuel, and medicines. They also provide a wide range of essential services which affect the provision of nutrients, water, air and the modulation of the planet's climate. The loss of species and the resulting damage to ecosystems affects the planet's own life support systems and can result in undesirable positive feedback to global climate change.

Even in managed cropping systems, biodiversity is crucial to production and sustainability. The interactions between flora and fauna in arable systems above-ground and in the soil contribute to the maintenance of the system. Without a healthy and properly functioning soil ecosystem, erosion is increased, water and nutrient availability reduced and the sustainability of production systems compromised.

Finally, the relatively few plant species used by people for food have a large store of unused genetic diversity in cultivated types and wild relatives that will be essential to the adaptation of crops, by breeding, to rapidly changing climates. Conserving these resources and using them wisely is essential for sustainable agriculture.

Pressure to reverse losses of biodiversity extends to human-dominated ecosystems including farmland, where diverse weed floras harbouring beneficial insects and other wildlife can return under appropriate management.

International and national action

Several international and national agreements drive policy relating to biodiversity. In 1992 at the Rio Convention on Biological Diversity (CBD), many countries pledged themselves to maintain their biological and genetic resources and exploit them in a sustainable manner. Ten years on, most world leaders affirmed their aim to achieve 'a significant reduction in the current rate of biodiversity loss at the global, regional and national level' by 2010, and that pledge has since been extended at EU, UK and Scottish government levels to halt and reverse rather than simply reduce the decline in biodiversity. With such a commitment to tackling biodiversity loss, practically-orientated programmes, such as the UK Biodiversity Action Plan (BAP), as well as related Scottish and local BAPs and Habitat Action Plans have been put in place to protect and restore habitats and species. In Scotland, a strategy for the protection of biodiversity during a 25 year period was published in 2004 (Scotland's Biodiversity: It's in Your Hands). This strategy contains elements which cover the conservation of species and habitats, landscape and ecosystem-level issues, social aspects including public awareness, integration and coordination, and the knowledge base.

In addition to binding countries to protect native biodiversity, the CBD brings an obligation to preserve *ex situ* genetic resources in a manner which respects the rights and needs of donating countries. International obligations on crop plant biodiversity were extended in 2004 with the adoption of the International Treaty on Plant Genetic Resources for Food and Agriculture which aspires to extend the provisions of the CBD to bring about a system of multilateral benefit sharing from the exploitation of genetic resources. Defra act as the UK focal point for the implementation of these international agreements, but obligations for the preservation and ethical exploitation of such biodiversity extend to devolved administrations and research providers.

SCRI maintains a globally important genebank of wild and landrace potatoes, the Commonwealth Potato Collection, as well an extensive fruit collection and a wide range of barley germplasm. The biodiversity in these collections is crucial to the adaptation of crops to the changing environment.

Biodiversity in Scotland

Scotland's habitats and living natural resources are now seen not only as important heritage worth preserving, but also as an economically valuable asset as green tourism rises in popularity. The land and surrounding sea areas of Scotland support around 90,000 species, many on the edge of their range. The affinities of Scotland's flora and fauna show a remarkable mix of subtropical, Atlantic, Arctic, Arctic-Alpine and Boreal elements. Internationally important communities of bryophytes, lichens and arctic alpines are key elements of Scotland's unique plant biodiversity. Among 79 Scottish rare or endemic plant species re-surveyed in the early 1990s, 40% had shown further declines with arctic-alpine and grassland species prominent amongst those in decline.

In human-dominated ecosystems such as arable land, biodiversity is important to the resilience of the system in ways that are incompletely understood. Both above-ground and below-ground food webs are important for the functioning of the system, including the ecosystem services of nutrient recycling, soil structure and moisture retention. The soil hosts an exceedingly richly diverse flora and fauna, and plays a key role in the modulation of climate through carbon storage and greenhouse gas emissions (Scotland's Soil Resource: Current State and Threats, 2006).

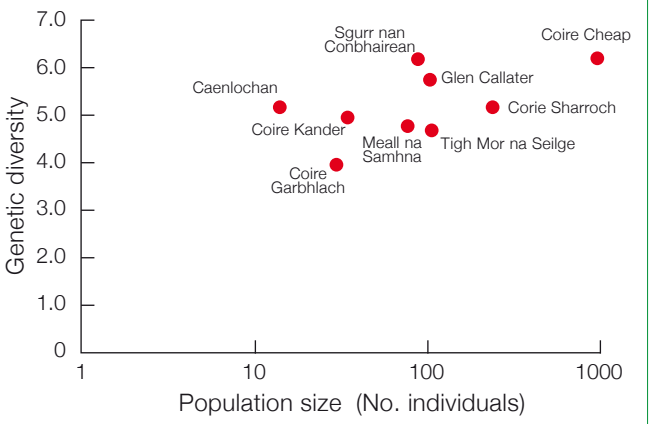
The biodiversity of crops and crop relatives in *ex situ* collections acts as the main source of traits for use in the breeding of new cultivars for more sustainable

Scotland is particularly rich in bryophytes. In a collaboration with the Strathclyde Institute for Drug Research (SIDR) and the Royal Botanic Garden Edinburgh (RBGE), SCRI investigated the biochemical diversity of a broad range of bryophytes for potential pharmaceutical exploitation.

agriculture. The biodiversity in these collections is of particular value, providing the raw material to permit the adaptation of crops to meet many new challenges. Even a single gene such as the *H1* gene from an accession in the Commonwealth Potato Collection has provided remarkable benefits for agriculture and the environment through protection from pathogenic nematodes. SCRI holds internationally important collections of potato, potato relatives, barley and soft fruit germplasm, and this *ex situ* biodiversity is essential to the adaptation of crops to changing environments.

Pathogens and pests are also components of the biodiversity present in Scotland, and in a time of changing climate and rapidly responding pests and pathogens, understanding their changing diversity becomes a crucial component of sustainable agriculture.

Scotland's biodiversity has always been subject to change. While the preservation of biodiversity is a useful aim, with climate change the migration of species will continue and ecosystems evolve. Research can provide guidance on the likelihood of gene exchange and adaptation of native populations to new conditions, the impacts and management of invasive species in natural and human-dominated ecosystems, and on the likelihood and effects of the northward extension of southern species.



SCRI expertise in molecular genetics has enabled improved understanding of the population genetics of vulnerable Biodiversity Action Plan species such as the woolly willow, *Salix lanata* in a collaboration with the Royal Botanic Garden Edinburgh. In this case, populations retain significant levels of diversity, independently of population size.

Current Biodiversity Research

SCRI has an excellent record of research into topics relevant to biodiversity, including arable and soil biodiversity, gene flow in natural and cropped systems, and conservation genetics. Recent and current research includes:

- Understanding arable biodiversity and the place of functional diversity in the maintenance of resilient arable ecosystems capable of supporting sustainable agriculture. This research is at different scales, with a focus on the interaction of different broad functional categories of organisms at the local scale, through to knock-on effects at the field scale. It draws on data generated during the Farm Scale Evaluations project that investigated biodiversity in the different herbicide regimes associated with GM and traditional cropping.

- High throughput molecular and traditional methods to enable assessments of the biodiversity in soils from arable and natural habitats are permitting SCRI to examine, for example, mycorrhizal diversity across disturbance gradients.

- In collaboration with partners at the Royal Botanic Gardens Edinburgh, and using SCRI's advanced molecular expertise, we have determined the genetic structure and floristic affinities of several Scottish native plants of conservation concern, and are currently exploring diversity in Scots

SCRI studies biodiversity in arable habitats and the interactions of functional groups in the ecosystem.

pine. Such conservation genetics studies provide key data for the responsible management, conservation and restoration of threatened populations.

- SCRI has extensive experience of researching gene flow in tree species for conservation and seed production, in raspberry where connectivity with wild native populations has been studied, and in oilseed rape where levels of cross pollination to other crops were determined on the landscape scale. Gene flow regulates biodiversity within wild species, provides variation for adaptation to new environments, and determines levels of purity in the harvested crops.

- With molecular methods we are continuing to explore the variation in Commonwealth Potato Collection and related collections, and have delivered new evidence for the domestication of potato and the relationship with its wild relatives.

- Exploration of the biochemical diversity of material in SCRI's *ex situ* collections and native flora is enabling new understanding of the potential for such material in more nutritious, healthy foods of the future, and is revealing new possibilities for the sustainable exploitation of natural resources.

- SCRI studies the shifting patterns of diversity in key pests and pathogens such as *Phytophthora* and aphid species. These have revealed the responsiveness of such pests and pathogens to changing environments and are assisting the development of strategies to counter new threats to sustainability.

SCRI has extensive experience of the experimentation, measurement and modelling of weed populations in arable contexts, and with the University of Abertay, Dundee, has developed the Arable Seed Identification System as a web resource.

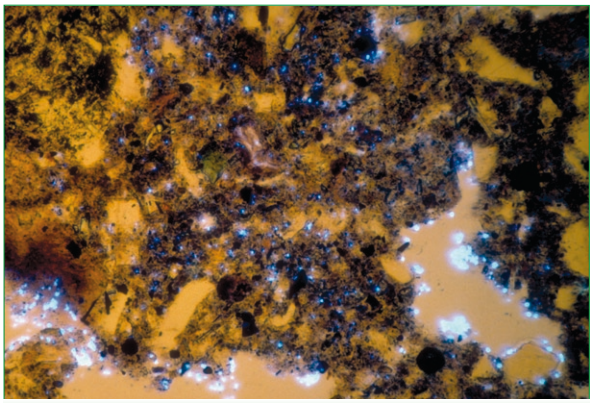
Future Biodiversity Research

Research areas in which SCRI will increase its research effort include:

- Determination of the effects of climate change on biodiversity in arable ecosystems including soils
- The connectivity of species and habitats in relation to current and predicted shifts in ecogeographic zones

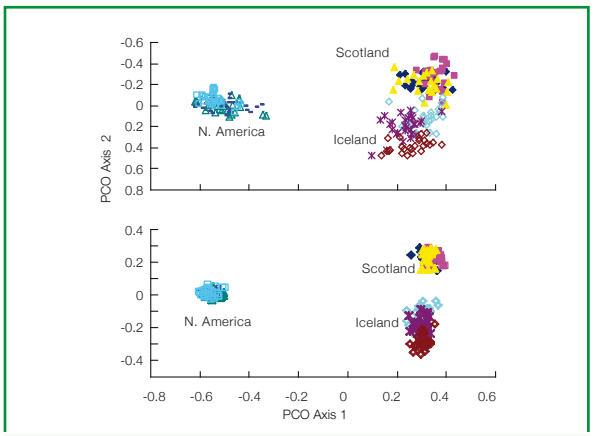
New threats to biodiversity and crop and horticultural production regularly arise from changing pathogen distribution, such as the Asian species *Phytophthora ramorum* on oak which appeared in the EU and the USA in 2000.

- Relate *ex situ* crop-related functional biodiversity in germplasm collections to the genetics of traits relevant to climate change, including water and mineral use efficiency and resistance to new pathogens
- Investigate diversity, population structure and pathogen pressure in invasive species, including UK native species extending their range, and non-native invasives with the potential to displace native species



Soil is an extremely diverse habitat with over 48,000 different organisms per gram, over 90% of which cannot be cultured. SCRI is at the forefront of research on molecular methods to understand this system.

- Further develop molecular systems for the classification, identification and monitoring of biodiversity in different groups of organisms
- Explore the potential for new products from biodiverse plant material
- Investigate the interactions between cultivated and wild plants and their invertebrate and pathogen populations



The affinities of Scottish species with widely disjunct origins have always been controversial. Using two molecular marker systems we have revealed the affinities of the mountain fern *Athyrium distentifolium.*

Further information

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