Scottish Crop Research Institute

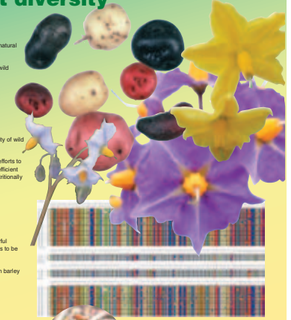
Biodiversity for sustainability

Crop and wild plant diversity

- The maintenance of biodiversity is important for quality of life, natural heritage, economic and social activities.
- The diversity within plant species is crucial to their survival as wild populations, and to their adaptability as crop plants.

The potato

- One of Scotland's most important crops is the potato.
- We look after one of the world's major potato *genebanks*, the Commonwealth Potato Collection, which houses a wide diversity of wild and cultivated types of potato.
- Using the latest molecular methods, we are at the forefront of efforts to understand and classify the variation present, and to develop efficient means to use this variation for environmentally friendly and nutritionally superior crops.

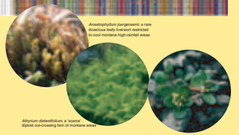


DNA sequencing

- High-capacity DNA sequencing technology coupled with powerful informatics tools have allowed the genomes of many organisms to be sequenced.
- Sequencing is being used to examine patterns of biodiversity in barley following the bottleneck of domestication.

Genetic science

- Genetic science can also be applied to species of high conservation priority and offer novel insights into their biodiversity.
- Work with the Royal Botanic Gardens, Edinburgh has sequenced 3000 genes to allow detailed genetic assessment of populations of three rare Scottish plants.
- The evolutionary history of these species has been explored, yielding surprises on their international affinities.



Conservation management

- Efficient conservation management and species recovery programmes depend on an understanding of species diversity.
- In the UK, sub-arctic willow scrub is essentially restricted to the Scottish mountains, where they occur on steep crags and other inaccessible areas.
- Patterns of spatial distribution of genotypic diversity were assessed at two main study sites (Coire Sharnoch for *Salix lanata* and *S. lapponum*; and Meall Ghaordie for *S. herbacea*)
- These sites show contrasting patterns of diversity indicating clonal patch formation in *S. herbacea* but extensive reproduction from seed in *S. lanata* and *S. lapponum*.

Scottish Crop Research Institute

Scottish Crop Research Institute

Crop and pathogen diversity

Crop diversity for reduced inputs

Re-introducing biodiversity into cropping systems has been demonstrated to reduce some disease problems

Deployment of crop species at different spatial scales from inter-field (different crop species and varieties) to intra-field (mixed species or varieties) can stabilise pest and pathogen populations. This may avoid strong selection pressures that favour the fittest, most pathogenic genotypes (disease management rather than pathogen elimination).

Mechanisms are complex - our goal is to understand processes to allow the development of the best deployment strategies.

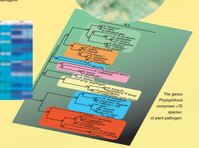
Mechanisms include diversity of genotype (resistance genes) and phenotype (canopy structure, multiplication and dispersal).

Improving the sustainability of potato production through the monitoring and managing of pest & pathogen diversity.

- Potato crops are damaged by many pests and pathogens but late blight (*Phytophthora infestans*) and aphid-transmitted viral diseases are the most serious threats.
- Insecticide application damages both the pest and beneficial insect communities with an impact on crop biodiversity.
- We monitor pathogen and pest biodiversity using state-of-the-art genetic markers.
- Such data allows us to predict how rapidly aphids and blight evolve and how best to manage future threats, improve disease management and reduce agrochemical inputs.

DNA-based SSR markers are used for detailed monitoring of genetic diversity in pests and pathogens

A comparison of genetically diverse (Right) and uniform (Below) pest or pathogen populations. The right-hand example is typical of populations in which both mating types (*P. infestans*) or sexes (Aphids) are found.



Threats to biodiversity from introduced pathogens

- Not all biodiversity is good!
- Members of the genus *Phytophthora* include plant pathogens that devastate crops and natural ecosystems.
- Introductions of exotic *Phytophthora* species include: *P. ramorum* (the cause of sudden oak death), *P. alni* (kills riparian Alder species) & *P. fragariae* (raspberry and strawberry root disease)
- Using DNA-based molecular methods SCRI has developed diagnostic and identification tools to help counter the threat of further introductions.

The introduced pathogen *P. fragariae* var. *rubi* threatens wild and cultivated Scottish raspberry.

Scottish Crop Research Institute

Scottish Crop Research Institute

Soil diversity

Soil is an essential part of every habitat

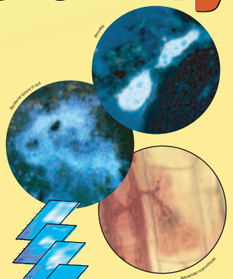
Every major group is represented, including bacteria and animals (including amoebae)

It is probably the most diverse system on the planet with, for example, up to 30,000 different bacteria per gram

Soil has a complex food web complete with all trophic groups

Soil is, despite its importance, very poorly understood

Work at SCRI focuses on soil in order to provide a greater understanding, and future protection, of this essential system.



Mycorrhizas

- *Arbuscular mycorrhizas* are an ancient symbiotic association between plant roots and fungi which may have been necessary for plant land colonisation.
- They have a wide range of functions including nutrient acquisition, pathogen resistance and improved water balance.
- Up to 30% of carbon fixed by the plant can be transferred to the fungus.

Nitrogen Cycling - Nitrifiers

- Nitrogen is cycled in soil.
- Nitrifiers convert ammonia to the more mobile nitrate. This process is performed by a limited group of bacteria.
- Nitrifier activity is variable in both spatial and temporal scales.

Nitrogen Cycling - Denitrification

- Denitrification converts nitrate to nitrogen gas though a range of intermediates. It is widespread; we have identified a range of bacterial groups capable of this function.
- It results in the loss of nitrogen compounds from the system.
- If this process is incomplete there is a release of nitrogen oxide gases (potent greenhouse gases).

Nematodes

- Nematodes are the most abundant metazoan on earth in terms of species richness and are indicators of ecosystem change.
- Free-living nematodes are recognised as 'keystone' organisms involved in soil nutrient cycles.
- The functional status of nematode communities can be characterised by analysing the proportions of their main trophic groups.

Scottish Crop Research Institute

Arable food web diversity

Intensification of arable systems has reduced the diversity and abundance of weeds and the animals that depend on them.

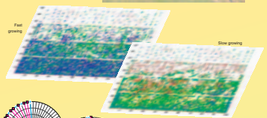
This loss of diversity can reduce sustainability and productivity.

We are investigating the complex relations between organisms in arable food webs

Our aim is to identify management practices that optimise crop yield and biodiversity.

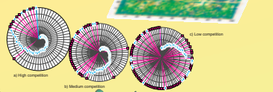
Modelling plant communities

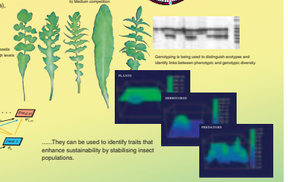
- Plant community models show that trade-offs between vegetative growth and reproduction can determine diversity. Fast-growing plant types (blue) are gradually replaced by slow growing types (green and red).



Measuring individual variation

- Field experiments demonstrate the effect of competition and spatial scale on plant traits.
- Diversity of plant traits can be as great within a species as between species.
- Individual plants, ranked by vegetative growth (blue) and reproductive state (pink), show great diversity under high (a), medium (b) and low (c) levels of competition.





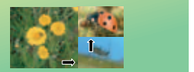
Predicting effects on food webs

- Plant traits affect the diversity of the arable food web.
- Models have been constructed to examine interactions between plants, herbivores and their predators.....

.....They can be used to identify traits that enhance sustainability by stabilising insect populations.

Functional diversity provided by the weed flora results in higher diversity of invertebrates compared to crop monocultures.

Diversity of arable plants is essential for diverse, productive above-ground arable food webs.



Scottish Crop Research Institute

Products and collaborations

Benefits for Industry

- As a LEAF (Linking Environment And Farming) Innovation Centre, SCRI demonstrates its research to farmers and other interested groups through visits, meetings and agricultural shows.
- As a member of Scottish Agronomy Ltd., we produce, gather, interpret and disseminate technical information to arable farmers
- SCRI breeding programmes produce new cultivars of potato, soft fruit and cereals with inbuilt resistance to pests and diseases, reducing the need for chemical treatments and permitting more environmentally friendly cropping systems.
- MAPP, an integrated, decision support system for potato growers (www.potatomapp.co.uk).

Education

- Educational Support - SCRI works closely with schools, education authorities and other education providers to promote public awareness and understanding of bioscience and environmental issues.
- The Arable Seed Identification System (ASIS) is a tool for identifying weed seeds. Seedbanks are indicators of plant biodiversity and ASIS has utilised three decades of SCRI expertise to produce this easy to use key. (www.scri.sari.ac.uk/asis).
- The Living Field Projects - Interactive CD's, an educational website and a Community Garden on agriculture, science and the environment are being used, together with demonstrations and discussions, to attract and encourage an interest in science and the environment.

Collaborators: Learning and Teaching Scotland, Primary and Secondary Teachers and Education Authorities

Funding: Scottish Executive Education Department, Biotechnology and Biological Sciences Research Council (BBSRC), Myrtafield Trust.

Suppliers: SEPA, Greenvale AP plc, ADT plc.

Information and advice to policymakers

- SCRI was one of the partners in the Department of Environment, Farming and Rural Affairs (Defra) Farm Scale Evaluation of Genetically Modified Herbicide Tolerant Crops.
- SCRI staff were part of Defra's Advisory Committee on Releases to the Environment (ACRE).
- SCRI provide policy advice to the Scottish Agricultural Science Agency, Scottish Natural Heritage, the Scottish Environmental Protection Agency and the European Union.
- Staff from SCRI have participated in worldwide Workshops for the International Organisation for Biological Control.

Science/Academic collaborations

SCRI has a wide range of collaborative partners including:

- National and International PhD and Post doctoral fellowships
- University and research establishments throughout Europe and the rest of the world

For more information on SCRI please visit www.scri.sari.ac.uk

Genes to systems

Scottish Crop Research Institute