SWAP Access to Science Students do their John Muir Discovery Award

‘John Muir’s and Tom Weir’s Way’

A Project by SWAPWest, North Glasgow College and SWAP Access to Science Students Class of 2011-12

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1. Introduction

1.1 SWAPWest and the project participants

The Scottish Wider Access Programme - West Consortium (SWAPWest) coordinate SWAP Access Programmes, for adults returning to education, at Colleges throughout the West of Scotland. SWAP students usually have no or few or they have been out of education for some time. Students can progress to study at university after successfully completing their SWAP year at college.

SWAPWest offer programmes to access university courses in Arts, Social Sciences, Primary Education, Social Work, Nursing, Health Professions, Biological and Life Sciences, Science, Technology, Engineering and Maths (STEM), Medicine, Veterinary Medicine and Dentistry.

The SWAP students who participated in the project were studying on the 'Access to Chemistry and Biological Sciences' programme at North Glasgow College in Springburn, Glasgow.

The students on this programme progress to university to study subjects like zoology, marine and freshwater biology, biomedical science, virology, medicinal chemistry, medical studies and similar science subjects.

1.2 The idea

In December 2011, Lisa Marsili, a SWAPWest Development Officer, attended a John Muir Trust Leader Training event at the University of Stirling. This event was for professionals who work in Further Education and was organised and funded byColleges Scotland.

Further to this training day, in early spring, 2012, Lisa sought volunteers from the Access to Science group at North Glasgow College to participate in a SWAP project in which students could gain their John Muir Award at 'Discovery Level'. The award involved learning about John Muir and local Springburn hero Tom Weir.

John Muir Discovery Award:
John Muir's and Tom Weir's Way

SWAP Access to Science students, 2012
North Glasgow College

1.3 Acknowledgements

Firstly, SWAP would like to thank the Access to Science students for their dedication and hard work during the award, which made it such a positive experience. We are also extremely grateful to Kim McIntosh, Scotland Inclusion Manager of the John Muir Award, for her marvellous support, enthusiasm and guidance throughout the award, and of course to both Kim and Rob Bushby for enabling us to meet Rhona Weir. We would also like to express gratitude to Glasgow City Council Natural Environment Officers, Carol MacLean and Cath Scott for their advice on creating the wildflower woodland area and the species identification leaflets. Many thanks are also given to North Glasgow College lecturers; Patricia McGowan, Alan Forsyth and Barbara Stephens for allowing time for the students to work on the wildflower area and for their general support. We also appreciate the financial assistance from North Glasgow College and the collaboration and insights provided by Associate Principal George Stewart and his assistant Elaine Campbell. SWAP also

appreciates the University of Glasgow, Top-Up Programme, allowing us to use the resources from 'The Invaders' section of the programme on non-native species present in the Loch Lomond area.

Finally, we would like to express our deep gratitude to Rhona Weir, who was so kind as to invite us into her home, feed us, entertain us with terrific tales, take us on a lovely walk and award us our John Muir Award certificates. Thank you so much! We will always treasure the afternoon we spent with you, it was a delight and you were inspirational.

2. Background of John Muir, Tom Weir and the John Muir Award

This section gives background information on John Muir and Tom Weir.

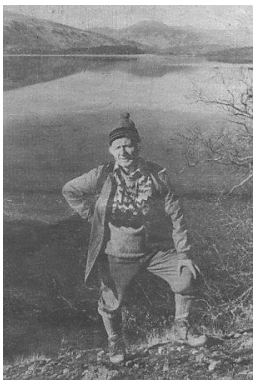
2.1 John Muir, the Trust and the Award

John Muir is a conservation icon who was born in Dunbar, East Lothian, in 1838 and moved to the USA aged 11. He was a free spirited explorer who spent much time in the mountains of Sierra Nevada and Yosemite Valley in California, exploring these wild places and documenting his experiences is his writing. He helped to found the modern conservation movement and the conception of national parks. Muir also encouraged President Roosevelt to act to protect wild places from commercial development and urged us all to spend time conserving and exploring our natural environment.
Further information on John Muir can be found here: http://www.jmt.org/assets/john%20muir%20award/resource%20guide%20john%20muir.pdf.


John Muir 1838-1914

The John Muir Trust (JMT) is the leading UK conservation charity and was set up in Muir's memory. The JMT owns and protects wild land in Scotland, for example, the trust owns the Ben Nevis, East Schiehallion and Isle of Skye estates. The John Muir Award (JMA), the trust's educational initiative, is an environmental award scheme that encourages awareness and responsibility for the natural environment. There are three levels that the award can be achieved; the **Discovery** Award requires a total of 4 days commitment; the **Explorer** Award requires 8 days and finally, the **Conserver** Award, entails 20 days work.

2.2 Tom Weir


Tom Weir 1914-2006

Tom Weir was born in Springburn on 29th December 1914, five days after John Muir died. He Worked in Cowlairs Co-operative as a grocer's boy before joining the army. After serving in the Royal Artillery in World War II, Tom worked as a surveyor for Ordinance Survey. He loved meeting local folk and walking, skiing and climbing in Scotland's wild places. Tom is well known for his television series, 'Weir's Way', but it is lesser known that he was a writer, conservationist, ornithologist, photographer, mountaineer, climber, historian and champion of Scotland. He was an intrepid explorer and participated in exploratory expeditions to the Himalaya, Nepal, Greenland, Norway, Morocco and Turkey.

In the year 2000, Tom was the first person to ever be awarded a John Muir Trust Lifetime Achievement Award. He is one of only four people to ever receive this award.

2.3 Award Summary

In addition to learning about John Muir and Tom Weir, the group created a wildflower woodland area on the college grounds in memory of Tom Weir. We discovered and explored Springburn and visited Springburn Park and the area where Tom Weir grew up, Adamswell Street (which is located behind the old North Glasgow College building). We also studied the biodiversity of the Loch Lomond area and read research papers on the Loch Lomond ecosystem. A field trip was organised to explore Gartocharn near Loch Lomond, where Tom Weir later settled, and the group were lucky enough to be invited to meet Tom's widow, Rhona at their house in the village. We climbed 'the Dumpling', Duncryne hill, that Tom climbed every day, explored the area and enjoyed the magnificent views of Loch Lomond. On the Dumpling, we debated the importance of conserving the Loch Lomond area, and other wild places, in a 'Dialogue on the Dumpling'.

The group's award experiences were presented at the North Glasgow College SWAP party and the SWAP Access to Science curriculum meeting, both in June 2012. A poster, photo albums and report have also been created to share the award activities with others. Our activities will feature in the John Muir Trust Journal and Glasgow Biodiversity News.

2.4 The Four Challenges

This section includes details of all of the activities involved in achieving the awards. For resource materials used, **please see the annex in section 6**.

To gain the John Muir Discovery Award participants tackle the **four challenges** set by the John Muir Trust; **Discover, Explore**, **Conserve** and **Share**. Participants also complete the required time commitment (four days for Discovery level), show enthusiasm and commitment to the Award, develop an awareness of John Muir and have a sense of doing something positive for wild places. There are many resources available on the John Muir Award website: http://www.jmt.org/jmaward-resources-links.asp.

3. Our Award

In this project, the students completed the award at Discovery level, requiring a total of four days commitment. The award activities were carried out between the March and June 2012.

3.1 Discover and Explore Springburn

The group discovered and explored Springburn, where Tom Weir grew up. We learned about Tom's early life from his autobiography, Weir's World, and walked to Adamswell Street, where Tom grew up and is just behind the old North Glasgow College building. We also explored Springburn Park and learned about the fascinating history of Springburn.

It was appreciated by all involved how rich and impressive Springburn's past was and it was particularly remarkable how famous Springburn was for heavy industry and engineering, for example, locomotive fabrication. We discovered that Tom Weir's mother worked as a locomotive coach-painter after his father was killed in World War I. We read Tom's

evocative descriptions of the lively Springburn of his youth and group agreed that it unfortunate that Springburn's rich history is now barely visible, on the surface at least.

Adamswell Street, Springburn


The group at Springburn Park


Derelict winter garden in park

The students photographed and identified some of the wildlife that we encountered in Springburn Park and on the North Glasgow College grounds. We were pleased that despite being an urban environment, the biodiversity was more diverse than expected. The students also mentioned that it is very fortunate that North Glasgow College has a grassy area, where students can gather to relax in the sun and a quieter woodland area, where the wildflower seeds were sown, for students to find some quiet time. It was thought that these areas contribute towards a positive learning environment.


A robin's egg in the wildflower area


Lucie and bluebells on the college grounds


***Pieris rapae:* caterpillar of the cabbage white butterfly**

3.2 Discover and Explore: Gartocharn

In contrast, the group also discovered and explored Gartocharn, near Loch Lomond, where Tom later settled, with his wife, Rhona. Before the visit, we learned about the Loch Lomond ecosystem and read research papers by the University of Glasgow on specific conservation issues (these can be found in section 6 annex). We also read about a proposed wind farm that, given permission, will be constructed just south of the village, on Auchenreoch Muir.

A field trip to Gartocharn was arranged for Wednesday 23rd of May, 2012, which was a hot, sunny day. We reached Gartocharn by train and bus by 10am and climbed the Dumpling (Tom Weir reportedly done just this every day). 'The Dumpling' is Duncryne Hill, a modest 157m high volcanic plug to the south of the town. Although small in stature, the views of Loch Lomond from the Dumpling are impressive and it was the perfect place to have a 'Dialogue on the Dumpling' about the importance of conserving Loch Lomond and other wild places, calling on the knowledge we gained before the visit. We also discussed issues related to energy and the environment, as we had learned that many locals, including Rhona Weir, oppose the proposed wind farm development. We read a letter opposing the wind farm, written by Rhona, which was posted on Gartocharn's community website (this can also be found in section 6 annex) and considered her arguments against the wind farm.

The Dumpling and Gartocharn village

Walking through the woods to go up the Dumpling

Long-horned beetle

Panorama of Loch Lomond from the Dumpling

3.3 Meeting Rhona Weir

Fortuitously, after reading our award proposal, Kim McIntosh, JMA Scotland Inclusion Manager, informed JMA Manager, Rob Bushby, of our project. Rob was to meet with Rhona Weir at the JMT AGM early in May 2012 and when he informed her of our project, Rhona very kindly invited us to visit her at her home in Gartocharn on the afternoon of our trip.

After our morning exploring the Dumpling and enjoying the views of Loch Lomond, we walked to Rhona's house to meet both Rhona and Kim McIntosh from the John Muir Trust. Kim had asked us if the John Muir Journal could include a feature on our award in the John Muir Journal and we were delighted to accept her offer.

On our walk with Rhona

Tom's John Muir Lifetime Achievement Award

The group with JMA certificates and Rhona with Tom's Award

Rhona had cooked a pot of spring vegetable soup and baked us delicious, home-made ginger biscuits (we enjoyed these immensely with lots of tea). She chatted to us about Tom, their life together and adventures they had been on. She also showed us Tom's John Muir Trust Lifetime Achievement Award, an accolade that she said he valued more than his MBE.

Afterwards, Rhona took us on a scenic walk around Gartocharn before awarding us our certificates in her sunny back garden, accompanied by more tea and biscuits.
One of our favourite stories she told us was how Tom and her met: Rhona and some friends from the Ladies Scottish Climbing Club, were permitted on the Scottish Mountaineering Club minibus (a men only club at the time) to Glencoe. The men went off rock-climbing and the ladies went hill-walking and climbing by themselves. Rhona, however, had forgotten her waterproof trousers and her trousers had been soaked in the rain. Back on the bus, Tom thoughtfully offered Rhona his spare pair of dry trousers, which she accepted gratefully. When she returned the trousers to him, he asked her out and their relationship progressed from there. They married in Aberfoyle Kirk, in 1959 and moved to Gartocharn, where Rhona taught in Gartocharn Primary School and later became the school's Head Mistress.

3.4 Conserve – Planning the wildflower woodland area

The wilflower area is on the right of the path

For the conserve part of our award, we created a wildflower woodland area outside college in Tom's memory. This is an ongoing project and it is hoped that the area can be further developed in years to come. The wildflower area is a long, 400m^2 piece of land adjacent to the college beside a path.

The seeds were sown on the ground to the right of the recently constructed path, shown in the photograph opposite.

We were inspired by the Royal Horticultural Society (RHS) **Wild about Wildflowers: Britain in Bloom** campaign. As part of the campaign, groups were requested to sow wildflower seeds as part of a nationwide project to celebrate the Queen's Diamond Jubilee and also to provide habitat for pollinators like bees, hoverflies and butterflies, whose numbers are reported to be declining. A campaign report as well as information and advice on how to create wildflower areas can be found on the Wild about Wildflowers: Britain in Bloom website at: www.rhs.org.uk/gardening/community-gardening/britain-in-bloom.

We also read about the concerns of the decline of pollinators in a short paper by Professor Dave Goulson of the University of Stirling on bumblebee conservation (this can be found in the annex, in section 6 of this report).

The group sought guidance from **Glasgow City Council's Natural Environment Officers**, Carol MacLean and Cath Scott (pictured in the photo, right). Carol and Cath very kindly visited us at the college to provide us with advice from their practical experiences of creating wildflower areas.

They helped us develop our plan to create the wildflower woodland and we were very grateful for the helpful insights that they provided us with.

Natural Environment Officers Carol (second from left) and Cath (second from right)

The advice given to us was:

- Use woodland wildflower seed mix for under the trees, a hedge bank mix further out and a meadow mix for areas that receive direct sunlight.
- Sow yellow rattle seeds as this plant increases biodiversity by inhibiting the growth of grasses.
- Clear the area of litter, rocks, large stones and dead wood.
- Remove creeping buttercup as this can be invasive, otherwise no weeding required.
- Lightly rake the ground before sowing seeds.
- After sowing, the seeds need water – hope for rain or water the seeds if necessary.
- Seeds should be sown during towards the end of March or during April. They can also be sown in late autumn.
- Wildflowers do not need compost, they prefer nutrient poor soils.

Suggestions on how we could further develop the area were:

- Create woodpiles and stone piles as invertebrate habitats as well as bee-habitats and bird (and bat) boxes. This increases the biodiversity of the area.
- Create a pond or wetland area to encourage amphibians, dragonflies and damselflies.
- Plant thyme, crocuses and primroses and other native species around the area.
- Create a hedge of hawthorn and honeysuckle near the fence surrounding the area Plant more brambles and other fruit plants.
- Develop more woodland by planting cherry or fruit trees.

3.5 Conserve - Creating the wildflower area

Elaine Campbell and George Stewart with the wildflower seeds

As advised, we carried out a litter-pick of the college grounds as well as the wildflower area, cleared the ground of debris, weeded out creeping buttercup and raked the ground to prepare for seed sowing.

We sowed our wildflower seeds in mid-April, at a similar time to that of the RHS Britain in Bloom campaign. The seeds that were sown were mixtures of annuals and perennials suitable for a light woodland area. They were sown at a density of roughly 3g of seeds per m^2 along with some sand and light compost.

The seeds were sourced by Elaine Campbell and Associate Principal, George Stewart (shown bottom left on the previous page). The costs of the seeds were met by North Glasgow College and SWAPWest also provided a contribution. The annual seeds were purchased from Scotia Seeds and would flower this year, after which the seeds can be collected and re-sown next spring. The perennial seeds were purchased from Boston Seeds and will only bloom a little this year; however they will fully flourish in late spring/summer 2013 and continue to bloom in coming years.

Rachel, Lucie, Sarah and Guy

The team hard at work

Sowing the seeds

Invertebrate habitats were constructed with dead wood and stones from the clear-up. North Glasgow College students studying environmental biology complete practical activities with invertebrates and they will be able to locate specimens for their experiments within these habitats. This work can be continued by next year's student cohort.

Rachel and her bug house

Guy and invertebrate habitat

Lucie and her log pile

3.6 Sharing our award experience

The group's experience of undertaking the award was shared with students and staff at the North Glasgow College SWAP end of year party in June 2012, where photos were shown. The award was also presented at the June SWAP Access to Science Curriculum Group Meeting. An online photo record of our activities has been created, as well as a poster, to communicate the award experience and hopefully inspire this year's cohort of SWAP students to participate in a John Muir Award this academic term.

End of year North Glasgow College SWAP party

Presenting to staff and students at the SWAP party

John Muir Award team: Rachel, Lucie, Guy and Sarah

Further sharing includes:

- Presenting to those who attended the John Muir Award Gathering in Glasgow Botanic Gardens in October 2012.
- Featuring in the **Autumn 2012 issue of the John Muir Trust Journal**, which can be viewed on pages 24-26 here: http://issuu.com/johnmuirtrust/docs/jmt-journal_53-autumn_12/1.
- It is also hoped that we will feature in a coming issue of Glasgow City Council's Biodiversity News.

Images (JMA) from the John Muir Award Gathering
Glasgow Botanic Gardens, October 2012

Inspiring Lives – the feature on the group in the Autumn 2012 John Muir Trust Journal
http://issuu.com/johnmuirtrust/docs/jmt-journal_53-autumn_12/1

4. Future plans

This section shares the future plans for the wildflower area and also the participants.

4.1 Plans for the wildflower area

It is hoped that during the coming academic year, this year's Access to Science students will become involved in developing the wildflower area. The participants of this project would like to continue their involvement with the project. We hope to:

An invertebrate habitat

- Create an invertebrate habitat, as shown above.
- Construct an open outdoor teaching area and outdoor classroom.
- Raise awareness of Tom Weir and John Muir within the college and promote conservation and appreciation of the natural environment.
- Build a stone cairn, from stones brought in to the college by staff and students, to commemorate Tom in the wildflower area.
- Produce information signs to explain the wildflower area, habitats and cairn.
- Keep in touch with Rhona to inform her of progress and developments.

4.2 Future plans for the participants

Rachel Forbes is studying Zoology at the University of Glasgow and helps organise events at the university Zoology Society. She will be embarking on an expedition to Trinidad in the summer of 2013. Rachel completed John Muir Award training and hopes to help lead a John Muir Award at North Glasgow college with this year's SWAP students.

Guy Paul Henderson is now studying Marine and Freshwater Biology at the University of Glasgow. He is also involved in the zoology society and will participate in a university expedition to Egypt. Guy is a dedicated fly fisherman and hopes to focus his future research on salmon migration.

Lucie Provaznikova is now studying Zoology at the University of Glasgow. She participated in an expedition to Tobago in the summer of 2012 and will travel to Peru for her 2013 expedition. She hopes to pursue her interests in reptiles and turtles. Lucie is from the Czech Republic.

Sarah McIntosh has been accepted onto SWAP's sought after Access to Medical Studies programme at Stow College. Sarah hopes to gain a place studying Dentistry at the University of Glasgow after completing this course. Sarah enjoys rock-climbing in the mountains and lowland crags as a hobby.

Lisa Marsili works to help widen access to the study of sciences in Higher Education with SWAPWest and the University of Glasgow Top-Up Programme. She also teaches science at North Glasgow College. Lisa is interested in conservation and loves to climb mountains with her family. She is a big fan of John Muir and Tom Weir.

5. Evaluation

A short online evaluation was carried out, which can be viewed at the following link: http://swapwest.wufoo.com/forms/john-muir-award-evaluation/. Three of the four participants completed an evaluation.

5.1 Award activities

This section contains feedback on the award activities.

5.1.1 Responses on award activities

How did you find…	Number of students who found the activity…			
	Very good	Good	Satisfactory	Unsatisfactory
The award in general	3			
Exploring Springburn	3			
Exploring the Dumpling	3			
Visiting Rhona Weir	3			
Creating wildflower area	2		1	
Theory work	2	1		
Sharing the award	1	2		

5.1.2 Comments on award activities

- I had an amazing time at Gartocharn and I learned so much about Tom Weir.
- Rhona Weir was such an inspiration. It was awesome to meet her and she is doing a great job of carrying on Tom's legacy.
- I would have liked to have done more with the wildflower area with better resources and a more scientific approach.

5.2 Resources and organisation

This section contains feedback on resources and organisation.

5.2.1 Responses on resources and organisation

How did you find…	Number of students who found the activity…			
	Very good	Good	Satisfactory	Unsatisfactory
Communication with SWAP	3			
Pace of the award	2	1		
Balance of activities	3			
Materials and resources	1	2		

5.2.2 Comments on resources and organisation

- The materials and resources provided and delivered by Lisa were excellent but the college fell short with their resources for the wildflower area.
- We needed better equipment and more sand.
- Lisa was brilliant throughout the whole experience and struck up a nice balance and flow with the content, letting you get on with your own thing while always being on hand to help if needed.

5.3 Impact of the award

This section contains feedback on resources, organisation and content of the award.

5.3.1 Responses on award impact

Impact of the award			
For me the award…	**Yes, definitely**	**Maybe a little**	**No, it did not**
Raised my aspirations and confidence	3		
Gave my SWAP programme added value	3		
Raised my awareness of conservation issues	2	1	
Will benefit my CV	2	1	

5.3.2 Comments on resources and organisation

- I entered the SWAP programme with the intention of it being the fist step towards a future career in conservation. The John Muir award helped to cement my belief that this is what I want to do.
- I have learned much more about wild places and John Muir.
- I had an excellent experience working with Lisa.

5.4 Further comments

- I had a great time participating in the JMA and would recommend it to other SWAP science students.
- I felt it was an excellent way to finish the programme and it kept me motivated to go into college when most of my course content had finished.
- I learned some new skills, met and read about some inspiring people and had a right laugh.
- SWAP do a fantastic job at working with mature students and helping them achieve their dreams.

6 Conclusion

This John Muir Award flourished into a very successful and worthwhile project and it benefited the whole group in such diverse and unexpected ways. The main points of conclusion are summarised below:

6.1 Interdisciplinary outdoor learning

The award compliments Curriculum for Excellence through interdisciplinary outdoor learning. The award encouraged the four capacities of Curriculum for Excellence within us all; to be successful learners, confident individuals, responsible citizens and effective contributors. It was found that there are many opportunities to embed the award in the college curriculum, for example, learning about ecosystems, food webs and biodiversity in environmental biology units and writing about John Muir and Tom Weir or investigating the work of the men themselves in communication units.

6.2 Easy to use

Running the award is very straightforward; there is minimal paperwork required and information and useful resources are available on the JMA website. JMA staff are also supportive, friendly and knowledgeable and will assist leaders to ensure their awards reach their full potential. Although JMA leader training is available at a cost, it is not necessary to complete training to run an award. Furthermore, Colleges Scotland have provided free John Muir Award training through their Outdoor Learning group for college employees.

6.3 Educational and useful

The participants gained knowledge and understanding of ecology as well as developing practical conservation skills. The students also enhanced their academic skills, for example, in understanding academic writing and referencing, presentation skills, critical thinking and debating. It was useful for the University of Glasgow students to mention their award on their applications for Talent Scholarships at the university. One of the students who applied was successful in gaining a scholarship. It will also be advantageous to mention JMA in CVs, at interviews and in personal statements for postgraduate study or employment.

6.4 Inspirational

The John Muir Award is also inspiring. The three participants now studying at the University of Glasgow are deeply involved in university life and help organise the university Zoology Society. Learning about John Muir and Tom Weir's expeditions has proved inspirational to the students; one has already been on a university expedition to Tobago, and in the summer of 2013 all three will participate in expeditions to Trinidad, Peru and Tanzania. The students plan to use their expeditions to progress to the Explorer level of the Award. Furthermore, one of the participants plans to help lead this year's award at North Glasgow College and has attended JMA training provided by Scottish Colleges to help her accomplish this.

However, it was agreed by all that the most inspiring element of the award was meeting Rhona Weir. She inspired us to experience, enjoy, learn about and protect our beautiful wild places, here in Scotland and elsewhere. Her wise advice to us was to 'Live every day to the fullest and treat each day like it is the first day of the rest of your life.' The participants of this project indeed appear to be taking Rhona's advice and doing just that.

7. Annex

7.1 Dialogue Academy

Lisa attended the Dialogue Academy in 2010, which was held over three days at the Glasgow Science Centre. The academy was a free training course for science communicators in four cities in the UK. It was funded by the Welcome Trust and delivered by professionals from science centres. The course aimed to help science communicators gain the skills, ideas and techniques to use dialogue and debate to engage audiences with science.

Lisa, second from right, at the Dialogue Academy

Information and resources can be found on the Dialogue Academy website at: http://www.dialogueacademy.org.uk/.

7.2 The University of Glasgow 'Top-Up Programme' resources

Marsili, L., (2005) *Non-Native Species Case Studies*, Top-Up Programme: The Invaders; University of Glasgow

MAMMALS	Background	Impacts	Control
Grey squirrel (*Sciurus carolinensis*)	Adult squirrels were imported to the UK from North America and deliberately released for aesthetic reasons, probably as a desire to see the grey squirrel in the UK. At the time of this introduction (late 19th to early 20th century) there was less knowledge of possible harm. The movement of 'exotic' species around the world was considered favourable and fashionable.	The grey squirrel spread rapidly over Scotland, England and Wales, displacing the native red squirrel (*Sciurus vulgaris*). Competition for habitat and food between the species is thought to cause the decrease in red squirrel numbers The grey squirrel can tolerate the phytotoxins in acorns; this may give them a feeding advantage. Recent research suggests that the grey squirrel carries a parapox virus that is lethal to red, but not grey squirrels. Grey squirrels cause economic damage by stripping bark from a wide range of trees. This also inflicts wounds that can allow insects and fungi to penetrate and severely degrade timber quality. Estimated annual control costs for timber protection are £3 million.	Trial removal of grey squirrels has already taken place, however, strong opposition to culls exists from animal rights groups. In northern Italy, radical animal rights groups opposed a removal project, taking the National Wildlife Institute to court. A 3-year suspension was imposed, after which the numbers of grey squirrels had risen and removal was no longer practical. Research has proven that in grey-free areas, red squirrels have more offspring and gain more weight.
Hedgehog (*Erinaceous europaeus*)	Four hedgehogs were introduced to South Uist in 1974 and a further three in 1975 to control slug populations. Other possible introductions may have occurred, but were not recorded. The hedgehog population is now in excess of 5,000. The hedgehogs have since spread to North Uist and Benbecula.	The hedgehog is thought to be the main reason for the observed decline of some species and threatens the viability of the islands' large population of wader birds. Hedgehogs have especially attained particularly high population densities on Machair, an area that supports internationally important numbers of nesting waders, e.g., dunlin, snipe, oystercatcher, lapwing and redshank. Hedgehogs feed on the birds' eggs. Comparisons of wader breeding success before and after hedgehogs colonised the area show that egg predation by hedgehogs has greatly reduced hatching success of some wader species, with some species reduced by over 50% in less than 20 years.	After years of seeking alternative methods to control hedgehog numbers, e.g., fencing and sterilisation, Scottish Natural Heritage (SNH) began a hedgehog cull in 2003 in North Uist and Benbecula. The cull was opposed by many individuals and groups, including the Uist Hedgehog Rescue, a coalition of animal groups, which has saved over 800 hedgehogs since 2003 and relocated them to the Scottish mainland. SNH abandoned the cull in February 2007, with relocation of hedgehogs to the mainland now favoured.

Sika deer (*Cervus nippon nippon*)	The Japanese sika deer was first brought to Britain in 1860 for collectors with private estates and parks. Further introductions continued until the 1930s, but by then sika had escaped from the estates, or been deliberately released and they are now fully naturalised and spreading rapidly across Scotland and northern England.	Sika deer have expanded their ranges rapidly in comparison to the native species. It is projected that by 2010, the Sika deer will comprise 17 % of the total deer species in the UK and by 2015, this figure may rise to 21 %. Despite their size difference, Sika deer readily hybridise with native red deer. Hybrids between the two were first noted in the 1950s. Many hybrids do not look different to the pure red deer, raising concern that the genetic integrity of the native red deer may be lost. Coniferous forest, planted for timber production, has allowed the population to spread in recent years. The sika deer damage the commercial forest plantations and as they expand near populations of red deer, they threaten the native species through hybridisation and competition.	Controlling sika is harder than controlling red deer and might not be possible without vast resources. The Deer Commission for Scotland and Forest Enterprise, therefore, set up a project to monitor deer population densities and culling. Apart from standard culls, efforts may have to be increased to maintain separation between red and sika deer populations, if genetic introgression is to be restricted in the UK. This is already being attempted in Scotland, but relevant, centralised policy is currently lacking in England.
American mink (*Mustela vison*)	American mink were introduced to Europe, Iceland and South America for fur farming in the early 20th century. American mink first became feral in Britain in the 1950s as a result of escapes from fur farms and are now widespread. Escapes from fur farms resulted in large breeding populations in various European countries.	As predators, mink have been found to prey on native water voles in the UK and research has suggested that mink are responsible for the decline in water vole numbers in areas where both species co-inhabit. There is also evidence that mink could account for a large proportion of salmonid mortality in some river systems as well as the decrease in gull and tern numbers in the west of Scotland.	The numbers of introduced American mink in some countries is so large that complete eradication, without re-invasion from neighbouring countries, may be virtually impossibe. However, eradication of mink from islands is a more feasible project. A £1.6 million eradication project to remove mink from the Uists and reduce numbers in Harris is taking place. Recent research suggests that the presence of otters in areas occupied by mink may reduce mink numbers.

Ruffe
(*Gymnocephalus cernuus*)

Hedge-Holmes, K., (2011), Formerly Native Species Case Study – Update on Beaver re-introduction

Background

Beavers lived in Scotland until the 16th Century. They were hunted to extinction for their fur and for a secretion with medicinal qualities. In May 2009, The Scottish Wildlife Trust (SWT) and The Royal Zoological Society of Scotland (RZSS) introduced four families of European Beavers, transported from Norway, into the Knapdale Forest, Argyll. They have been introduced as part of a 5 year study into whether beavers can thrive in the Scottish environment.

Benefits of re-introducing beavers to Scotland

Beavers are a keystone species – a species which affects the survival and abundance of other wildlife in the community in which it lives. (www.scottishbeavers.org.uk). The reintroduction will improve biodiversity, allowing new species of plant to thrive. It may also provide opportunities for local businesses and communities to develop eco-tourism. Beavers modify their surroundings to suit their needs, including the felling of trees and building dams. These dams can help improve water quality, and breeding habits for local fish and wildlife.

Problems of re-introducing beavers to Scotland

Researchers at the Tweed Foundation argue that the reintroduction of beavers will have a negative impact on the environment. They claim that reintroducing the beaver would affect migrating fish, such as salmon and sea trout. The building of dams would prevent the fish swimming up and down stream. It would also affect the surrounding woodland by flooding areas of land, killing trees and other plantlife (www.tweedfoundation.org.uk/tweed_management/beavers)

First year update (adapted from http://news.bbc.co.uk/1/hi/scotland/10168449.stm)

May 2010 saw the first anniversary of the re-introduction of beavers to the Knapdale Forest in Argyll. Their impact proved controversial, according to James Cook. In his article, he points out, 'It's an impressive piece of engineering. Earth, moss and wood are propped up by a neat array of sharp twigs, supported by larger logs which even a human would find difficult to lift'. Nick Purdy of the Forestry Commission is impressed by the work carried out by the beavers, describing them as, 'natural woodland managers'.

Some opposition still exists to the beaver re-introduction with some local residents highlighting that they had concerns from the outset. Some have raised concerns that the impact has been extensive to the local environment. The project team are listening to the concerns of the residents and the opponents of the trial. However, the next stage of the trial will cause more concern for opponents. Breeding of the animals would be the next stage in the re-introduction process, and would be welcomed by conservationists. Attempts to begin the breeding process have started, with a male beaver introduced in the vicinity of a single female beaver in September 2010. The progress of the re-introduction will be closely monitored throughout the year.

Third year update – Beaver Re-introduction
Adapted from http://www.bbc.co.uk/news/uk-scotland-glasgow-west-13572348

It is apparent from the beaver blog: **http://blog.scottishbeavers.org.uk** that the re-introduction of beavers in Knapdale Forest has been going well. Volunteers from the trial are eagerly anticipating the arrival of new kits. Fundraising and awareness is also growing with events in Kelvingrove Museum and other venues highlighting the progress of the project.

However, according to a new report commissioned by Scottish Natural Heritage (SNH), efforts to monitor the beavers are being hampered by the terrain.

Steep and heavily wooded terrain has caused problems tracking the beavers. Researchers said some tags attached to beavers' tails were lost within two or three months of their release. The tags helped monitor the animals using a system known as radio-telemetry.

Even when tags were on the animals, the report's authors said the landscape challenged this method of monitoring. Researchers said Knapdale's thick woods and steep ridges between its lochs and river systems presented 'serious difficulties' to the transmission of radio signals. Trapping beavers from a boat to record numbers would remain the favoured way of monitoring the beavers.

The Scottish Beaver Trial reported in January 2011 that Knapdale has 12 beavers following the birth of two kits, and further introductions. Initially, 15 beavers were introduced in 2009. The annual report said two deaths were recorded in the wild, while a third animal that had been withdrawn from the programme died in captivity.

Simon Jones, Scottish Beaver Trial Project Manager, acknowledges that new kits hopefully will be emerging from their lodges this year. He emphasises that the trial has faced inevitable challenges due to the terrain, but that the project team are happy with how the beavers are progressing.

Adams, C.E. & Maitland, P.S., 'The Ruffe Population of Loch Lomond, Scotland: its introduction, population expansion, and interaction with native species' in *Journal of Great Lakes Research*, 1998, Vol. 24 (2), 249-262. (Excerpts)

ABSTRACT

The ruffe (*Gymnocephalus cernuus*), never before recorded in Scotland, was discovered in Loch Lomond in 1982… Between 1982 and 1992 the ruffe population grew exponentially. Since 1992 the population appears to have stabilized to some extent but at a very high level… [Ruffe] prey choice was diverse… The most important [prey] is the powan (*Coregonus lavaretus*), a [species] of national conservation value. To examine the possibility of dietary overlap with perch (*Perca fluviatilis*) and brown trout (*Salmo trutta*), the diets of these three species were compared. The data showed very little evidence of overlap in diet, suggesting that feeding resource competition between ruffe and trout and ruffe and perch does not occur between adults of these species. Evidence for the disruption of predator-prey relations by introduced ruffe is reviewed. Ruffe are now the primary prey species for cormorants (*Phalacrocorax carbo*), herons (*Ardea cinerea*), and northern pike (*Esox lucius*) feeding in Loch Lomond.

(p. 250)

INTRODUCTION

The species composition of the fish community of Loch Lomond appears to have been relatively stable in recent centuries and, up until the 1970s, was composed entirely of native species, 15 in total. However, during the 1980s, 5 new species appeared in the loch and there are now 20 fish species established there… The first record of one of these, the ruffe, was the first sighting of this species in Scotland.

Historical evidence suggests that [the ruffe] was originally absent from… Scotland… In the last two decades it has dispersed into… Scotland (Loch Lomond) apparently being transported and then released by anglers who used it as live bait for fishing for northern pike.

The goals of this paper are to:

a) describe the introduction, establishment, growth, and current status of ruffe in Loch Lomond…
b) examine the evidence for… feeding competition with… other common fish species and… other interactions within the ecosystem.

(p. 251)

METHODS

Systematic, continuous monitoring of fish populations from Loch Lomond began in 1981 utilising information obtained from fish entrained at a pumping station at Ross Priory, on the south shore of Loch Lomond…

Interactions with Other Fish
To examine the diet of ruffe and to determine the potential for feeding competition between ruffe and other fish species with similar feeding habits, the stomach contents of ruffe… was examined… After collection, all fish were… initially frozen… subsequently defrosted, the stomach contents removed, blotted dry, and weighed, and the number of each prey item counted under a low power stereo microscope…

(p.252)
Interactions with Fish Predators
To examine the possibility that the establishment of a large population of ruffe in Loch Lomond had influenced the relationship between predators of fish and their native prey, the diet of the three principal predators of fish feeding on Loch Lomond was examined between 1989 and 1991. [grey herons, northern pike and cormorant.]…

RESULTS

Ruffe Population…
No ruffe had been seen in Loch Lomond prior to 1982, but 17 were entrained that year, followed by 47 in 1983 and 406 in 1984… from year to year, the general very rapid upward trend continued until 1992 when 13,828 ruffe were collected from the screens. Though numbers declined somewhat in the following years they have never fallen below 4,820 since 1991 and reached 11,296 in 1996…[See Table 1 and Figure 1.]

(pp. 254-55)
Diet… Overlap with other Species
The stomach contents of ruffe collected at the Ross Peninsula in summer 1987… and of perch collected at the same site… in 1977 before the arrival of ruffe showed that perch diet differed substantially from that of ruffe caught at the same site… Diet analysis of the small number of perch caught contemporaneously with ruffe in… 1985 confirm that perch diet has not changed substantially since the arrival of a large ruffe population…

Both brown trout and ruffe had been feeding extensively on the eggs of fish, predominantly those of the powan which spawns in mid-winter. However, apart from this… the diet of ruffe and brown trout differs substantially…

Interactions with Fish Predators
Northern pike, herons and cormorants were shown to feed predominantly upon the new abundant ruffe population and showed a clear shift in diet away from native fish species…

(pp. 258-59)
DISCUSSION

Interactions with other Species: Resource Competition
Diet data presented here confirm that as with most other [ruffe] populations, ruffe in Loch Lomond are… highly flexible in their choice of prey… a wide range of benthic-living invertebrate[s] but also… the ova of other fish, such as coregonid [powan] and salmonid [brown trout and atlantic salmon] eggs. Ruffe also appeared to be cannibalistic at times…

The diet of ruffe changes… seasonally in Loch Lomond… The most significant change in diet was the heavy predation upon the eggs of fish (powan), which spawn… during winter… The data very clearly indicate that… there is no resource overlap and… no feeding competition interaction between [ruffe, brown trout and powan].

(p.259)

Concomitant Introduction of Parasites or Disease

…During extensive fish surveys in 1989 in Loch Lomond a parasite of fish, never detected previously there, was discovered. The crustacean, *Argulus foliaceous*… attaches externally to a fish… and feeds upon mucus and epidermis using a piercing stylet and rasping mandibles. Heavy infestations can cause substantial damage to fish… The most likely vector for its arrival is that it was introduced along with fish brought into the catchment…

Predation

…It is clear that ruffe, unlike other fish species, are feeding extensively in Loch Lomond in mid-winter… The ruffe are capable of maintaining food intake at temperatures previously affording protection for powan. The long-term effect of ruffe predation on the spawning success of powan is unclear… however, evidence… suggests that there has not yet been a catastrophic decline in the powan population.

(p. 260)

Direct predation by piscivorous ruffe on other species is not the only ruffe-induced predation effect that has been demonstrated in Loch Lomond. Changes in diet of piscivorous birds and northern pike would appear to amount to considerable predation relief for the native species that comprised the diet of fish predators before the arrival of ruffe (powan for northern pike and roach… for herons, (the diet of cormorants prior to the arrival of ruffe is unknown)…

A number of important points emerge from these studies. Firstly, it is clear that it is through changes in relationships between predator and prey that the most significant changes to the freshwater community resulting from the introduction and establishment of a large ruffe population in Loch Lomond have occurred. Secondly, the changes that have occurred have been fundamental, with potential repercussions throughout the whole ecosystem. [See Figure 2] Thirdly, although the changes in species interactions and their consequences described here cannot be considered of positive benefit they may not be, at least in the short term, deleterious and some changes that could have positive benefit to some members of the native community have been identified. Fourthly… there has been a shift in the main energetic pathways in the food-chain in Loch Lomond. Top predators feeding on fish prior to the arrival of ruffe were consuming prey that fed primarily on plankton. Now, by consuming ruffe, they are feeding on a prey that consumed benthos. Fifthly… although theoretically the mechanisms of interaction between invading and native species are understood, it is not possible to predict with any accuracy exactly which will occur when an invader enters a new community.

Table 1. Number of fish caught on trash screens at Ross Priory Pumping Station on Loch Lomond between 1982 and 1996.

Year	Ruffe	Non-ruffe
1982	17	192
1983	47	196
1984	406	324
1985	1551	1100
1986	798	464
1987	1280	118
1988	3015	377
1989	835	153
1990	2347	418
1991	5547	335
1992	13828	3073
1993	9428	3785
1994	4820	1722
1995	9803	2753
1996	11296	1842

Figure 1. Number of fish caught on trash screens at Ross Priory Pumping Station on Loch Lomond between 1982 and 1996.

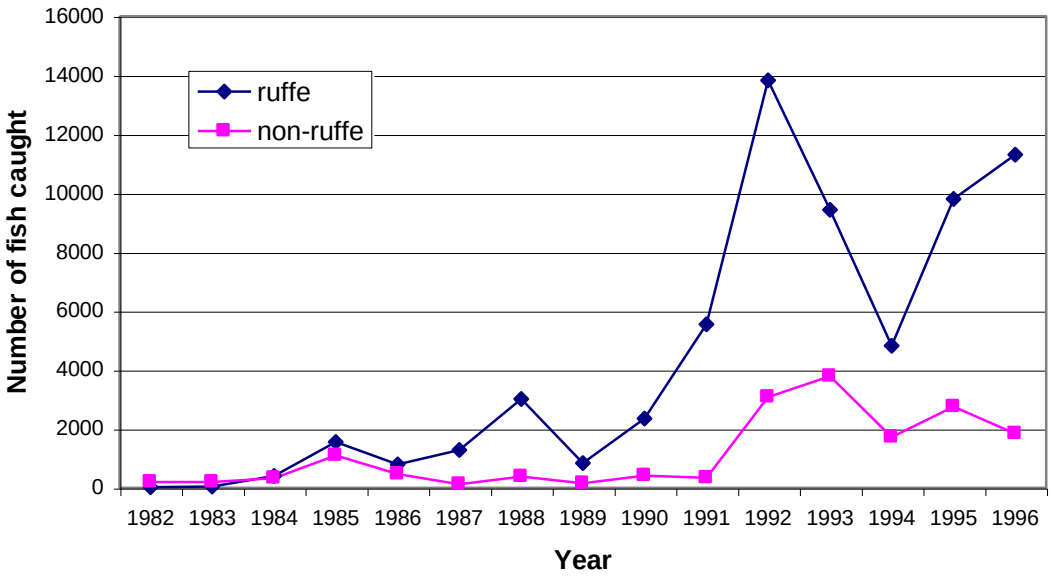
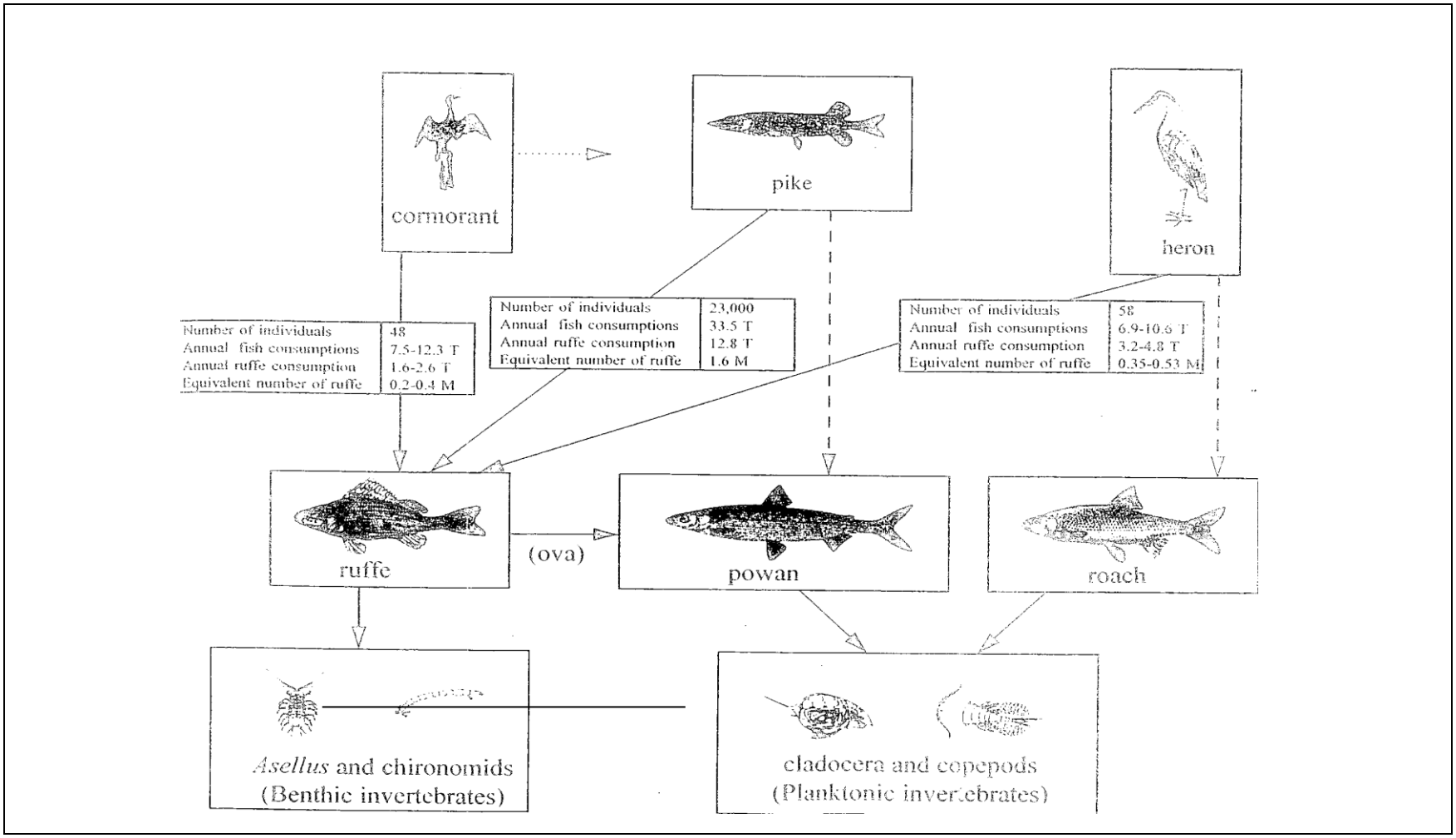


Figure 2: Loch Lomond ecosystem as affected by the introduction of ruffe



Some Questions to Consider

- **Do non-native species threaten the natural environment?**

- **Should 'alien' species be removed from their environment?**

- **How are non-native species introduced into new ecosystems?**

- **How can non-native species be so successful in new environments?**

- **Should the introduction of formerly native species be permitted?**

- **Do the introductions of non-native species and reintroductions of formerly native species have predominantly negative or positive effects?**

Introduction to Non-Native Species Practical – Otter Spraint Fish Bone Identification

The object of this scientific practical exercise is to examine the impact of the introduction of a non-native fish species, ruffe, on the diet of otters in the Loch Lomond ecosystem. The practical is modelled on the research methodology of Dr Dominic McCafferty (University of Glasgow), for his paper, 'The dietary response of otters (*Lutra lutra*) to introduced ruffe (*Gymnocephalus cernuus*) in Loch Lomond, Scotland' in *Journal of Zoology*, 2005, Vol. 266, 255-260.

You will study 12 copies of digital photographs of petrie dishes. Your tutor will provide these pictures. Each petrie dish contains the contents of a dried otter spraint. To analyse the spraint contents, you should compare them to the fish bone key provided. In this way, you can identify the species of fish consumed by each otter and determine what their diet has been. You only need to determine if the otter has eaten any of the five fish species named in the key. Other bones, scales etc are present in some of the samples, but these can be ignored. For this activity you will also need the 'Glossary of Terms' which again will be provided by your tutor.

By filling the results into the table on the 'Non-Native Species Laboratory Exercise: Results' handout and then using the formula at the foot of the table, you can determine the percentage of each of the five fish species within the otter diet. You should then use these percentage numbers to create the graph at the bottom of the sheet.

These results can be used alongside the written sources to help your discussion at the Campus Session 2 seminar and also for the scientific report, which you will complete in the final Top-Up sessions. Bear in mind that it is a relatively small sample you will be studying. McCafferty studied hundreds of samples to compile a body of evidence to support his research, but due to time constraints, you will study 12 samples to give you an idea of the scientific research process. You will read extracts from McCafferty's paper for your scientific report.

Glossary of Terms

Anterior – The designated front part. The anterior surface corresponds with the ventral surface.

Centrum – Spool shaped and cylindrical, main part of the vertebrae. Adjacent centra are joined by collagen fibres to provide a firm flexible rod.

Dorsal – The upper surface.

Operculum – Cover for the gill slits in fish that is stiffened with plates of bone.

Posterior – Part that is furthest away from the front. The posterior surface corresponds with the dorsal surface.

Spraint – Name given to the faeces of the otter.

Ventral – The lower surface.

Vertebral Column – A series of closely apposed bones (vertebrae) that runs dorsally from the skull to the tail in vertebrates. It is the main longitudinal strengthening element of the body and surrounds and protects the spinal chord. The articulating surfaces of the vertebrae are joined together by collagen fibres to minimise movement at the joint and to confer rigidity upon the structure.

Vertebrae – One of the individual bones of the vertebral column (see below).

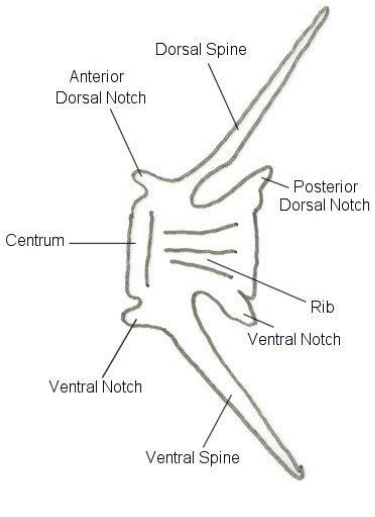
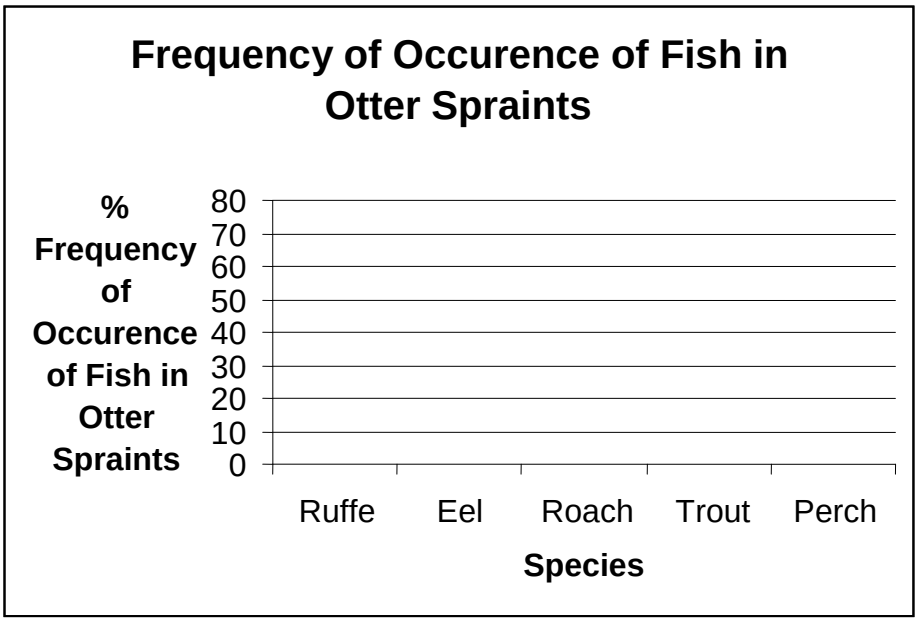


Figure 1. Main Features of a Fish Vertebra.

Non-Native Species Laboratory Exercise: Results

	Ruffe	Eel	Roach	Trout	Perch
Example	✓	✓		✓	
Spraint 1					
Spraint 2					
Spraint 3					
Spraint 4					
Spraint 5					
Spraint 6					
Spraint 7					
Spraint 8					
Spraint 9					
Spraint 10					
Spraint 11					
Spraint 12					
Total					
% frequency of occurrence (Total x 100) / 12 1					



McCafferty, D.J., 'The dietary response of otters (*Lutra lutra*) to introduced ruffe (*Gymnocephalus cernuus*) in Loch Lomond, Scotland' in *Journal of Zoology*, 2005, Vol. 266, 255-260. (Extracts)

ABSTRACT

In this study the diet of otters *Lutra lutra* was examined following the establishment of a population of non-native ruffe *Gymnocephalus cernuus* in Loch Lomond, Scotland. Otter spraints (*n*=453) were collected at monthly intervals from four sites during 2002. Overall, 98% of spraints contained at least one species of fish, invertebrates were found in 49%, 17% contained amphibians, while mammals and birds were found in 9%. The most frequent prey from all sites were ruffe, which were found in 69% of spraints. Eel *Anguilla anguilla*, cyprinids (roach *Rutilus rutilus*, dace *Leuciscus leuciscus* and minnow *Phoxinus phoxinus*) and *Salmo* spp. were also relatively common and were recovered in 60%, 35% and 33% of spraints, respectively. Northern pike *Esox lucius* (14%), perch *Perca fluviatilis* (12%), stickleback *Gasterosteus aculeatus* (9%), powan *Coregonus lavaretus* (14%) and lampreys *Lampetra* spp. (2%) were less common. The fact that ruffe were the most frequent prey in otter spraints in all regions and in all seasons of the year indicated that they are one of the most important prey for otters in Loch Lomond at the present time.

Key words: otter, *Lutra lutra*, diet, ruffe, *Gymnocephalus cernuus*, Loch Lomond

INTRODUCTION

The Eurasian otter *Lutra lutra* feeds predominantly on fish, together with crayfish and amphibia in some areas, and generally include in their diet a higher proportion of more abundant species rather than scarce species (for a review, see Chanin, 2003). The ability of otters to change their diet in response to prey availability is highly relevant given the introduction of non-native prey species into natural ecosystems. An example of a shift in diet to include new prey was the response of otters to the introduction of the invasive American crayfish *Procambarus clarkii* in Portugal and Spain (Delibes & Adri´an, 1987; Beja, 1996). Otters also take advantage of increased availability of prey in restocked rivers and fish farms (Kloskowski, 2000; Ludvig *et al*., 2002), although the extent to which they shift their diet to include other non-native prey species is not well known.

Loch Lomond has received considerable scientific interest in recent years as a result of the establishment of the non-native ruffe *Gymnocephalus cernuus*. This fish was introduced by anglers as live bait for northern pike *Esox lucius* and was first recorded in 1982 (Maitland & East, 1989). Captures of ruffe have increased on average by a factor of 10 between 1989 and 1996 (Adams & Maitland, 1998). The ruffe is found in lakes, slow moving rivers and canals throughout north Europe and across central and north Asia, also occurring in low salinity areas of the Baltic sea. This species is the smallest member of the perch (Percidae) family in Britain and has been indigenous to south-east England since the last ice age. It has only spread into north England, Wales and Scotland within the past two decades (Maitland & Campbell, 1992).

The introduction of ruffe has had wide-ranging effects on food web dynamics of the loch (Adams & Maitland, 1998). It is of particular concern as this species is known to be a major predator of powan *Coregonus lavaretus* ova, and Loch Lomond holds the larger of only two natural populations of powan in Scotland (Adams & Tippett, 1991; Lyle & Maitland, 1994).

Previously, the ruffe has not been considered to be an important prey of otters (Mason & Macdonald, 1986). Where both ruffe and perch *Perca fluviatilis* occur together, otters prey mainly on the latter (Webb, 1975; Ozolinš & Rantinš, 1992; Birzaks, Ozolinš & Ornicāns, 1998). As otters are widespread in the Loch Lomond area and are known to feed on ruffe (Green & Green, 1997; McCafferty, in press *a*,*b*), the aim of this study was to examine the extent to which otters have adapted their diet to include ruffe. A particular objective was to determine the temporal and spatial patterns of predation and the size classes of ruffe taken.

MATERIALS AND METHODS

The diet of otters was determined by identifying indigestible remains of prey in spraints. Spraints were collected at monthly intervals from January to December 2002 from 4 sites along the eastern shore of the loch… These sites were chosen as they were relatively undisturbed and were easily accessible throughout the year. Ten fresh spraints were collected each month by searching *c.* 1 km of shoreline and stored in a freezer at -20^{o}C for subsequent analysis. The same length of shoreline was checked each month and any remaining spraints were removed to prevent collection in future months.

Frozen samples were transferred to glass jars and covered with a saturated solution of biological detergent (Biotex ®, Blumøller Ltd). Samples were gently shaken and then left in an oven at 40^{o}C for 3-4 hours to separate. The sample was then washed with water through a plastic hand sieve with 1-mm square mesh, through a 250μm metal sieve and finally onto filter paper (No. 1, Whatman International Ltd). The prey remains were left to dry at room temperature overnight and then stored in marked universal plastic tubes.

Remains were identified using a binocular microscope (x10-20), compared with a reference collection of fish bones and using an identification key (CONROY *ET AL.,* 1993)…

RESULTS

Diet Composition

A total of 453 spraints were collected from the four study sites between January and December 2002… Fish identified included the ruffe, eel *Anguilla anguilla*, roach *Rutilus rutilus*, dace *Leuciscus leuciscus*, minnow *Phoxinus phoxinus*, trout *Salmo trutta* and salmon *Salmo salar* which were not distinguished, pike, perch, three-spined stickleback *Gastoerosteus aculeatus*, powan and lampreys *Lampetra* spp. Two spraints contained fish vertebrae that could not be identified. Amphibians included the common frog *Rana temporaria* and common toad *Bufo bufo*. Invertebrates identified were insects, molluscs, crustacea (Cladocera, Isopoda and Amphipoda), arachnids, diplopods and oligochaetes. Bird bones, feathers and mammal bones and hairs were recovered from a number of samples but were not identified to species level.

Overall, 98% of spraints contained at least one species of fish, 49% contained invertebrates, 17% contained amphibians, while mammals and birds were found in 9%. The most frequent prey item from all sites was ruffe, found in 69% of spraints... Eels, cyprinids and *Salmo* spp. were also relatively common and were recovered in 60%, 35% and 33% of spraints, respectively. Pike (14%), perch (12%), stickleback (9%), powan (14%) and lampreys *Lampetra* spp. (2%) were less common...

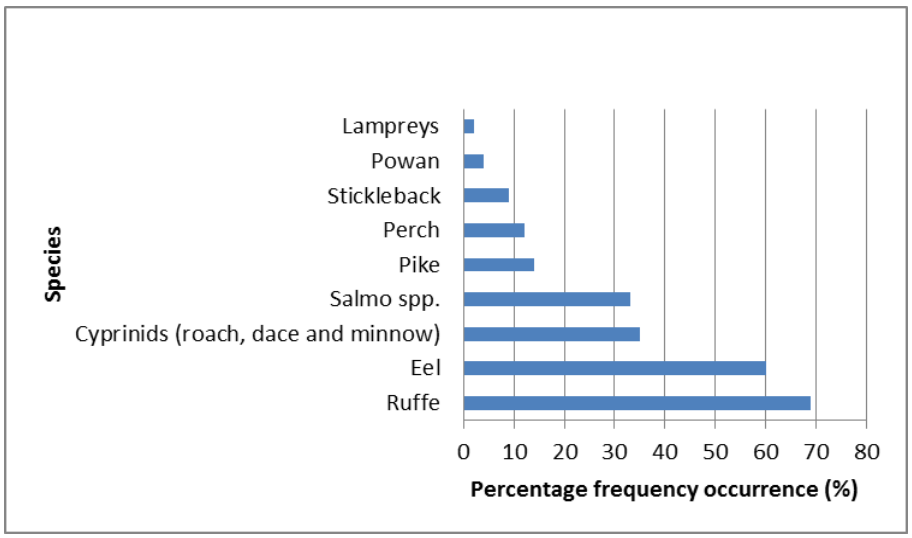


Fig 1. Percentage frequency occurrence of fish in otter spraints

DISCUSSION

Seasonal variation in diet

The diet of otters in Loch Lomond was found to be similar to other freshwater areas of Britain, with fish dominating the diet and amphibians being particularly common during late winter and spring (Mason & Macdonald, 1986; Weber, 1990; Chanin, 2003).

There was no significant seasonal difference in the frequency of ruffe in the diet, although the greatest frequency occurred in spring (75%) compared with other times of the year (66–68%). This corresponded to the spring migration and spawning period of ruffe in shallow regions of the loch. The highest frequency occurred in May (92%) when catches of ruffe are also greatest in Loch Lomond (Adams & Maitland, 1998). There was, however, a clear seasonal variation in several other fish eaten by otters in Loch Lomond as has been found elsewhere (Mason & Macdonald, 1986). An increase in frequency was associated with the migration and spawning habits of several species, most notably *Salmo* spp., pike, eels, stickleback and lampreys (Maitland & Campbell, 1992; Lyle & Maitland, 1994).

Dietary response of otters to ruffe introduction

Ruffe are medium-sized prey for otters, averaging around 90 mm in length. The size range of ruffe (25–154 mm) taken by otters was similar to the size range (35–125 mm) and size distribution of trapped ruffe in Loch Lomond (Adams & Maitland, 1998). This suggests that otters caught ruffe in proportion to their availability and did not specialize on small size or any age class.

The diet of otters in Loch Lomond is not well recorded before 1982 when ruffe first appeared. In 1980, otters within the Endrick marshes (close to the Endrick shoreline in this study) fed mainly on salmonids (50–80% by occurrence) and eels (20–70%), with cyprinids, perch, pike, amphibians, birds and mammals being present in 20% or less of spraints. At the same time mink *Mustela vison* fed predominantly on birds (50–80%) and mammals (18–38%) while fish (salmonids, eel, pike and cyprinids) were rarely taken and were recorded in *c*. 15% of scats (Cameron, 1981). It is probable that mink will now include ruffe in their diet but less frequently than otters, given their preference for birds and mammals around Loch Lomond (Bignal, 1978; Cameron, 1981).

The current dominance of ruffe in the diet of otters is in broad agreement with changes that have taken place in the diet of several fish-eating predators in the loch. Grey herons *Ardea cinerea* showed a shift from roach (63% of prey occurrence) to ruffe (61%) in their diet and pike altered their diet from powan (57%) to ruffe (44%) in response to ruffe introduction. The diet of the great cormorant *Phalacrocorax carbo* now consists mostly of ruffe (85% of their prey by number) (Adams, 1991, 1994). The prevalence of ruffe in the diet of fish-eating predators indicates how this species has been fully incorporated into food webs in Loch Lomond. Although there is a diverse range of alternative prey to support these predators, any change in the abundance of ruffe may have short-term effects on food availability…

7.3 Bumblebee conservation paper

Goulson, G., (2009) Conservation of bumblebees, *The Glasgow Naturalist* Vol. 25, Supplement. Machair Conservation: Successes and Challenges, 31-34.

ABSTRACT
Declines in bumblebee species in the last 60 years are well documented in Europe, where they are primarily driven by habitat loss and declines in floral abundance and diversity, in turn driven by changing agricultural practices. Amongst the most significant of these for bumblebees has been the loss of species-rich unimproved grasslands (haymeadows, chalk downland, machair etc.). Evidence suggests that the species which have declined most are specialists in collecting pollen from Fabaceae, especially red clovers, and loss of unimproved grasslands and abandonment of red clover leys have greatly reduced the abundance of red clover across western Europe. High densities of commercial honeybee hives may also impact upon bumblebees in some areas. Effects of habitat degradation and fragmentation on bumblebees are likely to be compounded by the social nature of bumblebees and their largely monogamous breeding system (queens mate only once) which renders their effective population size low. Recent studies suggest that surviving populations of some rare species consist of <30 breeding females, and such populations are susceptible to chance extinction events and inbreeding. Conservation measures must be implemented at the landscape-scale if they are to be effective, for small patches of habitat on nature reserves do not support viable bumblebee populations in the long term. Given the importance of bumblebees as pollinators of crops and wildflowers, it is vital that adequate steps be taken to prevent further declines. Suggested measures include careful management of surviving species-rich grasslands such as machair.

Many bumblebee species have declined in recent decades, particularly in developed regions such as Western Europe and North America (Goulson 2003a, Thorp & Shepherd 2005, Kosior et al. 2007, Goulson et al. 2008a). In the UK, three of the 25 native species have gone extinct and a further eight species having undergone major range declines (Goulson 2003a). The most severely affected species tend to be those with long tongues associated with deep perennial flowers (Goulson et al. 2005). Similar patterns are evident in Europe. In a review of declines in bumblebees of 11 central and western European countries, Kosior et al. (2007) describe extinctions of 13 species in at least one country between 1950 and 2000. Four species (*B. armeniacus*, *B. cullumanus, B.serrisquama, B. sidemii*) went extinct throughout the entire region. Most researchers agree that the main cause of bumblebee declines in Western Europe and North America is the intensification of farming practices, particularly during the latter half of the 20th century (Goulson 2003a,c). Permanent unimproved grassland was once highly valued for grazing and hay production but the development of cheap artificial fertilizers and new fast-growing grass varieties has meant that farmers could improve productivity by ploughing up ancient grasslands. Thus hay meadows gave way to monocultures of grasses which are grazed or cut for silage. Between 1932 and 1984 over 90% of unimproved lowland grassland was lost in the UK (Howard et al. 2003).

There is evidence to suggest that bumblebee forage plants have suffered disproportionate declines. A recent study in the UK found that of 97 preferred bumblebee forage species, 71% have suffered range restrictions, and 76% have declined in abundance over the past eighty years, exceeding declines of non-forage species (Carvell et al. 2006). Leguminous crops (notably clovers, *Trifolium* spp.) used to be an important part of crop rotations in much of

Europe, and these are highly preferred food sources, particularly for long-tongued bumblebee species (Goulson et al. 2005). Since the introduction of cheap artificial fertilizers, rotations involving legumes have been almost entirely abandoned, and it has been argued that this is one of the primary factors driving the decline of many bumblebees (Goulson & Darvill 2004, Rasmont & Mersch 1988).

In addition to floral resources, bumblebees need suitable nesting sites, the precise requirements for which vary between species (Kells & Goulson 2003). The carder bees (*Thoracobombus*) such as *B. muscorum* tend to nest in dense grassy tussocks while other species such as *B. distinguendus* nest underground in cavities. Both groups often use abandoned rodent nests. The loss of hedgerows and of unimproved pastures is likely to have reduced availability of nest sites for both above and belowground nesting bumblebee species (Banaszak 1992). Those species that nest above ground frequently have their nests destroyed by farm machinery, particularly 31 by cutting for hay or silage. The scarcity of weeds and field-margin flowers on modern intensive farms means that there are less seeds, and therefore less food for voles and mice. Lower populations of these mammals will lead to fewer nest sites for both above and below ground nesting bumblebee species.

One further potential threat to bumblebees is that they have to contend with commercial honeybees (*Apis mellifera*). Their potential impacts are reviewed by Goulson (2003b). Although honeybees are thought to be native to the UK (although probably not to the Western Isles), commercial beekeeping maintains much higher honeybee densities than could occurnaturally. Recent studies suggest that honeybees have negative effects on native bumblebees. Walther-Hellwig *et al.* (2006) found that short-tongued bumblebees avoided areas of forage close to honeybee hives, while carder bumblebees switched to foraging later in the day and were displaced from their preferred foodplant. Thomson (2004) experimentally introduced honeybees and found that proximity to hives significantly reduced the foraging rates and reproductive success of *B. occidentalis* colonies. Thomson (2006) found a strong overlap between the foraging preferences of the two species, which peaked at the end of the season when floral resources were scarce, corresponding with a negative relationship between honeybee and bumblebee abundance. In Scotland, Goulson and Sparrow (in press) found that workers of four common bumblebee species were all significantly smaller in areas where honeybees were present.

There is also evidence that honeybees can act as vectors for the bumblebee specific disease *Crithidia bombi* via flowers (Ruiz-Gonzalez & Brown 2006). Deformed wing virus, a viral honeybee pathogen, has been found in wild bumblebee nests (Genersch et al.2006), and appears to have higher virulence to bumblebees than to honeybees.

As a consequence of the various factors discussed above, populations of a number of bumblebee species have become increasingly small, fragmented and separated from one another by large distances. In the UK, where distributions are best known, declines appear to have followed a characteristic pattern. The last bumblebee species to disappear from the UK (*B.subterraneus*, the sister species of *B. distinguendus*),was once widespread across southern England, but declined rapidly in the years after World War II. By the 1980's the few remaining populations were small and isolated, surviving on habitat islands (nature reserves) that had escaped agricultural intensification. However, these populations subsequently disappeared despite the apparent suitability and protected status of the remaining habitat (Goulson 2003a). The species was last recorded at Dungeness National

Nature Reserve in 1988. Several other UK species such as *B.distinguendus* and *B. sylvarum* are in the late stages ofa similar process, and are likely to go extinct in the near future. Why do isolated populations go extinct? Understanding the consequences of the fragmentation of remnant populations of bumblebees is of great importance to conservationists, given the current distributions of many rare species.

Small populations of all taxa are inherently more vulnerable to local extinctions due to environmental and demographic stochasticity (Frankham et al. 2002). If these populations form part of a broader meta-population then regional extinctions can be balanced by subsequent recolonisation, but if fragmentation is severe then extinct patches may never be repopulated. In addition, a functioning metapopulation ensures that dispersal maintains genetic cohesion. However, if habitat fragmentation results in the isolation of populations, then they may face an additional extinction threat through inbreeding (Frankham et al. 2002). There are a number of reasons why bumblebees may be particularly badly affected by habitat fragmentation. It is the effective population size (*N*e) which determines the rate of genetic drift in a population. In bumblebees, as in many other social insects, *N*e depends on the number of successful colonies, not the number of bees in the population. Each bumblebee colony contains just one breeding female, and in most bumblebees she will have mated with a single male (Estoup et al. 1995, Schmid-Hempel & Schmid-Hempel 2000). Therefore, it seems that population sizes of bumblebees may be low, making them particularly susceptible to the loss of genetic diversity.

Given the potentially serious consequences of inbreeding in bumblebees, it is essential that we understand its prevalence within wild bumblebee populations. Until recently, studying the population genetics of rare bee species was extremely difficult, as lethal sampling was necessary. Work in this area was greatly aided by the development of a non-lethal DNA sampling technique (Holehouse et al. 2003), and this has recently been applied to studies of fragmented populations of rare species: *B. muscorum* (Darvill et al.2006), *B. sylvarum* (Ellis et al. 2006) and *B. distinguendus* (Bourke & Hammond 2002). All three studies found significant population structuring. For example in *B. muscorum,* all populations >10 km apart were significantly differentiated, as were some populations just 3km apart, suggesting that this species has very limited dispersal abilities. Ellis *et al.* (2006) used microsatellite markers to group workers into sisterhoods and so estimated the number of colonies (and hence *N*e) in populations of *B. sylvarum*, a species which is highly endangered in the UK.

Estimates of *N*e were very low (range 21-72) suggesting that these populations are very vulnerable to loss of genetic diversity through drift. In all rare species studied to date, genetic diversity (allelic richness and heterozygosity) is low compared to common species (Darvill 2007). If fragmented populations of rare bumblebee species are suffering from reduced fitness through inbreeding then we must take steps to conserve what genetic diversity remains. Management strategies in vertebrates routinely consider genetic factors, and 32 we may need to adopt similar measures in the management of rare bumblebee populations.

An interesting aspect of bumblebee declines is that a small number of species have remained relatively abundant. What is the difference between the species that have declined (and in some cases gone extinct) and those that have not? It seems that the rare and declining species tend to be long tongued and have narrower diets, with a very large

proportion of the pollen they collect being from Fabaceae (many of which have deep flowers) (Goulson and Darvill 2004; Goulson et al. 2005, 2006, 2008b).

This is supported by a substantial data set of bumblebee foraging records gathered from throughout the UK, and separated according to whether they were collecting pollen, nectar, or both. Some species tend to get 90-100% of their pollen from Fabaceae (for example *B. hortorum, B. ruderatus, B. subterraneus* and *B. humilis*), and these tend to be long-tongued and, with the exception of *B. hortorum*, they are all declining species. It should be noted that *B. distinguendus* almost certainly falls within this group. Parallel studies of more diverse bumblebee communities in Poland confirm similar patterns (Goulson et al. 2008b). Studies of the nutritional quality of pollen reveal that Fabaceae pollen is unusually high in protein and essential amino acids (Hanley et al. 2008). Fabaceae tend to dominate species-rich grasslands such as machair, because their ability to fix nitrogen gives them a competitive edge in nutrient-poor soils. Hence the massive loss of species rich grasslands throughout the UK has had adisproportionate effect on those bumblebee species that favour Fabaceae as their pollen source.

CONCLUSIONS

It is clear from studies of population structure that most bumblebee species cannot be conserved by managing small protected 'islands' of habitat within a 'sea' of unsuitable, intensively farmed land. Large areas of suitable habitat are needed to support viable populations in the long term. Unimproved flower-rich grassland is one of the most important habitats for bumblebees, but has been largely lost to agriculture in Western Europe and North America.

Many of the bumblebee species that have declined most are specialized on collecting pollen from Fabaceae, especially *Trifolium pratense*, and Fabaceae tend to dominate species-rich grasslands. This explains why machair supports substantial populations of rare bumblebees; large areas survive (although much has been lost), and it can be exceptionally rich in Fabaceae. Restoration of areas of this habitat will boost bumblebee populations. Substantial benefits for bumblebee conservation could also be obtained by reintroducing clover (e.g. *Trifolium pratense*) ley crops into rotations, reducing dependency on artificial fertilizers.

7.4 Letter from Rhona Weir on the proposed Lomond turbines. The letter can be found on the Gartocharn Community website here:
http://www.gartocharn.org/index.php/proposed-windfarm/comments

We have lost our shipyards and are no longer an industrial country. Our oil and fish production is limited, but we have an asset that has weathered the permanence of the ages – our unique diverse and very precious landscape, appreciated not only by ourselves but renowned throughout the globe. One way or another this scenery through tourism accounts for much of the revenue on which our country depends, and to deface it with the industrialisation of a proliferation of under productive wind farms when alternative and more reliable methods of electricity are available is an act of thoughtless folly.

Apart from their disastrous impact on the environment the impact of the enormous costs involved will hit every householder in the land. For none other can be indemnified for the prohibitive costs of manufacture, transportation, site preparation and installation to say nothing of the hefty renumeration to land owners and others including the percentage output "lure" offered to local communities.

I gather from the press that scientists are on the verge of creating some form of harmless nuclear power. If this materializes how would wind farms be affected? I wonder if this has been considered.

There are other detrimental issues to be considered; the noise factor for example, the impact of access roads on the environment and the indestructibility of the concrete bases that will outlive the allotted span of the turbines.

Judas Iscariot forfeited his soul for 30 pieces of silver. Our heritage is in danger of being forfeited for innumerable pieces of metal.

I rest my case.

Rhona M Weir