IAPETUS
doctoral training partnership

NERC SCIENCE OF THE ENVIRONMENT

Plant-pollinator networks: inferring the presence of interactions, and the influence of spatial scale (Ref IAP-16-73)

Centre for Ecology & Hydrology, Wallingford
In partnership with Newcastle University and University of St Andrews

Supervisory Team	• **Dr Michael Pocock, Centre for Ecology & Hydrology** • **Dr Darren Evans, Newcastle University** • **Dr V Anne Smith, University of St Andrews**

Key Words	1. **Pollination** 2. **Ecological networks** 3. **Spatial ecology** 4. **Modelling** 5. **Ecosystem services**

Overview

Ecological networks are a great approach for studying the resilience and robustness of ecosystems[1,2]. The networks are typically composed of interactions between species, which can be mutualistic (e.g. pollination) or antagonistic (e.g. feeding interactions). Understanding these networks is valuable because the emergent properties of the whole network (e.g. nestedness or modularity) influence ecosystem stability and resilience[3,4], while many ecosystem functions and services (e.g. pollination and pest control) are a direct result of interactions between species.

Therefore, network approaches are useful for studying environmental change. However, whilst information on species' presence is often available (collected with ecological sampling techniques, including by volunteers), information on interactions is severely lacking, mainly because sampling interactions can be a labour-intensive process[1]. One way to overcome this is to statistically infer interactions[5], enabling networks to be 'reconstructed' and ecosystem resilience to be assessed even where interactions have not been directly sampled. The methods to do this need further development for ecology and are untested against observed data on interactions.

The ultimate outcome of the project will allow researchers to predict interactions, and hence network structure, at places and times where interactions were not directly sampled. This will add value to biological recording data (such as that available via the Biological Records Centre at CEH) and so enable us to move from species-centric measures of natural capital to network-derived measures of ecosystem function[2].

One further challenge is that the spatial resolution, which is most relevant to decision-makers (landscapes up to national scales), is very different to the scale at which ecological networks are typically sampled (plots much less than 1 ha). Thus it is crucial to know how important spatial scale is when assessing network structure[6].

For this work we will study plant-pollinator interactions (though we recognise that this is shorthand for 'flower-visitors' where pollination is not proven to occur) because they are relatively well-recorded and easy to sample. Therefore we can use existing data on species to infer networks and test them against observed interactions in the field.

The objectives of this studentship are to:
(1) Develop methods for the inference of plant-pollinator interactions based on species data;

(Ia) initially based on variation in plant & pollinator abundance, and tested with existing field data;

(1b) further developed for co-occurrence data (e.g. Biological Records Centre datasets) and tested against observed interactions (from volunteer recording societies);

(2) Undertake field sampling to assess spatial scaling in networks and how this affects species traits (i.e. their role as 'connectors' or 'hubs' in networks).

Methodology

The project will apply a statistic approach called Bayesian Network Inference to infer species interactions. This approach has been used by one of the supervisors for ecological data (Dr Smith: e.g.[7]). These methods will be used to infer interactions, firstly from abundance data and secondly from occurrence data of plants and pollinators, and so 'reconstruct' plant-pollinator networks. The inferred networks will be ground-truthed with existing data on interactions.

The project will use two extant datasets for this work. Using extant data reduces the risk of relying upon data collected in the field and adds value to these existing datasets. (a) For the abundance-based inference we will use plant-pollinator network data already collected by one of the supervisors (Dr Pocock). (b) For the co-occurrence-based inference we will use distributions of plants and pollinators (e.g. bees and hoverflies) available via the Biological Records Centre. It is important to know how well the interactions can be predicted, and where interactions are not accurately predicted. Any lack of fit will tell us (i) about the limitations of this network inference (which could be partly due to a mismatch in spatial scale between the species and the interaction data) and, (ii) potentially, about the interaction-specific effects of environmental change.

As part of the project, there will also be field sampling of plant-pollinator networks across multiple scales (e.g. similar to [8] by sampling plots nested within plots at increasingly coarse resolutions: from 10x10m plots up to 10x10km squares) and so determine how species roles (e.g. as hubs or connectors between modules[9]) and whole network properties change according to the scale of sampling.

Timeline

Year 1. Develop and apply models to infer interactions using plant and pollinator abundance data, test with existing data (Objective 1a). During summer: field sampling of plant-pollinator networks in a nested design across scales from 10m to 10km (Objective 2).
Year 2. Extend models to plant and pollinator occurrence data, test with BRC data (Objective 1b). During summer: field sampling of plant-pollinator networks in a nested design across scales from 10m to 10km (Objective 2).
Year 3. Identification of insects from field sampling and spatial analysis of network structure and species attributes.
Year 3.5 Complete thesis and paper writing.

Training & Skills

This project provides a unique opportunity for the student to gain a highly-desirable mix of quantitative and practical ecological skills. Quantitative skills in network analysis are highly transferable across the multi-disciplinary field of complexity science, and are becoming increasingly important in ecology. The student will also gain skills in field sampling and identification of plants and pollinators.

The student will be hosted by CEH at Wallingford, Oxfordshire and will benefit from interactions within the Biological Records Centre. As well as practical experience working with volunteers (citizen science), staff at the Biological Records Centre have great expertise in data manipulation and analysis, analysis using R, visualisation and high performance computing – all of which will benefit the student.

Registered at Newcastle University, the student will benefit from being in the Network Ecology Group (led by Dr Evans) and the wider postgraduate community within the School of Biology, where they will gain skills in science writing, communication and analytical methods.

The student will benefit from hands-on training from the supervisory team in network analysis, field sampling of pollinators and inference methods. Full training in Bayesian Network Inference will be provided (with the student spending some time during Year 1 and 2 with Dr Smith in St Andrews).

They will participate in international, high profile ecology conferences and conferences/training in research on ecological networks.

References & Further Reading

1 Pocock et al. 2012 *Science* 335:973–7. **2** Thompson, et al. 2012 *Trends Ecol. Evol.* 27:689–97. **3** Sauve et al. 2016 *Ecology* 97:908–917. **4** Thébault & Fontaine 2010

Science 329:853–856. **5** Morales-Castilla et al. 2015 *Trends Ecol. Evol.* 30:347–356. **6** Kissling & Schleuning 2015 *Ecography* 38:346–357. Milns et al. 2010. *Ecology* 91:1892–1899. **8** Hartley et al. 2004 *Proc. R. Soc. London B* 271:81–88. **9** Olesen et al. 2007. *Proc. Natl. Acad. Sci.* 104:19891–19896.

Further Information

Students are encouraged to contact Dr Pocock in advance for consideration. Michael.pocock@ceh.ac.uk

This project is in competition with others for funding. Success will depend on the quality of applications received, relative to those for competing projects. See the IAPETUS website http://www.iapetus.ac.uk/aboutstudentships/ for full information.

To apply please email Dr Pocock at michael.pocock@ceh.ac.uk (cc Dr Evans - darren.evans@ncl.ac.uk and Dr Smith – vas1@st-andrews.ac.uk). Deadline is 20th January 2017. In your email include: 1) a two-page covering letter detailing your reasons for applying and why you have selected this project, 2) your CV with contact information for two references, 3) full transcripts of previous qualifications obtained to date.