Hedges and edges: landscape effects on forest biodiversity and ecosystem function

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Summary:

Forests represent the native climax vegetation of most of Britain and Europe, and are important both for the distinctive set of species they protect and the diverse range of important ecosystem services they provide. Forests are often highly fragmented, and recent conservation guidance argues that larger and better connected patches should be a goal; yet the effects of this patchiness on ecosystem function are poorly studied.

This project will explore the effects of forest patch size and isolation -- and in particular of connecting features such as hedgerows or "stepping-stones" -- on the biodiversity of forest specialist taxa in a set of well-studied forest patches of known ages (the WrEN project). It may also be possible to augment this set of sites with additional "experimental" woodlots planted as part of farm woodland grant schemes, and other past forest planting initiatives. Remote sensing data will be explored both to measure connectivity, and to test potential links between multispectral reflectance patterns and forest tree composition and structural properties. In addition, the effect of forest patch properties on a subset of ecosystem functions and services will be explored, using surveys of edge-to-centre transects to parameterise models of patch size and biodiversity effects on e.g. above and below-ground carbon storage, and hydrological modulation. This in turn may be used to explore and model the scaling properties of biodiversity:ecosystem function relationships. The supervisory team is multidisciplinary, spanning spatial ecology and geography, with Forest Research as an industrial CASE partner. The work will provide experience in a range of research techniques ranging from field biodiversity surveying, through remote sensing and GIS work to ecosystem service modelling, and thus will provide excellent preparation for a career in research or management.

Background

The so-called "Lawton review" (Lawton et al 2010) recommended that British conservation planners focus on building habitat networks that are "bigger, better and more joined-up." While there is a great deal of evidence that larger areas of natural habitats will harbour more biodiversity, and calls for "better" habitat are hard to argue against, there remains some disagreement as to the evidence for importance of habitat fragmentation *per se* in conservation (e.g. Fahrig 2017). If this is true for biodiversity conservation in general, even less is known about the role of habitat fragmentation in ecosystem service provision – increasingly one of the key goals of conservation (e.g. Ziv *et al*. 2018). This studentship is designed to address these issues, using British broadleaf forests as a focal system.

Forests have several advantages for studying fragmentation. They are the natural climax vegetation for most of Britain (and indeed Europe), and as such are key habitats for a fairly large number of plant and animal species. They also provide a range of distinctive ecosystem services, ranging from timber production, through carbon sequestration and hydrological flow modulation, to recreational, aesthetic and cultural values. Moreover, woodlands are relatively easy to locate both on historically published maps and in remote-sensing imagery (Fig. 1). While they were once distributed extensively across Britain, most woodlands today consist of discrete patches varying in size, age and isolation, making them ideal for studying the effects of habitat fragmentation on biodiversity and ecosystem service provision.

Fig. 1. Most woodlands in the UK have been reduced to isolated patches in an agricultural matrix, as in these examples near Leeds. Note that landscape features such as hedgerows and scattered trees may enhance functional connectivity between otherwise isolated patches. [Source: Google Earth]

The WrEN network and beyond

This project will work in collaboration with Forest Reearch's "WrEN" (**W**oodland C**r**eation and **E**cological **N**etworks) project: a set of isolated woodland plots of varying size, age and isolation which have previously been surveyed for a range of taxa including plants, birds, bats, and a range of invertebrate groups (Watts *et al.* 2016; Fuentes-Montemayor *et al.* 2017; Fig. 2). This project will focus on subsets of the network, chosen to be similar in some key variables, while contrasting sharply in others. A subset of sites near significantly older or "ancient" woodlands will be of particular interest here. Where necessary, additional sites may be added to the focal site set, e.g. to increase replication of key woodland categories. In addition, it might be possible to expand the project to consider "experimentally planted" woodlots planted as part of the Farm Woodland Grants scheme in the 1980s and 90s, or other recent woodland planting initiatives.

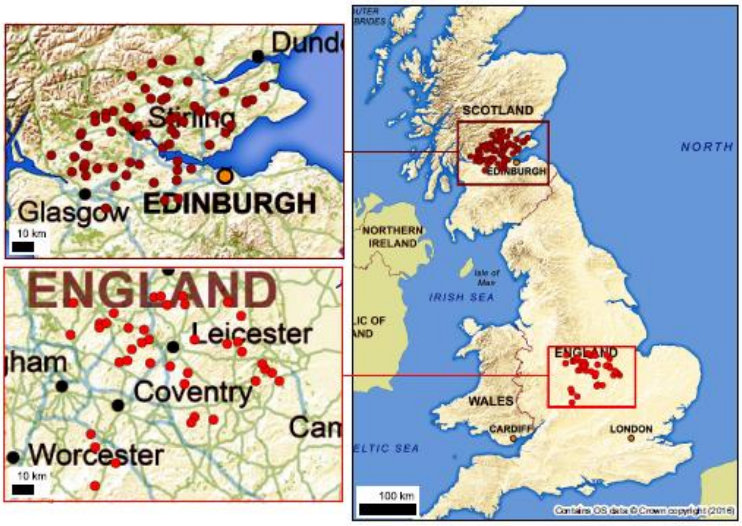

Fig. 2. Location of WrEN forest plots, in two clusters: in central Scotland and the English midlands. (Source: Watts et al. 2016)

Methodology

This PhD project consists of a set of inter-related topics, each of which has the potential to be developed into a thesis chapter. The precise set of tasks undertaken can shift to reflect the skills and interests of the student selected.

Mapping connecting features and assessing their importance

Making use of digital maps and satellite imagery, the presence of hedgerows and individual “stepping-stone” trees between WrEN woodlands and their nearest ancient woodland will be mapped. This will allow analyses to be performed testing whether local biodiversity within WrEN plots is affected by the proximity of older (putative source) forests, and whether connecting features help speed colonisation. This work could take advantage of existing woodland plot biodiversity surveys, but additional assays of biodiversity in the connecting features themselves might be considered.

Isle of Wight woodland connectivity

A second potential approach for looking at woodland connectivity effects on biodiversity would involve making use of a “natural experiment” in woodland planting carried out on the Isle of Wight late in the 20th century (the “JIGSAW” scheme; see Quine & Watts 2009). Growing interests in habitat connectivity resulted in a local initiative to focus Woodland Grant Scheme plantings in areas adjacent to and ideally interlinking other pre-existing woodland blocks. At the same time, an approximately equal area of other Woodland Grant Scheme plots were planted in other areas, not tied to existing woodlands. If habitat connectivity is important for speeding colonisation, these two sets might be expected to differ substantially in current biodiversity. New field surveys would be required to test this prediction.

Multispectral remote sensing and woodland composition

Increasing availability of multi-spectral remote-sensing imagery (e.g. from Sentinel 2) opens up new possibilities for mapping woodland properties and the ecosystem functions and services that depend on them (e.g. Cord *et al*. 2017). One potential extension of the project would be to develop and test approaches to map tree species composition and forest stand structure from aerial imagery, potentially employing seasonal reflectance shifts and comprehensive environmental datasets (e.g. elevation, solid geology) to provide improved resolving power.

Patch properties and ecosystem service provision.

As noted above, little is yet known about the effects of patch size and isolation on ecosystem service provision. Arguably, many services act approximately additively, such that if one woodland patch is twice the size of another, it can be expected to provide twice the level of service. However, this assumption is seldom tested, and it may be argued that some services are sub-additive or super-additive (such that a 2-fold larger woodland would provide less or more than twice the service). A promising approach for testing such issues is to look at the effects of proximity to a forest edge on service provision. If for example trees near forest edges face higher mortality rates, or (conversely) higher Net Primary Productivity than trees near the centre of woodland patches, the result would impact small patches (with higher edge:area ratios) more than larger ones, resulting in departures from strictly "additive" scaling. Detailed edge to centre assessment of one or more ecosystem functions would allow such ideas to be tested. The results of such field analyses could be used to parameterise simple computer models to simulate the effects of patch size and configuration on service provision (c.f. Gunton *et al.* 2017).

Scaling biodiversity:function relationships.

There is substantial evidence that increased biodiversity (e.g. species richness and/or functional diversity) can improve ecosystem functioning (and resulting services). However, there are reasons to think the relationship may be scale-specific. Biodiversity generally increases less than additively (that is: two plots each containing 10 spp are unlikely to contain 20 species together), whereas many services may be approximately additive (two plots each sequestering 10 kg of carbon probably <u>do</u> sequester 20 kg together). If biodiversity and ecosystem function have different scaling properties, it would likely result in the relationship between the two fading away if examined at inappropriate scales. Examining and/or modelling such scaling issues would provide a natural extension of the previous topic area.

Training

The proposed studentship would involve a wide range of research methodologies, ranging from field biodiversity surveying, through empirical service measurements, to GIS and remote-sensing work, spatial statistics and computer modelling. As such it will provide an unusually broad skill set for future research, either in academic or management contexts. Training will be provided to help the chosen student develop the needed skills and experience. The strong links to both university departments

(Biology and Geography) and Forest Research will also provide exposure to a range of research environments for futue career progression.

Research context and partners

The two supervisors, Prof. Kunin and Dr. Ziv, both have active research groups, providing stimulating research environments. Prof. Kunin is in the School of Biology and specialises in spatial ecology, especially of plant and insect communities, whereas Dr Ziv is based in the School of Geography, specialising in ecosystem service assessment. This project thus bridges their research areas, providing excellent interdisciplinary linkage. The project will receive CASE support from Forest Research, with active participation by Dr. Kevin Watts in project design and supervision. This will not only supplement the project's research budget, but also provide access to essential data resources and forest science expertise.

Relevant references:

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