Studying past landscape change to inform future conservation

The WrEN project, led by the University of Stirling, Forest Research and Natural England, is taking advantage of the opportunities offered by Britain's landscapes to study the ecological networks concept. The results will improve our understanding of how different species respond to different characteristics of habitat patches and the wider landscape, and so inform the design of future conservation landscapes.

NICHOLAS MACGRGOR, KEVIN WATTS, KIRSTY PARK, ELISA FUENTS-MONTEMAYOR, SIMON DUFFIELD

Designing conservation landscapes, wild or otherwise

Since the publication of *Making Space for Nature*[1] and the various policy documents and conservation initiatives that followed it, the idea of ecological networks – networks of sites that will collectively support resilient populations of species and allow movement across the landscape – has been a prominent theme in English conservation as it is in other countries.[2,3,4] As well as giving a very clear message that England's existing wildlife sites "do not constitute a resilient and coherent network", the report provided some general principles for thinking about ecological networks, including the often-quoted 'bigger, better, more, joined' principles. It also proposed a conceptual outline of the types of areas a typical network could contain, including core areas, corridors, stepping stones, and restoration areas.

This ecological networks concept is very relevant to many of the different strands of (re)wilding thinking; parallels can be drawn with the first two components of the 'core areas, corridors and carnivores' school of wilderness conservation from North America.[5] While the spatial scales and landscape history and context are very different, the general principle is equally valid here. The remaining semi-natural areas in Britain are highly fragmented, experiencing continued overall declines in wildlife value (despite some notable individual conservation successes)[6] and faced with a range of current and potential pressures[7,8,9] that are likely to bring further changes to ecosystems and the species they support. Against that backdrop, creating bigger and more coherent conservation areas that enable species movement and other natural processes should probably be seen as an essential basic level of 'wildness' that needs to be re-introduced to Britain's heavily modified and damaged landscapes, even if some level of human management (at least to reverse past damage) may be required in many places.

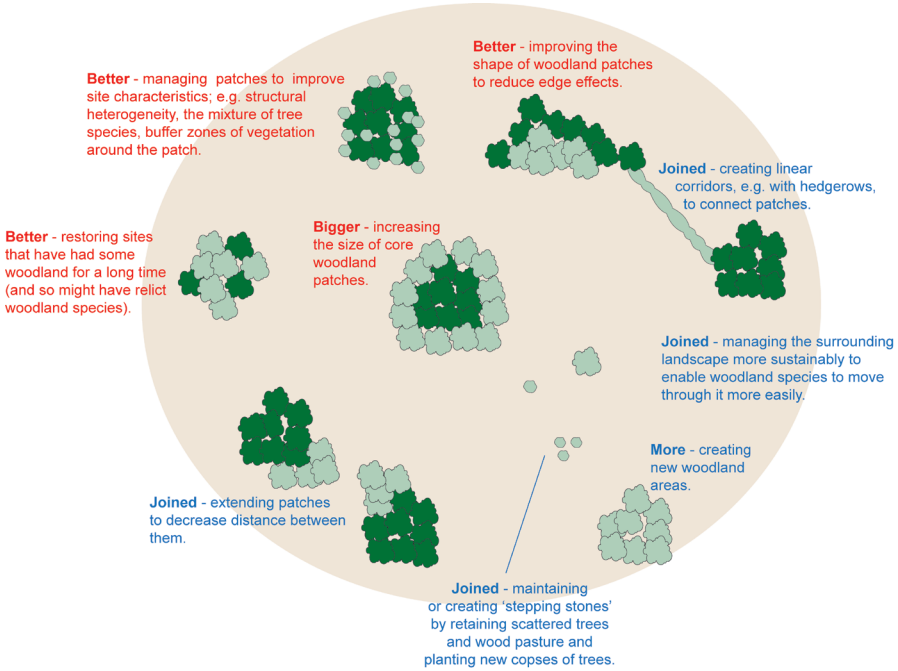
More broadly, the issue of how best to design conservation landscapes is relevant whether one's preferred conservation model involves (at one end of the spectrum)

identifying and acquiring areas of land of a suitable size and scope and leaving nature completely to its own devices, or (at the other end of the spectrum) simply facilitating species dispersal among existing managed protected areas.

Ecological networks in practice

Making Space for Nature has prompted a move away from a view based on individual sites to thinking about networks of sites and the wider landscape around them. But applying these concepts on the ground is not always straightforward. Thinking about whole landscapes means there is quite a complex range of features and management options at both the site level and the landscape level for a conservation manager to consider. An obvious starting point is to make sure that existing sites are in good condition; that is that they have the appropriate characteristics to actually provide habitat for the species we want to conserve.[10] Beyond that, however, there is often a wide range of things that could be done. Individual sites can be made bigger, or made a more compact shape to reduce 'edge effects'. At the scale of the wider landscape, gaps between individual sites can be reduced by extending them towards each other or by putting 'stepping stone'

Fig 1. **Some of the many different management options (related to Lawton et al.'s 'better', 'bigger', 'more' and 'joined' principles) that a conservation manager is faced with when considering ecological networks. Dark shapes indicate existing vegetation; lighter shapes indicate new planting or management. Actions can be taken at site level ('better' and 'bigger') and at the level of the surrounding landscape ('more' and 'joined'). The diagram refers specifically to woodland, but a similar set of issues applies to conservation and restoration of all other natural systems.**



sites between them or by physically linking them; efforts can be made to make the 'matrix' of land cover surrounding patches of conservation land easier for species to move across; and new sites can be created to increase the total amount of habitat in the landscape (Fig 1).

Conservation managers usually have a fairly clear idea about how those actions could be implemented – there is now a lot of good experience in restoration ecology to draw on in the UK and elsewhere. Given limited resources, which of the range of different landscape elements/management actions would be most cost-effective for different species in different cases? All of them could be important, but there is still uncertainty and debate about their relative importance.[11,12,13] One reason for this complexity and uncertainty is that different species vary in what sort of and how much habitat they require, in their dispersal abilities, and in their ability to cross gaps between habitat patches. There are also differences among species in how they perceive and respond to patches, edges, pathways and barriers in a landscape which may be quite different from human perceptions.[14,15,16] Thus, different species do not always respond in the same way to different features at site and landscape level. Another problem is that many studies have looked at only a few species (there are very few multi-taxa studies), have examined only a sub-set of site and landscape variables, and conducted research over small spatial and temporal scales.[17] As a result, there is still quite a lot we don't know when it comes to designing networks in practice. In some cases this is hampering action on the ground. Improving our understanding would enable us to target conservation management in a more cost-effective way.[18]

Of course, there are a lot of large-scale conservation projects under way.[19] Over time, if both funding and detailed ecological monitoring are maintained, they have the potential to give us useful information about the best way to design ecological networks. For example, work by Butterfly Conservation is improving our understanding of how to manage butterfly metapopulations,[20] and monitoring at Wicken Fen Vision will produce information about how species colonise new areas.[21] But overall it could be many years before broad conclusions can be drawn from many of these projects about the ways that different species respond to different components of landscapes, simply because it often takes a long time for new conservation areas, ecosystems and species populations to develop.

Looking back in time

While we are waiting for further data to be collected from Nature Improvement Areas, Living Landscapes, Futurescapes and other large-scale conservation initiatives, existing British landscapes offer a rare opportunity to learn conservation lessons from the effects of past landscape changes. This is particularly the case for woodlands.[22] Around the turn of the 20th century, forest cover in England, Scotland and Wales had dropped to around 5%.[23] Since then, through extensive creation of new woodland areas, this has risen to around 10-15% (still one of the lowest levels in Europe, but a great improvement).[24]

From a scientific point of view, this means that from a blank canvas of very low woodland cover, creation of new woodlands over the last 150 years or so has

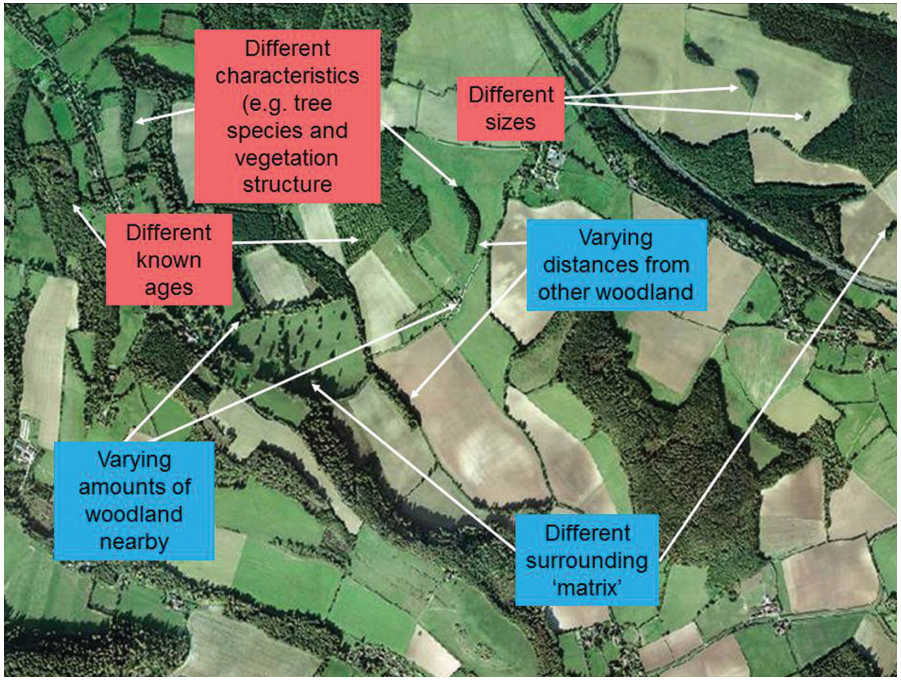


Fig 2. **The varied landscapes resulting from woodland creation over the last 150 years provide an excellent opportunity to test the effect on biodiversity of different ecological network components at both the level of individual sites (pale labels) and of wider landscapes (dark labels)**

produced, almost inadvertently, varied landscapes of woodland patches – patches of different sizes, with different internal characteristics, with varying levels of total woodland cover around them, of varying distances from other patches, and with different surrounding vegetation (Fig 2).

In addition, because the UK has very good historical land cover maps, recently available in digital format, we can often estimate to within a few decades when a patch of woodland appeared. This enables us to distinguish 'new' woodlands from fragments of older forest and, for those new woodlands, study the effects of their age, alongside their shape, size, and surrounding landscape, on the species that are found there.

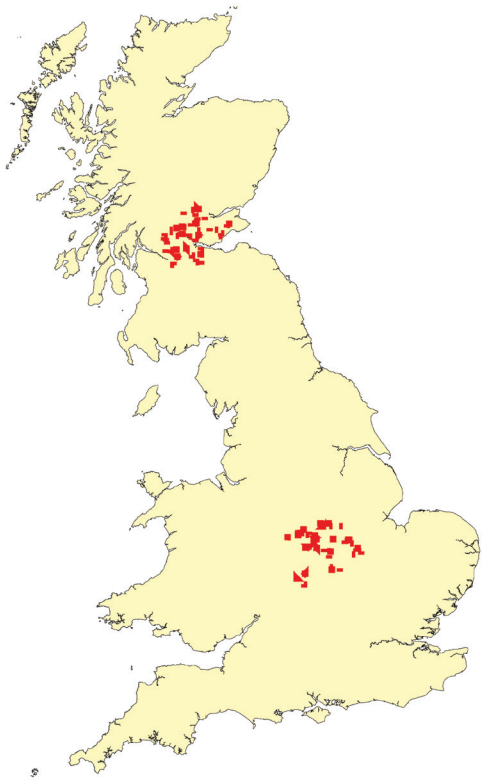
Together, these woodland areas and maps of their history, provide us with test landscapes that we can use to explore the ecological networks concept over the spatial and temporal scales necessary to obtain meaningful results. Because the focus is on 'created' or 'restored' landscapes, it is highly relevant to the activities of NIAs and other large-scale conservation initiatives. It also offers a research approach that is complementary to studies overseas that are looking at the effects of fragmentation of old forest or other land cover types.[25], [26] In other words, we are studying the effects of putting things back in the landscape (restoration) rather than taking them away (fragmentation).

The WrEN project

This is the basis of a major current research initiative called the WrEN (Woodland Creation and Ecological Networks) project. This is a collaborative research project between the University of Stirling, Forest Research and Natural England, working in partnership with Scottish Natural Heritage, the National Forest Company, the Woodland Trust, the University of Derby, and Defra. The aim is to study landscapes created through past woodland creation to evaluate the relative importance of a wide range of site and landscape components of ecological networks for a wide range of woodland species.

Across two study areas – one around Stirling in Scotland, the other around Leicester in England – we have identified a large number of woodland patches of different sizes, ages, levels of isolation and with differing amounts of woodland cover around them. The focus is on secondary woodlands to try to control for potentially confounding effects of not knowing the age and history of older sites. Sites have been chosen in fairly homogeneous lowland agricultural landscapes to control for other things such as climate, soil and topography. These are also the landscapes in which much of the future landscape-level conservation action might be expected to take place.

Fig 3. **The location of WrEN study sites in Scotland and England.**



At these sites we're surveying a wide range of species, which have been selected on the basis of trying to pick a range of woodland-dependent taxa that are thought likely to be affected by spatial structure, with different life-histories and behaviours, about which we have sufficient ecological knowledge and that are relatively easy to survey and identify. The project currently includes surveys of trees, vascular plants, lichens, bryophytes, ground invertebrates (especially spiders and beetles), bats, terrestrial small mammals and birds. At the time of writing, more than 100 sites have been surveyed for at least some of these taxonomic groups (Fig 3).

WrEN's gameplan

Surveys of plants will continue in 2015, and research on birds to 2017. There is still much work to do, both to continue field surveys and to bring together and analyse a large amount of data on many different taxonomic

and functional groups of woodland species and many different sites and landscape variables. It is likely that results for different taxonomic groups will be available at different stages during the project. We aim to share interim findings with conservation practitioners along the way through talks, publications and workshops.

We have also recently extended the approach of the WrEN project to look at grassland sites. Here we don't have 150 years of grassland regeneration, but we do have 25 years of grassland restoration through agri-environment schemes, and we're using a similar approach to try to look at the effect of site and landscape variables on invertebrates in these restored sites.

The data collected through this research should give us a much clearer picture of the relative importance of the 'bigger', 'better', 'more' and 'joined' principles, and the many individual features of the landscape that influence them, for the presence and abundance of the different species.

With that information we will be in a much better position to develop rules of thumb for conservation managers that want to create more functionally-connected landscapes that will support larger and more resilient species populations. This will be relevant to any conservation initiative that aspires to move beyond traditional site management, whether aiming for a 'wild' or 'managed' approach or anything in between. The information gathered about designing landscape for wild species can also be combined with new data about wild lands[27] and human perceptions of landscape change[28] to identify and conserve areas that will provide habitat for both wildlife and people.

More information about the project is available at:
http://www.stir.ac.uk/natural-sciences/research/groups/bes/ecologyevolutionandconservation/wren

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Nicholas Macgregor *is principal specialist in landscape ecology at Natural England; his work focuses on evidence to inform conservation strategies. nicholas.macgregor@naturalengland.org.uk*
Kevin Watts *is senior landscape ecologist at Forest Research working with a team of ecologists, geneticists and spatial analysts to understand and model the interactions between biodiversity and forested landscapes. Kevin.Watts@forestry.gsi.gov.uk*
Kirsty Park *is a Reader in Conservation Science at the University of Stirling, focusing on anthropogenic impacts on biodiversity and solutions to try and mitigate the negative effects of human activities. k.j.park@stir.ac.uk*
Elisa Fuentes-Montemayor *is a Research Fellow at the University of Stirling studying how human activities impact biological communities and how to optimise conservation actions for biodiversity. elisa.fuentes-montemayor@stir.ac.uk*
Simon Duffield *is an ecologist at Natural England specialising in climate change and in landscape ecology of grasslands and farmland. simon.duffield@naturalengland.org.uk*