Applying connectivity mapping to spatial planning in Wales

J. Latham[1], J. Gillespie[2].

[1] Countryside Council for Wales, Maes-y-Ffynnon, Bangor, Gwynedd LL57 2DW, UK. e-mail: j.latham@ccw.gov.uk
[2] Baker Shepherd Gillespie, Wyastone Business Park, Monmouth NP25 3SR, UK. e-mail j.gillespie@bsg-ecology.com

Abstract

Action to improve ecological connectivity is seen as an important element of adaptation for biodiversity to the effects of climate change. The Countryside Council for Wales is working with partners to develop maps of connectivity based on least-cost modelling for a range of key habitats. These maps are key elements of a wider framework of actions to improve connectivity and protect biodiversity. There is strong political interest in this approach in Wales and a drive to include concepts of ecological connectivity within spatial planning at local and national levels to contribute to a broader green infrastructure. To this end, there have been recent pilot projects to: develop the policy background at a regional scale; refine local connectivity mapping to include new datasets; develop linkage to local biodiversity action; and explore how the concepts may be included within planning systems. This paper reviews the overall approach in Wales to date and reports on the findings of studies in South East Wales.

Keywords: ecological connectivity; habitat networks; biodiversity; spatial planning; green infrastructure; Wales

Introduction

It is widely recognised that the combined effects of habitat fragmentation and climate change could have serious negative impacts on biodiversity (Hopkins *et al.*, 2007). Fragmentation reduces the size and viability of species populations and their ability to move within the landscape. Climate change compounds these effects by increasing stresses on populations, as well as their need to move. These effects may be offset to some degree by taking action at a landscape scale, so that ecological connectivity is improved. Within Wales, there is political interest in such action, especially when set within wider policy frameworks, *e.g.* within spatial planning at local and national levels.

As the Welsh Assembly Government's (WAG) statutory advisor on nature conservation, the Countryside Council for Wales (CCW) has been exploring approaches to action to improve ecological connectivity and how these may be placed within a policy framework (Latham *et al.*, 2008). A central piece of research to underpin this initiative is the mapping of Wales-wide habitat networks for broadleaved woodland, various forms of unimproved grassland, heathland, bogs and fens. This has been done as a collaborative project with Forestry Commission Wales and Forest Research (Latham, 2006, Latham *et al.*, 2004; Watts *et al.*, 2005b; Eycott *et al.*, 2007). Habitat networks are patches of habitat that are predicted to be functionally connected by virtue of the ability of species to move, to some extent, through intervening habitats. Network maps provide a basic guide to understanding how habitat patches in the landscape function and have a wide range of potential uses.

The Wales-wide mapping project predicts the location of habitat networks in Wales based primarily on Phase 1 habitat survey data. The modelling identifies two network extents for a given habitat. The **core network** encompasses patches of source habitat and a relatively restricted area around each source habitat patch. Put simply it represents the extent to which 'typical' species of a given habitat that require extensive habitat and are poor dispersers might be able to move. **Focal networks** are more extensive than core networks. They include land through which 'typical' species of a given habitat that can use smaller habitat patches and have a greater dispersal ability might be able to move.

The maps will be refined as species' movement is better understood, and the underlying datasets and the models themselves improve. However, there is an urgent need to provide guidance for action, and inevitably this results in some tension between the delivery of practical guidance and the prudence required in scientific development. A balance needs to be struck, so that guidance is useful, as well ecologically meaningful and flexible enough to accommodate change.

The two recent projects in South Wales described below, explore how the scientific outputs of ecological connectivity research can be applied to policy development.

South East Wales regional connectivity study

WAG recently ran a project called 'Framework for the South East Wales Networked Environmental Region' (NER). This is an element of the Wales Spatial Plan (Anon, 2004), and sets out a high-level vision of a network of multifunctional ecological connections to complement the city-regions of South East Wales. The report (EDAW, in press) identifies the benefits of environmental networks, stressing the inter-relationships and synergies of the approach for biodiversity, recreation, employment, tourism, educational opportunities and especially the importance for provision of ecosystem services. Relevant policies are reviewed and generic maps provided that integrate a diversity of analyses of 'natural connections' habitat networks and ecological corridors. South East Wales is one of six Spatial Plan areas in Wales and this study, once published, has the potential to be a model for the rest of the country. It should provide a strategic framework for integrating action for ecological connectivity into a wider green infrastructure.

South East Wales Econet project

The South East Wales Econet project complements the NER work, by exploring at a finer scale how habitat network maps might be provided for guidance and how they might fit within local planning mechanisms. The Wales-wide core and focal networks of Watts *et al.* (2005b), Eycott *et al.* (2007) and Latham *et al.* (2008) form the starting point and further spatial analyses of these outputs have been undertaken to explore how they might inform the targeting of conservation effort and policy planning and control.

Further spatial analysis of the Welsh habitat networks:

The network maps provide an indication of connectivity between habitat patches. However, as they can be very extensive there is a danger that policies based on protecting their total area could be 'dilute' and hard to apply. Some prioritisation is, therefore, needed to identify the most important networks and parts of networks to inform planning policies. The first analysis attempted to identify the most obvious areas of connection between patches of habitat within and between different parts of the network (habitats of the same type and less than 1,000m apart). Some connecting areas fall within the focal network; these have been termed areas of 'existing connectivity'. Those falling outside of the focal areas are termed areas of 'potential connectivity'. Figure 1 shows an example area based on the original colour Geographic Information System (GIS) output, and rendered in a grey-scale for this paper.

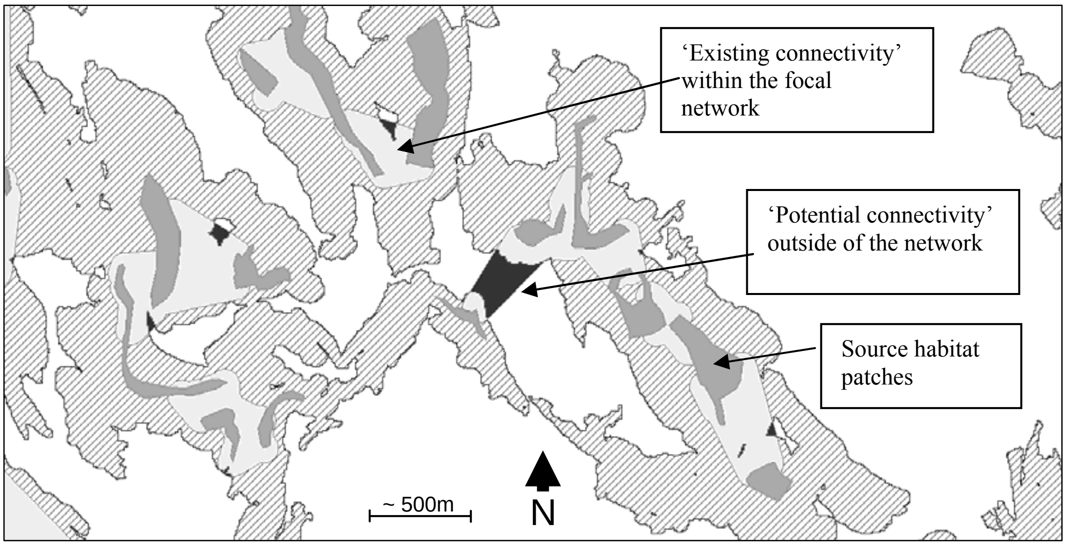

Figure 1. 'Existing and potential connectivity' based on habitat networks (broadleaved woodland example)

An analysis of opportunities for further linking of a network was then undertaken. This looked outside the predicted network of a given habitat for locations where best opportunities might lie for linking parts of a network. Land outside of the networks was divided into 100m square units and a value assigned to each unit based on the number of core networks of similar habitat types within 1km. The values are mapped using colour thematic mapping. In Figure 2: parts of the focal network are grey hatched; core networks are solid, within the focal networks; and habitat patches (ancient woodland) are dark patches within the core network. Land outside the network but with potential for connecting parts of it are shown as 100m resolution pixels between networks in progressively darker shades of grey depending on the number of parts of networks they provide linkage for.

Thirdly, overlap analysis was undertaken to identify areas that might function for multiple focal networks of different habitats. The land area was divided into 10 metre square units and the focal networks for each habitat type were mapped over these squares. A value was assigned to each square based on the number of focal areas wholly or partially covering it. The darker the colour the greater the number of overlapping focal networks (see Figure 3).

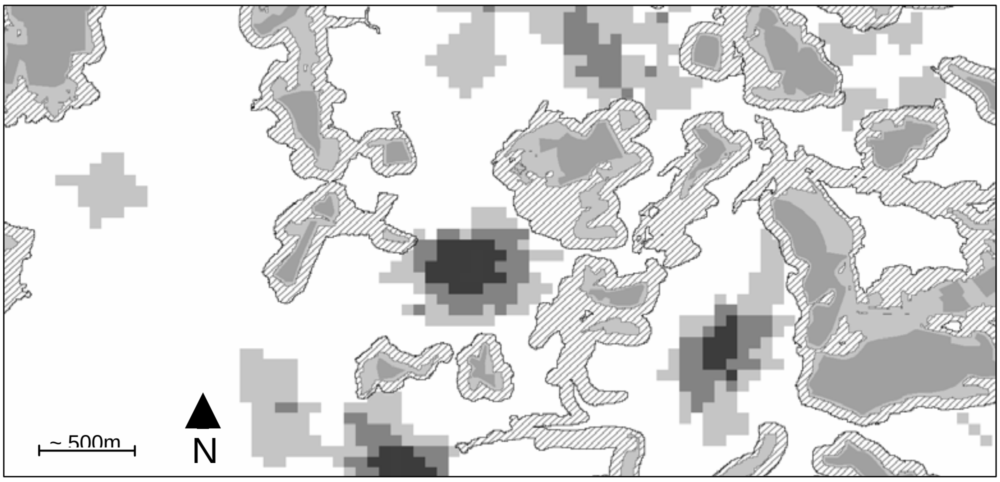

Figure 2. Opportunity analysis: potential linkage between networks

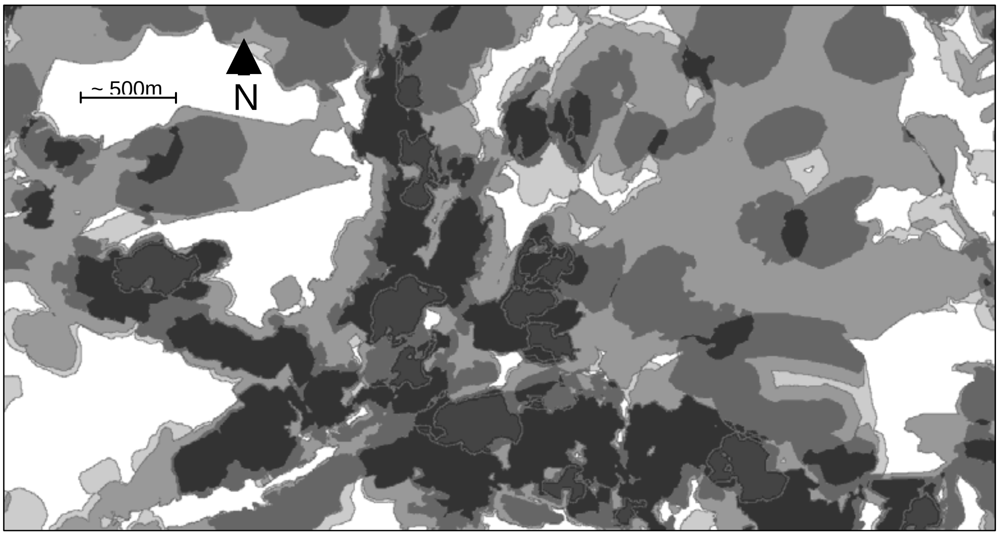

Figure 3. Overlap of focal networks for five habitat types

Adding new data and recalculating the least cost analysis

The network maps are based on habitat data that will inevitably change or be refined. There is, therefore, a need to explore how sensitive they are to changes in input data, as this can affect how confidently they can be applied to policies. The effect of adding new data to the Wales-wide marshy grassland and broadleaved woodland networks was examined. To enable comparability of outputs, the analysis was based on that used by the habitat network tools in Forest Research's BEETLE toolkit (Biological and Environmental Evaluation Tools for Landscape Ecology, Watts *et al.* 2005a, 2005b). Input datasets used for new least-cost analysis were a recently captured, digitised Phase 1 dataset from Torfaen County Borough

Council (approximately 6 x 5km) and the National Inventory of Woodland Trees (NIWT II) dataset, along with the 'typical' species variables used in the original model (where possible).

Figure 4 shows a greyscale version of the original Wales-wide habitat network for marshy grassland, which remains constant, and a more extensive network defined through use of local data. The results of further spatial analysis ('existing' and 'potential' connectivity) are also shown. This example demonstrates that networks generated through least-cost modelling are highly sensitive to input data.

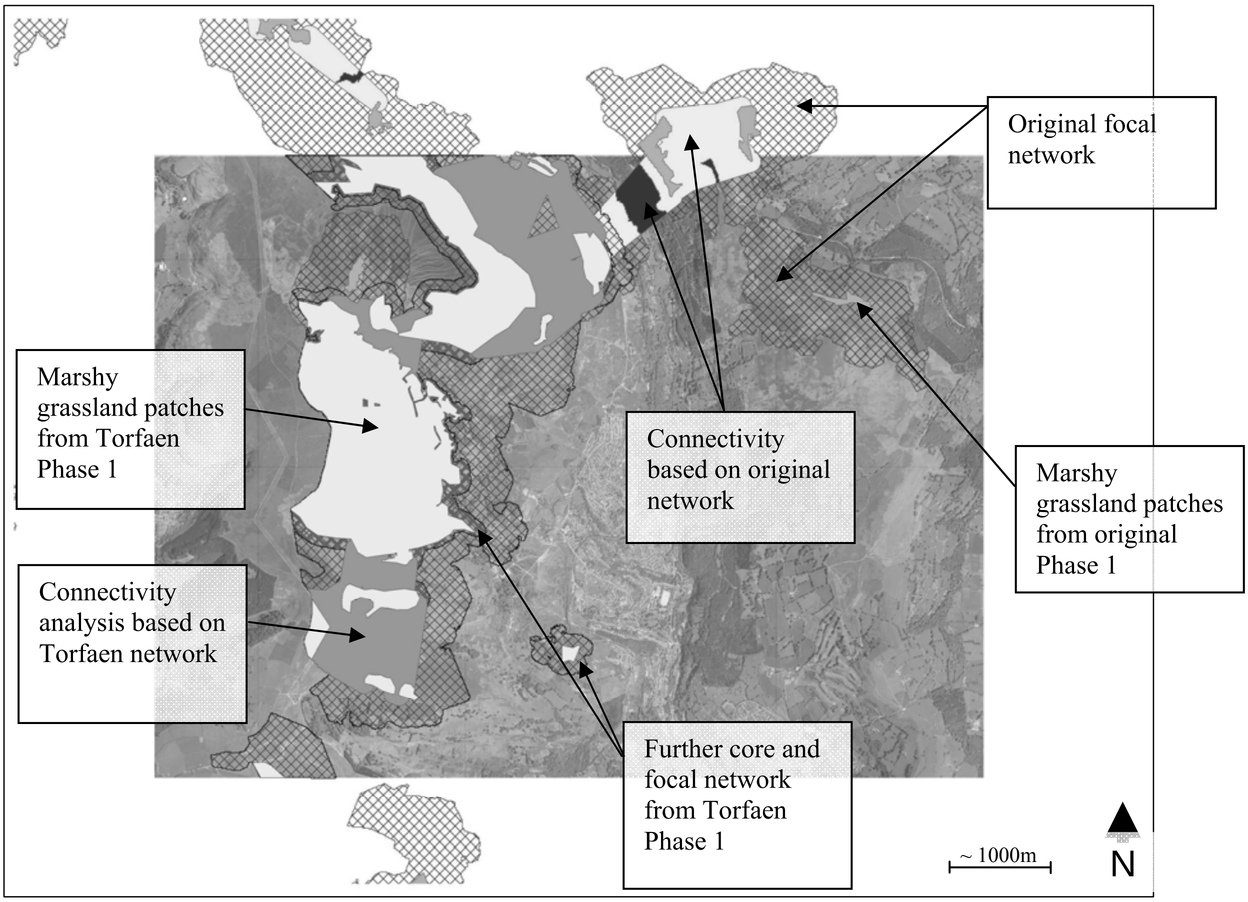

Figure 4. Spatial analysis based on original network and additional Torfaen Phase 1 data for marshy grassland

Discussion and application of results

Different species have different requirements of connectivity, for example, in terms of habitat type, structure and, importantly, spatial scale. Resources for action are inevitably limited and strategies to improve connectivity will always be a compromise. Two policy areas have been identified for development to achieve action for improved connectivity (Latham *et al.*, 2008). The first relates to targeting of grants and incentives towards protected sites, habitat networks and areas of regional connectivity. The second is the identification of opportunities for conservation and enhancement of important areas for connectivity, together with appropriate delivery mechanisms, such as the Wales Spatial Plan, Rural Development

Plan or Local Development Plans. These can be placed within a nested hierarchy of scales to promote connectivity for different aspects of biodiversity (Table 1). The results of the Econet project provide an opportunity to explore how such inclusion in policies may be achieved.

Table 1. An outline policy framework for action to improve ecological connectivity in Wales (adapted from Latham *et al.*, 2008)

Landscape level	Description	Biological function	Actions required
1. Sites	SSSIs and other designations.	Biodiversity hotspots with good chance of persistence in the face of climate change; sources for dispersal.	Management to achieve favourable condition; completion and review of series.
2. Buffers	Land in the neighbourhood of sites.	Support and protection for biodiversity sites; opportunities for local movement in response to climate change.	Targeting grants and incentives to these areas to provide appropriate management; use of heterogeneity maps to inform planning; recognition in Local Development Plans.
3. Habitat networks and permeability	Series of habitat patches and intervening land that form functional systems.	Support biodiversity sites by increasing effective area; enhanced metapopulations; opportunities for species movement in response to climate change.	Use of network maps to inform land use; targeting of grants and incentives for appropriate management; agri-environment measures to improve permeability; recognition in Local Development Plans.
4. Large landscape areas	Large, heterogeneous landscapes with good connectivity for a wide spectrum of biodiversity. Examples include: coastal zones; ffridd zones (upland fringe); upland ranges; and some river corridors.	Resilient framework of semi-natural habitat at a regional scale; long-term population persistence and movement of taxa in response to climate change. Convergence with environmental services (as a product of all levels).	Recognition within planning policies (*e.g.* Wales Spatial Plan) for protection; targeting of schemes to aid development.

Planning policy formulation

The analysis in this project has shown that least-cost analysis is highly sensitive to input data and that small changes will alter the size and appearance of networks. At country or regional level there is probably little to be gained in considering a scale finer than that already represented in the Wales-wide networks. These remain constant if further data are added and the usefulness of the resulting extra information is lost at lower resolutions. This is important when considered against the resources required to gather, prepare and analyse extra data. However, when considering a more local situation a clearly different picture is painted when finer-grained input data are used, which has implications for decision-making at that level.

It is suggested that no definition of a network is more ‘right’ or ‘wrong’ than another based on input data collected and analysed or the scale at which a network is examined. This does not preclude adoption and strategic use of the Wales-wide network but there are two particular issues for consideration:

- Networks should be considered as indefinitely provisional (as per the provisional Ancient Woodland Inventory).
- Policies need to acknowledge that networks will appear differently depending on the scale at which they are examined and that finer-grained datasets will give rise to a finer-grained network.

Although areas to which conservation policies apply should usually be shown on a proposals map, where this is not practical criteria-based policies may be used. It is suggested that the Wales-wide network maps be complemented with a criteria-based policy. Its basis is discussed in the Econet report. It suggests that representations of networks are not definitive and that there should not be an expectation that all policy decisions should flow from them. Networks should be considered in terms of best available information and policy should encourage use of a process based on it. This will guide all parties through an agreed process of data gathering and analysis to enable options for connectivity to be identified and presented, *e.g.* as part of a planning application, without over-reliance on fixed lines on maps.

Other outcomes from the Econet project

Data format and standardisation

In reprocessing local datasets for least-cost analysis, age of data, habitat definition, GIS protocols and disparity between local authorities in approaches to data gathering, all had an effect on effort required and outputs achieved. Without cross-county approaches to finer-scale mapping, the potential usefulness of such mapping is unlikely to be realised. In considering more broadly whether to work towards locally refined network identification throughout the region, the following are just two areas for consideration and discussion:

- Counties are at different stages of habitat survey and digitisation; data are gathered at different scales, levels of detail and minimum recording areas. Discussion about data standardisation is required, including habitat naming conventions and GIS protocols.
- There should be agreement about the treatment of county edges to make them match and allow a continuous data surface to make the most of the network concept.

Presentation of network information to a wider audience

If network information is to be recognised in planning policy terms then how this information is presented to a wider audience becomes important. The concept is likely to give rise to a range of expectations and a clear understanding of the sources and limitations of information is required to ensure appropriate interpretation. The need for a structured approach to dissemination and the complexity of interpretation prompted the development of a pilot web-based application. This aims to guide users through locating a site, interpreting habitat data sets and downloading data for more detailed local analysis, perhaps in combination with other datasets, as appropriate. The pilot web site is currently being trialled.

The importance of context

Examining networks without a backdrop of the real world can help in spotting patterns over expanses of land and may help to provide a relatively uncluttered opportunity to think about biodiversity planning. However, decisions need to be made with an appreciation of the nature of land in between networks, and any opportunities that network maps identify (*e.g.* see Figure 2) need to be considered in this context. It is, therefore, important that the role of other datasets, such as allocation maps, land ownership or soil type, is explored in arriving at decisions that use network information. Once these datasets are overlaid, whether via GIS or visually, a much more practical picture of what can be achieved will come to light.

Ecologists also have a role in this process of providing context, for instance, in helping explain what it might mean that a piece of land is part of the focal network for two apparently dissimilar habitats. In this sense, a GIS-based approach is no substitute for the input of an ecologist and any computed network should not be used in isolation from such expert input to inform any significant land-use decisions.

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