EXPANDING NATIVE WOODLANDS: A STRATEGIC APPROACH USING RIVERS AND LAKES AS PART OF A FOREST HABITAT NETWORK

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Abstract

There are 78,000 km of rivers and streams in Ireland and an estimated 5,000 lakes. Every fragment of native woodland in the country is adjoined by at least one stream or lake. The river network, therefore, provides an opportunity of connecting fragmented and vulnerable native woodland habitats as part of a forest habitat network. Here, I consider some of the advantages for establishing native riparian woodlands for river ecosystem health. I suggest that the river network provides an obvious framework for reconnecting and reinvigorating the existing native woodland resource.

Introduction

The Native Woodland Scheme (Anon, 2001) has put new energy and urgency into the protection and expansion of Ireland's woodland heritage. However, starting from a very small base of approximately 80,000 ha (Anon, 2001), means that in order for the scheme to make a sufficient impact in achieving its objectives, its implementation will need to be strategic and targeted. A 'shotgun' scatter approach to new woodland development would only add to the already large numbers of isolated small woods, and as has been suggested by Perterken (2002) for woodland restoration programmes in the UK, would homogenise the landscape with minimal ecological benefit and potential loss of locally distinct landscapes. Population biology and the emerging scientific discipline of landscape ecology present new opportunities to: firstly, understand the dynamics of habitat and species expansions, contractions and extinctions; secondly, to consider general principles underpinning the ecology of land mosaics or large spatially heterogeneous areas; finally, to adopt these principles as a means of strategically increasing the effectiveness of efforts to restore and expand the native woodland resource in Ireland.

The objective of this position paper is to introduce some of these new ideas in the context of developing Irish native woodlands, particularly with regard to the use of riparian corridors as a constituent part of forest habitat networks; to consider the potential benefit of riparian corridors to ameliorate effect of global warming induced temperature increases on freshwater fisheries; to stimulate interested parties to evaluate, discuss and carry out additional work that would be complimentary to a landscape ecology approach.

Landscape ecology

Ireland's native woodland is a fragmented habitat of about 11,750 discrete natural woodland patches (Forestry Inventory and Planning System or FIPS GIS database), covering at most, 1.5% of the total land surface. Approximately 9,000 of these woods are in the Republic of Ireland (FIPS) and a further 2,750 existing in Northern Ireland (McElarney *et al*., 2005). The woodlands are small; 40% are less than 5 ha (Martin *et al*., 2005).

There are very few patches of any significant size with only 3% of these woodlands greater than 50 hectares in size.

An examination of the spatial distribution of woodlands across the island would suggest that there is a considerable degree of clustering (Figure 1). Typically, these woodlands are aggregated into approximately 10 km^2 blocks and are separated from each other by distances of between 5 and 20 km. Within these aggregations, small woodland patches, which effectively operate, in a biological sense, as isolated island habitats, are separated by distances of between 100 meters and 1 km, and confined by barriers such as ditches and fences and by grazing, they are captured in a background habitat mosaic of farmland, commercial forest, urban development and other land uses, with little semi natural or transitional habitat (Figure 2).

Landscape ecology theory (Forman, 1995), island bio-geography theory (MacAurthur, 1967) and metapopulation theory (Hanski & Gilpin, 1997), would suggest that small, isolated and fragmented habitats and populations are more vulnerable to decline and an increased rate of extinction in comparison to habitats and organisms living in large interconnected habitats (Figure 3 and Figure 4). There is significant literature describing the health of populations living in fragmented woodland habitats (see references in Peterken, 2002). As the size of the island increases so does the number of species that they support. For example, on average a tenfold increase in size of a woodland habitat leads to a doubling of species numbers (MacArthur & Wilson, 1967). There is little information on the impacts of size and isolation on the trees within the habitat, or the habitat itself in its totality, but the concepts outlined above equally apply to the movement, growth and development of the woodland habitat and the tree species within, in terms of species richness, quality and longevity.

Native woodlands fit well into the metapopulation paradigm. A metapopulation is a population consisting of spatially separate sub populations (discrete woodland patches) that are connected by dispersal of individuals (seeds). For subpopulations on separate patches (trees and other flora in a woodland), the local extinction rate decreases with greater habitat quality or patch size, and the rate of re-colonisation increases with corridors, stepping stones, a suitable matrix habitat or short inter-patch distance. There will be slow colonising species and fast colonising species. Metapopulation dynamics are of special importance because sub populations may drop to zero (local extinctions) especially in small isolated patches. If each sub population dropped to zero, this would mean extinction of the whole population. However, because individuals sometimes move between sub-populations, two results occur. First the local extinction rate (the number of species disappearing from a patch per unit time) is lowered. Second when local extinction does take place, re-colonisation of individuals may re-establish a new population at the site.

What is required to restore woodland habitat?

The destruction or fragmentation of Ireland's native woodland habitat over the millennia would have followed a sequence or sequences similar to those described by Forman (1995). Land is transformed from a more or less suitable habitat in a small number of what Forman describes as basic mosaic-sequences. Five sequences are widespread. **1. Edge:** a new land type spreads uni-directionally in more or less parallel stripes from an edge. **2. Corridor:** a new corridor bisects the initial land type at the outset, and expands outward on opposite sides. **3. Nucleus:** spread from a single nucleus within the landscape proceeds radially, and leaves a shrinking ring of the initial land type. **4. Nuclei:** growth from a few nuclei produces new land type areas expanding radially toward one another. **5. Dispersed:** widely dispersing new patches rapidly, eliminates large patches of the initial land type and prevents the emergence of large patches of the new land type until near the end of the process. Essentially what is required, then, to restore and reinvigorate the native woodland resource is a process or processes capable of reversing these mosaic sequence events.

This might be achieved by regenerating a forest habitat network (Peterken, 2002). A network can be visualised as an array of nodes or individual woods, connected by links, such as streams, rivers, hedgerows or road networks, but set in a constraining matrix of farmland and urban development. A forest habitat network comprises forested nodes and links in a matrix of other habitats.

Peterken (2002) recommends that establishing a forest habitat network involves 'adding new woodland to the landscape where it will enlarge small woods and link scattered woods of all sizes; keeping existing woods and managing them to retain habitat diversity throughout the woodland area; and associating other habitats with the woodland'. He goes on to consider how such a network should be designed. One principle that should be incorporated is design efficiency. 'The design must aim to maximise connections between woodland with the minimum amount of additional woodland. This is not just an issue of cost effectiveness, but is also a recognition that agriculture, living space, communications and other land uses will inevitably restrict the land available for a forest network'. The use of riparian zones in this regard offers a way of expanding the forest network while minimising the impact on the usefulness of agricultural land.

Earlier research by Peterken (2000) indicated that woodland should cover at least 30 per cent of the land within 'Core Forest Areas', as this is the minimum proportion at which the landscape starts to function as if it were a single, large wood for most woodland species (including the trees themselves and associated fauna). A core forest area would be a landscape in which woodlands are well distributed, well connected, and cover at least 30 per cent of the land. The aim should be to reinforce clusters of existing woods until at least 30 per cent woodland coverage is achieved.

In this regard riparian woodland development would seem to have an obvious and useful role in increasing the critical size and connectivity of the existing natural woodland reserve. There are 78,000 km of rivers and streams in Ireland and an estimated 5,000 lakes. Every fragment of native woodland in the country is adjoined by at least one stream or lake. The river network, therefore, provides the best opportunity to reconnect fragmented and vulnerable native woodland ecosystems.

The development of riparian woodland corridors has significant potential to contribute to the native woodland resource. For instance, the development of 10% of the existing stream and river channel network (7,800 km), establishing woodland of 40 metres (recommended in the Native Woodland Scheme) on both banks, would create 62,400 ha of new woodland habitat, which would almost double the estimated existing woodland habitat area of 80,000 ha.

Game (1980) has argued that long, thin woods are better at catching species moving through the landscape, but that compact woods are better at retaining species once they have been caught. So while riparian corridors would be good at capturing organisms they would still need to be sufficiently wide to optimise the benefit. As a rough rule of thumb, it is known that changes in microclimate extend to up to three times the canopy height in from forest edges (McCollin 1998), suggesting a minimum size for effective woodland corridors. Interestingly, Peterken (2002) found that woodland shape had no significant impact on the number of plant species, although specifically referring to ground flora. It is doubtful if this holds for developing tree communities and mixtures in woodland habitats.

Fisheries and commercial forest development

Overall, commercial forest activity has had a significant detrimental impact on ecological functioning of Irish rivers due to: hydrological change (Mueller, 1999); deterioration in morphological structure; nutrient enrichment; changes to sediment transport regimes; acidification (Allott *et al.* 1990). Consequently, based on these experiences, fisheries interests, have by and large, viewed forestry development rather negatively. In response to the findings of these and other studies, Forestry and Fisheries Guidelines (Anon, undated) and Forestry and Water Quality Guidelines (Anon, 2000) were agreed, with the net effect of excluding commercial woodland development from riparian areas and a reluctance, applying the precautionary principle, to facilitate woodland development near rivers and streams.

Yet, excluding trees from riparian areas maybe counter-productive, as sensitively established native riparian woodlands (as opposed to commercial conifer plantations), have the potential to provide a number of tangible benefits for stream ecosystem functioning such as increases in habitat complexity and stability in addition to temperature regulation. Temperature regulation is critical in protecting aquatic resources where climate change is already resulting in significantly higher freshwater temperatures and episodic and extreme delivery of water (rainfall) to river systems.

Temperature increases as a consequence of climate change

Fish are poikilothermic and cannot regulate their body temperature. Thermal conditions will therefore influence their metabolism, growth, and development and temperature extremes may cause mortality. The determinants of the well being of the *Salmonidae* (salmon, trout and charr), the most sensitive of the fish living in Irish freshwaters, are influenced by environmental factors such as water temperature, rainfall, stream flow and the coherence between freshwater and seawater temperatures. These environmental factors are in turn controlled to a large extent directly by meteorological phenomena such as air temperature, storms, wind and the stratification of large water bodies such as lakes. Irish freshwaters are warming through a combination of natural climatic variations described by such processes as the North Atlantic Oscillation and the gulf stream index (GSI) (Jennings *et al*. 2000) and by a process of anthropogenic forcing (global warming) so much so that they are now considerably warmer than they were fifty years ago (unpublished data, P.McGinnity *pers.comm*.). Similar temperature increases have been observed by Langan *et al*. (2001) in upland streams in the Scottish Highlands. Long-term climate model forecasts suggest that mean air temperature will continue to increase by an estimated 3 to 5°C in the next 50 years (Hulme & Jenkins, 1998). It is likely that water temperatures will rise accordingly. Predictions of higher summer water temperatures resulting from current climate change scenarios will result in increased thermal stress and potentially lethal effects in fish (Langan, *et al*., 2001).

In those Irish rivers where long-term biological data exist (1960 to present), changes in smolt quality and performance have been observed and measured, concurrent with changes in the freshwater environment. These studies indicate that salmon and sea trout smolts are entering the sea earlier in Spring than they have done since monitoring of these rivers began, but are also migrating at a smaller size and at a younger age and perhaps in consequence are surviving less well at sea (P.McGinnity, *pers. comm*.).

Evidence from North America suggests that increases in direct solar radiation due to reduction (or absence) of riparian vegetation is mainly responsible for high stream temperatures (Brown & Krygiers, 1970). Other, research has shown that complete riparian canopies transmit about 10 percent of incident short-wave solar radiation (light) and thereby have a cooling or at least moderating effect on steam temperatures. Malcolm *et al*., (2004) in investigating the influence of riparian woodland on the spatial and temporal variability of stream water temperatures in an upland salmon stream found that riparian woodland had a substantial impact on the thermal regime, reducing diel variability (over a 24 hour period) and temperature extremes. They concluded that this temperature effect was likely to have a significant effect on freshwater ecology in general and on salmonid fish in particular.

Management of riparian areas

It appears that the moderation of high summer water temperatures conferred by riparian woodland is likely to be beneficial to salmonids. Consequently, to protect streams against direct solar heating, riparian buffer strips are now usually considered best management practice by the forest industry in North America. In the UK the most recent edition (4th) of the Forest and Water Guidelines, arbitrarily recommends that 50% of each river reach be shaded by riparian trees where salmonid fish predominate. In Scotland, forestry (e.g. Scottish Native Woodlands) and fisheries groups (e.g. Tweed Foundation and Galloway Fisheries Trust) are promoting the (re)introduction of semi natural woodlands to improve the quality of river habitat for fish.

These recommendations assume a diverse, complex and climatic riparian flora. However, in the early stages of development, tunnelling can occur in young riparian woodlands, where large numbers of a single species of tree are recruited synchronously on to a riparian area subsequent to a natural disturbance event or as the result of a deliberate management action and develop into a dense monoculture. The management activity could be the fencing of a riverbank to exclude grazing, the drainage and maintenance of arterial channels or targeted planting that is envisaged in the Native Woodland Scheme. O'Grady (1993), investigating the effects of varying levels of deciduous bank side vegetation on salmonid stocks in Irish rivers found that in summertime, marginal vegetation could limit the extent of incident light reaching the river bed resulting in a marked decline in both juvenile salmon and juvenile and adult trout numbers relative to stocks in adjacent areas with a less dense canopy. O'Grady also collected data showing that the length of a tunnelled channel, upstream of tunnelled sites influenced the standing crop of juvenile salmon with numbers of these fish falling with increasing tunnel length.

On the basis of O'Grady's findings, and in order to protect aquatic ecosystem functioning, some level of ongoing intervention maybe necessary, particularly in the early stages of riparian woodland development.

Summary

The ultimate aim of the Native Woodland Scheme should be to reinforce clusters of existing woodland until 30 per cent woodland coverage is achieved within the clusters Peterken, 2002). An examination of the distribution of woodlands across Ireland would indicate that surviving natural woodland and scrub exists in such clusters or aggregations. The river and lake network presents a logical and natural habitat network framework that could allow prioritisation of appropriate development within these clusters. The precautionary principle would suggest that a considerable amount of research and testing is needed. Nevertheless, it appears, that if managed properly, this forest-stream network provides a 'win-win scenario' with potential benefits for the ecological functioning and protection of both woodlands and freshwaters. Large natural vegetation patches are probably the only structures in a landscape that protect aquifers and interconnected stream networks, sustain viable populations of most interior species, provide core habitats and escape cover for most large, home range vertebrates and permit near natural disturbance regimes (Forman, 1995). Sensitively established woodlands could regulate temperatures, help restore ecological functioning envisaged by the EU Water Framework Directive, improve water quality and habitat quality, while at the same time providing a template for the regeneration of native woodland. Finally, Forman's comments in his 1995 paper seem apt as a concept to form a basis for landscape planning in the future. 'Land containing humans is best arranged ecologically by aggregating land uses, yet maintaining small patches and corridors throughout developed areas, as well as outliers of human activity spatially arranged along major boundaries'.

Figure 1. *A map (FIPS) of the distribution of clusters of native woodland in an area south and west of Lough Gill in County Sligo. These clusters cover areas of approximately 10km² in size and are separated from each other by distances of between 5 and 25 km.*

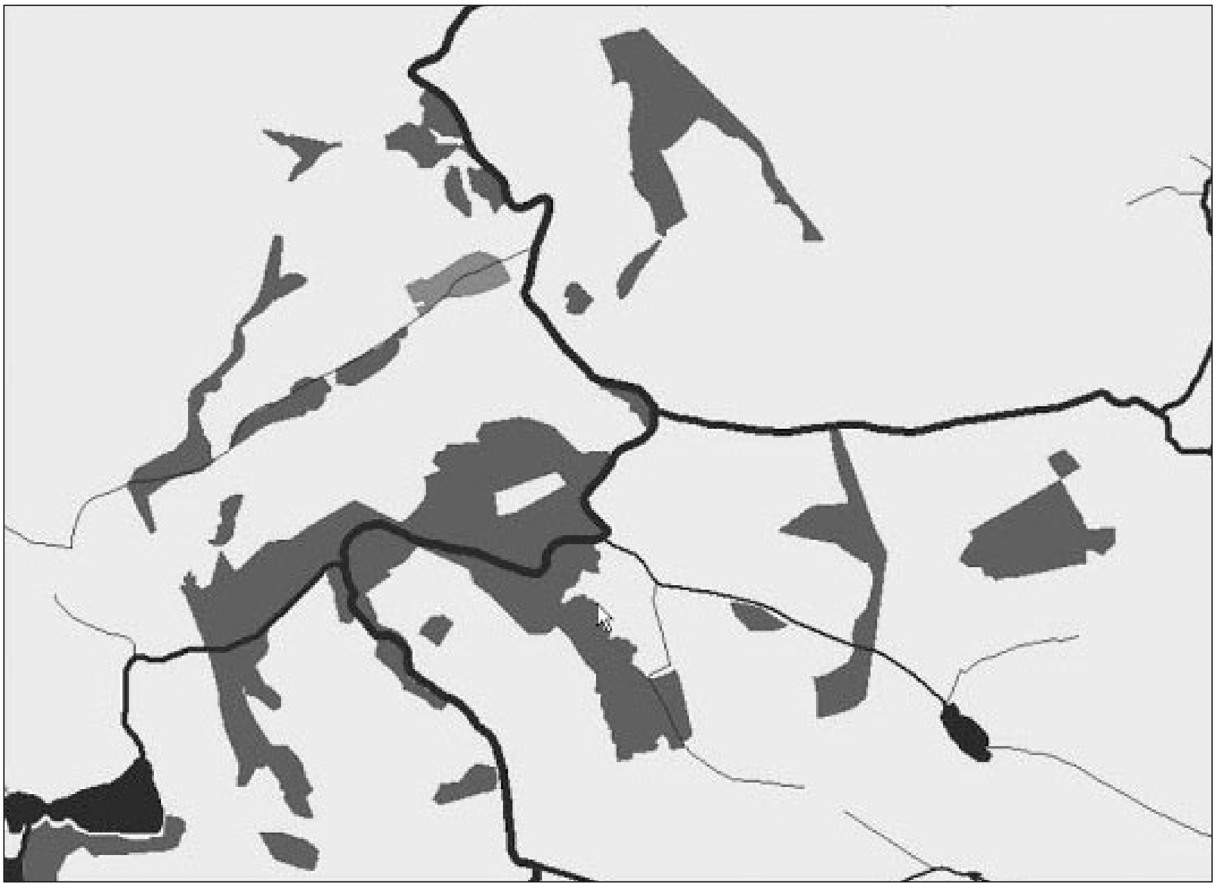

Figure 2. *A close up map (FIPS) of a woodland cluster showing discrete woodlands linked by network of rivers and streams.*

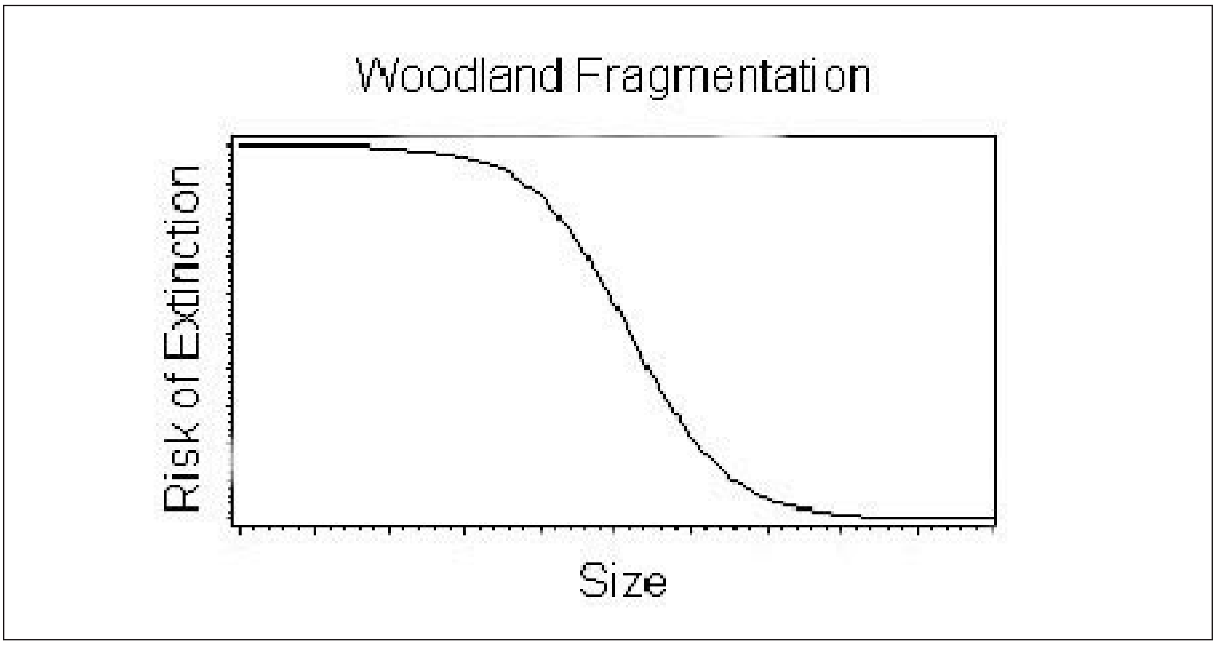

Figure 3. *Theoretical model illustrating the relationship between the size of individual woodland fragments and their risk of extinction.*

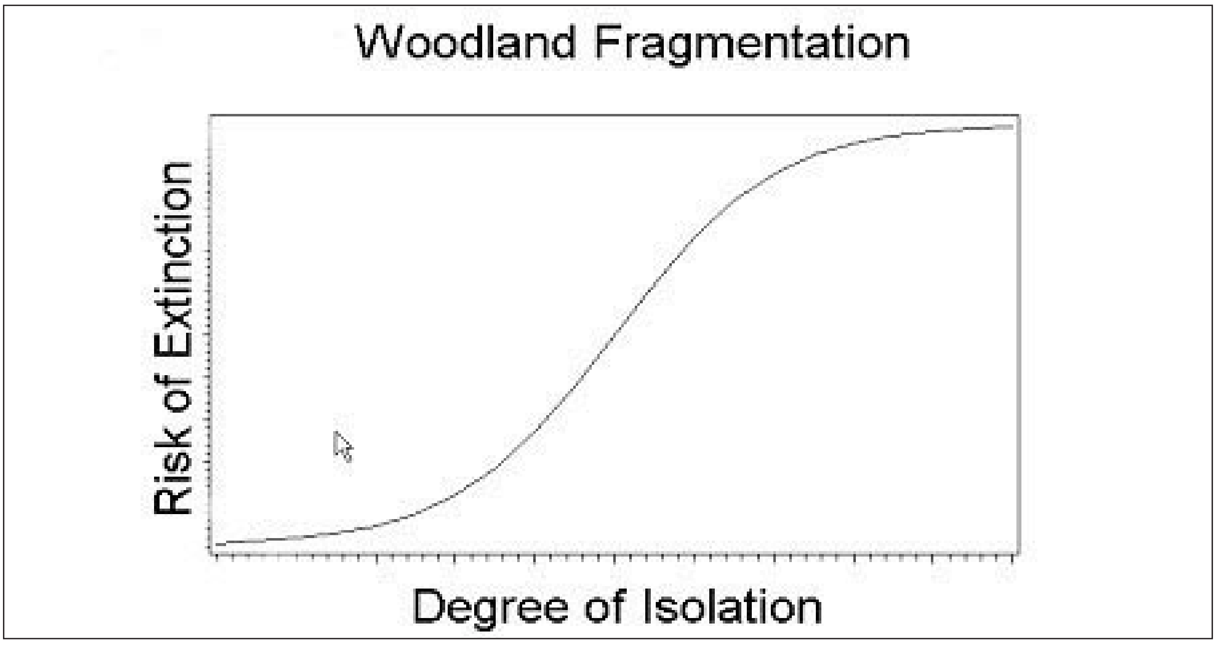

Figure 4. *Theoretical model illustrating the relationship between the degree of isolation (distance) between individual woodland fragments and their risk of extinction.*

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