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## Long term biodiversity planning and monitoring of new native woodlands

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Oral presentation

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ABSTRACT

Demonstrating the value of the Scottish Forest Alliance sites for biodiversity requires its monitoring over a sufficiently long time period to assess ecosystem function. The objectives are to yield information on changes in biodiversity as the new woodlands develop to inform management planning, and to allow the SFA to assess progress in achieving biodiversity objectives. A scientifically robust innovative methodology has been developed to achieve this and will be implemented through a series of planned periodic surveys that will quantify changes woodland over the next 100 years.

This has been coupled with a strategic approach to the planning and management to achieve better integration between woodlands and other valued habitats as a means of enhancing biodiversity at the landscape scale. The Integrated Habitat Network (IHN) modelling approach will support this which can contribute to climate change mitigation and adaptation through the development of resilient landscapes.

Keywords

Biodiversity monitoring, habitat networks

BACKGROUND

The restoration of native woodlands is one of the key conservation objectives in Scotland set out in both the Scottish biodiversity and forest strategies, and also contributes to climate change mitigation and adaptation. The Alliance is a collaboration between BP, Forestry Commission Scotland, the Woodland Trust Scotland and RSPB Scotland aimed at regenerating 10,865 hectares of native woodland at 14 key sites across Scotland The aim is to enhance biodiversity, encourage community involvement with woodland and forests and further research into carbon sequestration. The Alliance intends that the value of these new woodland areas for biodiversity should be clearly demonstrated over the long-term, and that management is targeted towards encouraging the development of biodiversity in tandem with fulfilling the other Alliance and Scottish Government objectives.

The Scottish Government's Scottish Forestry Strategy (2006) sets out a framework for an integrated, cross-sectoral approach to the use and enjoyment of woodlands and forests into the future. Within this there are targets to increase forest cover in Scotland from 17% of the total land cover to 25% across all forest management alternatives. This should lead to a more resilient landscape that is better adapted and reacting to environmental change. The role of habitat networks and new native woodland has a key role in climate change adaptation strategies.

The outputs of the first of a series of planned periodic surveys, that will quantify changes as woodland at the sites develop over the next 100 years, have been collated. Data from plots nested within section squares have been used in a pattern analysis to determine the relationships between different vegetation and species groups. The monitoring will identify interesting species, unusual patterns of biodiversity and their interrelationships between vegetation communities. This will improve the ability to predict future trends in floral and faunal development, particularly the impact of increasing tree cover and the progressive development of woodland ecosystems on each site and across the landscape.

## BIODIVERSITY MONITORING

The Alliance set up an expert biodiversity group to take this work forward with the primary objective of monitoring sites is to assess progress or changes in woodland ecosystem development. A secondary objective to is to assess changes in the condition of existing woodland or open ground, which may occur as a result of changes in management (e.g. selective thinning or reduced grazing pressure) and any alterations in the local microclimate. The terms 'old growth' and 'ancient woodland' are often used to indicate value or quality in a stand. The premise being that because it is late successional woodland or has been woodland for long period of time that it has developed certain structures and functional ecological processes. For new woodlands it is the establishment of aspects of structural development, the colonisation by woodland specialist species and ecological process that will give an indication of sites becoming woodland.

To maximise the biodiversity benefits of the Alliance projects they should contribute to the development of ecological processes and function. This is applicable across the range of representative habitats, communities and species at a range of scales. This functionality should also allow for the development of increased connectivity across the landscape to reverse the effects of habitat fragmentation. To assess if these ecological processes are functioning will require monitoring of the habitats, communities and species at the tree stand, forest unit and landscape scale. This, in turn, will require cost-effective methodologies that are easily implemented by forest managers.  While it is impractical to monitor all aspects of biodiversity a careful selection of methodologies is required to adequately reflect the state and changes in forest ecosystems and diversity

There is widespread interest in the use of biodiversity indicators to represent and monitor complex phenomena and processes such as ecosystem and biodiversity responses to environmental change.  Changes in climate and land use impose new challenges for the effective monitoring of ecosystems and biodiversity.  To date, there has been a focus on modelling species specific responses.  However, for forest ecosystems there is a need to develop ways of assessing changes in the structure and composition of communities and to evaluate how ecosystem development will affect biodiversity through climatic range shifts, changing existing communities and potentially triggering the development of novel assemblages.

Biodiversity indicators need to be non-specialist based and cost-effective. This has to be balanced with the requirement to be meaningful and based on our best understanding of ecological process through research, by drawing on the breadth of research and past practical applications.  The aim for the Alliance's biodiversity monitoring was to develop a set of protocols that can be used to assess changes in biodiversity. The methodology should be able to assist in making comparisons between sites or projects, and track changes over time so that adaptive management can be put in place to maximise the biodiversity value and other ecosystem services that such projects provide. To enable monitoring of complex ecological phenomena and processes, the indicators should: combine the structural and compositional elements of forest biotypes and the ecological processes that drive them and work effectively in the different management alternatives applied to them.

It has been widely recognised (Angelstam and Donz-Breuss, 2004; Noss, 1999; Spanos and Feest, 2007) that biodiversity indicators can be grouped into 3 categories (though these are not mutually exclusive).

Table 1

| Structural indicators | Compositional indicators | Functional indicators |
|---|---|---|
| Physical pattern | Species diversity | Ecological processes |
| Spatial pattern | Genetic diversity | Natural disturbance |
| Temporal pattern | Biotype diversity | Nutrient cycling |

The three indicator categories are then related to the different scales at which they operate.

(1) Tree: Trees are the building blocks of woodland ecosystems. Their growth and development is crucial in assessing woodland development. As trees mature they create a range of different niches that can be colonised and used by a suite of different species and become habitats that have their own dependent food chain.

(2) Stand: The ways trees interact with each other across a site and over time will determine aspects of woodland development. As with trees, as a stand matures a range of niches and key woodland habitats develop.

(3) Forest Unit: How the different wooded stands and open space that make up the forest unit interact with each other in terms of their ecological function

(4) Landscape: The context and distribution of the forest units within the matrix of other habitats and landcover. Landscapes are determined by the prevailing land uses and management practices.

The effects on ecosystem development and functionality as a result of Alliance projects will have a direct impact on a forest unit or a site's biodiversity. The relationship between biodiversity and ecosystem function (the degree to which an ecosystem is working effectively) has been of interest to ecologists for some time (Schulze et al., 1993). These can be split into the physical structures that are present and develop as a result of ecological processes and the species that use them. The compositional element of biodiversity is 'variability of living organisms from all sources' (CBD, 1992) and these develop as a result of structural and functional development.

The spatial arrangement of the various components of a forest ecosystem can give a good indication of woodland development and influences the species that will be present on a site and as such are a key component of any monitoring strategy. Functional development is based on the principle that species can be used as indicators of ecosystem function. There is continuing discussion about the effectiveness of such indicators and the most appropriate method of assessment of ecosystem function but there is wide support for the use of what are termed 'functional species groups' (Davic, 2003; Patchley, 2002).

There is no single way of defining what comprises a functional species group. It has been proposed that there should be an evolutionary basis to the groupings (Chapin et al., 1992) so that these have a natural basis rather than a pragmatic one (Baker et al., 2003). Here, attributes such as phenology, physiology and life form would be selected to define the groups, but behavioural environmental responses or trophic criteria have also been used (Cohen and Briand, 1984). For example, ground beetle species (Coleoptera: Carabidae) in Scottish farmland have been allocated into functional groups by the use of multivariate analysis of their ecological traits (Cole et al., 2002).

Fox and Brown (1993) suggested that intraspecific competition could be the basis for groupings so that species that have evolved to exploit a similar niche are aggregated to form a functional group. This allows for species of different taxonomic groupings with similar ecological niche requirements to be allocated to the same functional group as they have evolved to fulfil similar functional roles within an ecosystem. Key woodland niches that represent a range of microhabitats within an ecosystem are identified with species groups representing their functionality. The assumption is that the key woodland niches are functioning if the representative species of that niche are present. These species should have similar evolutionary and ecological traits (i.e. are in intraspecific competition with each other) which can then be used to form a functional species group.

An innovative approach for these monitoring protocols was to identify functional indicators that could be readily used to measure ecosystem development. The identification of possible functional species groups was investigated (Smith and Humphry 2005) and two possible methods of sampling are proposed: Directly measuring the species themselves or Evidence of their activity – 'the smoking gun' The aim was to identify a range of functional species groups that are representative of key woodland niches. The monitoring of these would have the ability to assess temporal changes in these functional species groups and functional diversity within the forest ecosystem. The challenge is to find practical and cost-effective field methodologies that are able to measure this functionality without having to assess the biodiversity resource as a whole within an ecosystem.

The selection of possible directly measured functional species groups have been based on the conditions outlined by Speight and Castella, (2001) and systematic review (Smith and Humphry 2005). The Syphidae (hoverflies) and Shelled Gastrapods (Snails) groups fulfils the six Speight and Castella conditions. For both groups there are established field-tested methodologies for assessing key woodland niche functionality. There are, however, questions about the geographical range of gastropod species and whether there is sufficient species with a suitable distribution for the purposes of this project. This will be investigated further as this group would be useful to include as their dispersal rates are thought to be slow compared to the Syrphidae and so colonisation of new habitats will take longer.

The 'smoking gun' element uses the evidence of invertebrate activity on micro-habitats within a woodland as a rapid assessment of faunal biodiversity and therefore ecosystem function. It is proposed (Smith and Humphry 2005) that by measuring the evidence of activity of individual invertebrates or populations of invertebrates on a known unit of habitat (e.g. 1 metre of canopy branch) it will be possible to calculate an index of diversity for that unit. Changes in this index over time will reflect ecosystem development within a new native woodland.

Indirect signs of insects are more easily identified than the species themselves. Oliver and Beattie (1993) have shown that estimates of species richness, based on recognisable taxonomic groups, can be made by non-experts as readily as by taxonomic experts. This principle of biodiversity assessment has been put forward by

Angelstam and Donz-Breuss (2004) for dead wood species. While they recognise that the measure is coarse, it does allow for rapid assessment of elements of diversity. Some background research has been undertaken by Forest Research to test methods, justify them scientifically and validate them as a methodology for long-term monitoring. The further development of Rapid Assessments of Biodiversity is ongoing through the SFA monitoring programme looking at canopy leaf herbivores (leaf galls, miners, rollers, etc.)

Based on the above rational a detailed survey plan and protocols was developed (Smith and Humphrey 2006) which was then undertaken on the SFA site over the summers of 2006/7.A total of 398 plots were surveyed and the full details of these contained in the Alliance report on the first round of monitoring (Smith and Harcombe 2009). This provided the baseline on which subsequent rounds of monitoring can be compared.

For each of the sites there is report comprising:

a) Detailed qualitative description of each site – climate, soils and vegetation characteristics; planting schemes; photographic records; management inputs and site objectives etc.

b) Tabulated data from the first round of monitoring – standardised template for all sites showing tree related variables such as height, density, basal area (currently wooded sites) and vegetation measures (species presence/absence)

c) Analysis – data are recorded in section squares and elements within these. This allows for pattern analysis of the different vegetation communities in relation to extent of tree cover

d) Report key findings – interesting species, unusual patterns within the vegetation communities biodiversity etc

It is not intended that the monitoring should be used to compare between sites. Nevertheless combining the data from the sites allows greater replication and hence analytical power in terms of teasing out relationships between different species groups. At this stage with only tree and vegetation data finalised, there is limited scope for analysis other than to look for relationships between tree cover and vegetation as some of the sites already have established tree cover over part of the area (e.g. Glenmore). This also includes a record of any issues revealed by the monitoring, e.g. potential threats to rare vegetation assemblages and /or species from increasing tree cover or other management activities.

The analytical procedures outlined above would provide a basis for future analysis. Data from the second round of monitoring will allow the construction of a time series for each site. As there is replication of monitoring plots within sites, it should be possible to test statistically for changes in species abundances and distributions and for changes in functional groups in relation to change in forest cover over time.

There is scope for carrying out an analysis of syrphids, and gastropod datasets to reveal patterns in the different functional groups found within each of these taxa. This will allow testing of the relationship between functionality and forest cover/tree presence, i.e. in changes in the relative proportions of species in different functional groups in wooded as compared to unwooded conditions.  Similar analyses could be done which related the smoking gun measures ( leaf invertebrate activity) to the presence of forest cover.

This work is crucial in demonstrating support (or not) for the original paradigm underpinning the monitoring methodology, i.e. that changes in the proportions of different functional species groups and in the occurrence of “smoking gun” evidence are good indicators of woodland ecosystem development. We need this evidence to be assured that the monitoring will pick up changes in ecosystem development on the sites where trees have only just been established, but where woodland cover will develop over time.

LANDSCAPE ECOLOGY AND PLANNING

Spatial planning and landscape ecology can help to determine how best to expand our tree-cover for the benefit of biodiversity. A range of GIS-based tools can be used to support spatial planning. These provide the means to apply a landscape scale approach to habitat and resource management and to select land uses and habitats that are ecologically suited to sites. They can also help to ensure that new woodlands and trees are located where they can provide most benefit. This approach has been applied to the Great Trossachs Forest area. Here the neighbouring land-owning organisations of the Alliance are working across an extensive area of the Trossachs hope to achieve an enhanced and more integrated approach to the delivery of land management objectives for the benefit of biodiversity and people.

This proposes the development of a strategic approach to the planning and management to achieve better integration between forestry and other land-uses as a means of enhancing biodiversity at the landscape scale. One of the most important issues is the need to find a balance between semi-natural open ground and native woodland habitats. Through the UK Biodiversity Action Plan (UKBAP) process there is a continuing drive to restore and expand both semi-natural open and woodland habitats (UK Biodiversity Group, 1995a).  The Scottish Biodiversity Strategy (Anon, 2004) and the Scottish Forestry strategy (Anon, 2000) have reiterated a commitment to this process.

The Integrated Habitat Network (IHN) modelling approach will support this by providing a strategic framework for functioning habitat networks across The Great Trossachs Forest focusing on key woodland and open habitat types. Habitat networks are a configuration of habitats that allows species to move and disperse through the landscape. The development and application IHN modelling provides a Decision Support Tool that can identify areas that are ecologically connected and can be used to target and justify planning gain and conservation effort in relation to policy drivers.

The planning tools, ‘Biological and Environmental Evaluation Tools for Landscape Ecology’ (BEETLE), and ‘Ecological Site Classification’ (ESC-GIS), were employed in a desk study to test: a) the degree of fragmentation of Atlantic oakwood remnants within the matrix of secondary plantations and open ground; and b) the potential to convert stands of secondary woodland to native woodland types and reduce habitat fragmentation of remnant stands of Atlantic oakwood.

Least Cost Distance Tools for Focal Species of forest and open habitats and the Hybrid IFM connectivity Indicator (Watts and Handley 2009) within the BEETLE toolbox provides a landscape-scale approach to habitat management. These tools consider how habitat patches of different size and carrying capacity, and the successional and structural phases of forests are spatially arranged within the whole landscape. Landscape ecology focal species tools will be used to test how species may utilise and disperse between habitat patches. Various iterations of these models have been described by Humphrey et al. (2004a, b), Watts et al. (2004) and Humphrey et al. (2005), (Watts and Handley, 2009)

The Ecological Site Classification Decision Support System (ESC-DSS) was designed to be used at the stand-scale helping to guide forest managers and planners to select species that are ecologically suited to sites by drawing on site-related knowledge of suitability for a range of species. The method uses six factors as criteria for testing site suitability: four climatic factors (accumulated temperature, moisture deficit, windiness and continentally) and two soil quality factors (soil moisture regime and soil nutrient regime) (Pyatt et al., 2001). ESC-DSS (Ray, 2001) calculates the climatic indices from the grid reference and elevation of the site. The ESC suitability models assess which factor is likely to limit suitability and growth on any particular site by calculating a suitability score from response functions (Ray, 2001). ESC-GIS was used to give a landscape view of ecologically suitable species (Yield Classes of species) or habitat (NVC woodland type), deriving climate factors from a digital elevation model, and calculating default values of soil quality from digital soil maps, or vegetation community maps that had been validated by field surveys. This approach gives forest managers the ability to implement a landscape scale approach to habitat and forest management using ecologically suited species to sites.

The Integrated Habitat Network (IHN) modelling approach will support this by providing a strategic framework for functioning habitat networks across The Great Trossachs Forest. This involves joint working between Alliance members - WTS, RSPB & FCS - who own adjoining land across an extensive area of the Trossachs in central Scotland. The long term vision is landscape-scale habitat enhancement with a more integrated approach to woodland and other habitat management, biodiversity management and monitoring.

The network outputs constitute part of the decision-making system for strategies designed to reduce the impacts of habitat fragmentation and improve habitat connectivity and biodiversity. The interpretation and suggestions for the application of these outputs are part of this process but need to be implemented in conjunction with sound judgement, based on ecological principles.

The woodlands, grasslands, heathlands and wetlands of GTF been assessed using the Forest Research BEETLE: least cost distance tool in terms of their functional connectivity. The most up-to-date maps of the distribution of land cover types were assembled in a Geographic Information System (GIS). This land-cover data was related it to be best ecological information on species dispersal to evaluate habitat linkages across the study area. Different species have different dispersal abilities and habitat requirements. The different species selected are used to represent key functions of selected habitats and the species that use them

Habitat networks were calculated separately for each of the 8 focal species (woodlands, grasslands, heathlands and wetlands) and for 2 dispersal distances of: 500 m and 2 km. The dispersal distances have been derived from the autecological assessment, with the smaller distance representing a mean dispersal, and 2 km representing the maximum. By overlaying the 500m m network onto the 2 km network we can examine the extent of dispersal overlap of larger networks surrounding the smaller dispersal networks. This allows an assessment of the degree of permeability of the matrix (land cover types not classed as habitat) surrounding a woodland generalist network.

## CONCLUSIONS

Through the Alliance's biodiversity monitoring programme, an innovative set of protocols that can be used to assess the impacts of forest-based climate change projects on biodiversity has been developed.  The methodology has the be ability to assist in making comparisons between sites or projects, and track changes over time so that adaptive management can be put in place to maximise the biodiversity value and other ecosystem services that such projects provide. It is a forward looking approach that acknowledges woodland ecosystem development is a slow process and therefore the programme needs to be long term. The Alliance programme of monitoring has been designed to be repeated after 5 years and then every 10 years in order to track ecological change, over the 200 year lifetime of the project.

The approach allows for monitoring and planning to be linked into the future and the functionality of forest habitat networks assessed. The ecological connectivity of woodland areas that are predicted through the habitat network modelling can be tested through the plot based monitoring. In many ways the ideal scenario is where the focal species selected for the modelling is also included within the functional species groups. This, however, may not always be practical. Therefore the success of the habitat network should not only be measured by the presence of the focal species used, but also by the presence of species that are indicators of the ecological functioning of the habitats that make up the network. The future work of the Alliance biodiversity group can focus on developing such approaches

## REFERENCES

Angelstam, P. and Donz-Breuss, M. (2004) 'Measuring forest biodiversity – an evaluation of indicators in European forest history gradients', *Ecological Bulletins* 51: 305-332.

Chapin, F.S., III, E.D. Schulze and H.A. Mooney (1992) 'Biodiversity and ecosystem processes', *Trends in Ecology and Evolution* 7: 107-108.

Cohen, J.E. and F. Briand (1984) 'Trophic links of community food webs', *Proceedings of the National Academy of Sciences* 81: 4105-4109.

Cole, L.J., D.I. McCracken, P. Dennis, L. Baker and D. Parish (2002) 'Relationships between agricultural management and ecological groups of ground beetles of Scottish Farmland', *Agriculture, Ecology and Environment* 93: 323-335.

Davic, R.D. (2003) 'Linking keystone species and functional groups: a new operational definition of the keystone species concept', *Conservation Ecology* 7(1): article no r11.

Fox, B.J., and J. Brown (1993) 'Assembly rules for functional groups in North American desert rodent communities', *Oikos* 67: 358-370.

Humphrey, J.W. and Smith, M.A. (2006). 'SFA Biodiversity monitoring Survey plan and field protocols'. Unpublished Forest Research Ecology Division Survey Plan;

Humphrey, J.W.; Ray, D.; Watts, K.; Brown, C.; Poulsom, E.G.; Griffiths, M. & Broome, A.C. (2004a). Balancing upland and woodland strategic priorities. Scottish Natural Heritage Commissioned Report. 037 (ROAME No. F02AA101). Scottish Natural Heritage, Edinburgh.

Humphrey, J.W.; Hope, J.C.E. & Poulsom, E.G. (2004b).Balancing upland and woodland strategic priorities - phase 2.Unpublished contract report to Forestry Commission Scotland and Scottish Natural Heritage. Forest Research, Roslin, Midlothian.

Noss, R.F. (1999) 'Assessing and monitoring forest biodiversity: A suggested framework and indicators', Forest Ecology and Management 115(2-3): 135-146.

Oliver, I. and A.J. Beattie (1993) 'A possible method for the rapid assessment of biodiversity', *Conservation Biology* 7: 562 568.

Petchey, OL; Gaston, KJ (2002) 'Functional diversity, species richness and community composition', *Ecology Letters* 5: 402 411.

Pyatt, D.G.; Ray, D., & Fletcher, J. (2001) An Ecological Site Classification for Forestry in Great Britain : Bulletin 124 Forestry Commission, Edinburgh.

Ray, D. (2001) Ecological Site Classification Decision Support System V1.7 Forestry Commission - Edinburgh.

Schulze, E.D. and H.A. Mooney (1993) 'Ecosystem function of biodiversity: a summary'. In E.D. Schulze and H.A. Mooney (Eds) *Biodiversity and Ecosystem Function.* Springer-Verlag, Berlin, Germany, pp 497-510.

Smith, M.A. and Humphrey, J.W., (2005) Scottish Forest Alliance Biodiversity Group Developing a biodiversity monitoring system for the SFA sites: Paper 1 Proposals Internal Forest research report

Spanos, K.A. and A. Feest (2007) 'A review of the assessment of biodiversity in forest ecosystems' *Management of Environmental Quality* 18: 475-486.