RUSHMORE WOODLAND BIODIVERSITY RESEARCH PROJECT

Rushmore Estate

Dorset County Council

Dorset Environmental Records Centre

Manchester Metropolitan University

PROJECT DESCRIPTION

BACKGROUND

Since 1945, a number of ***woodland bird species*** sensitive to changes in woodland structure have been experiencing declines. Causes are varied e.g. shading, reduction of structural complexity due to lack of any woodland management and increasing effects of deer browsing which intensifies the simplification of vegetation structure. Despite the absence of primeval woodland in Britain, the development of structural heterogeneity through irregular or 'close to nature' management of woodlands has the potential to increase bird richness in structurally homogenous stands.

Well-structured woodland provides a large number of niches for ***invertebrates***, and in Britain, woodland has the richest invertebrate fauna of any habitat, resulting from the continuity of woodlands over thousands of years, the former abundance of woodland in the country, and the complexity of habitat within. In comparison with post-glacial wildwoods, the woods of today probably exhibit much less structural diversity and substantially fewer ancient trees than they did. One of the key aims of nature conservation in woodlands is to retain and rebuild niches that would have been present in wildwoods.

The ***management of broadleaved woodland***, in particular coppice woodland and wood pasture, has drastically altered the original wildwood: of these two dominant historic practices, 'coppice' contains few mature or over-mature trees and constrains structural complexity, whilst 'wood pasture' retains many ancient trees but tends to lose the characteristic woodland ground flora and structural diversity of the understorey. Management of woodland for game, and for intensive timber production, especially through introduction of plantation silviculture and non-native species, has also had drastic effects on what once would have been natural woodland.

Traditional management began to decline in the late 18th century and accelerated after the First World War. In the first half of the 19th century a significant proportion of woods in southern England were subject to plantings designed to convert coppice stands to high forest, often using a proportion of native species. Woods remaining under coppice management began to change through the tendency to allow or promote increased stocking of standards as the economic balance between underwood and overwood changed in the latter's favour. In the 20th century 'commercial' management of broadleaved woodland focused on conversion to even-aged plantations, usually of exotic species. Management activity declined in the remaining semi-natural stands, punctuated in some cases by drastic fellings to meet the demand of the wartime Ministry of Supply or of an owner's need for income.

Sometimes attempts have been made to apply even-aged, plantation forestry to semi-natural woodland by small-scale fellings and replanting but this has very rarely been sustained. Across a small area coppice management has been resumed with the aim of improving biodiversity but again has rarely been sustained on any scale.

The end result is that there has been, by design and by natural processes, both a general structural development towards high forest and a severe decline in the level of management intervention. This situation reflects the failure within the forestry and ecology professions to prescribe and implement a sustainable approach to the management of broadleaved woodland, particularly semi-natural broadleaved woodland.

Coppice management is not the only way to manage woodlands to create structural diversity, variation in light intensity and penetration. High forest can be managed to produce a range of structure and habitat conditions and this potential range of options is not widely appreciated; 'high forest' is often visualized as proceeding inevitably to close canopy, mature woodland.

Irregular high forest management, a form of Continuous Cover forest management, involves periodically and selectively harvesting individual trees or small groups of trees, creating a permanently irregular structure of mixed size stems; this allows existing trees with good timber potential to expand in size and permits the long-term regeneration and sustainable development of the stand. It also encourages the majority of stems within a stand to develop good crowns and increased resistance to disease pathogens. Natural regeneration of trees takes place sporadically throughout the stands and increases the chances of continual adaption to changing environmental or climatic conditions. The presence of an under-storey is encouraged as an important silvicultural tool in controlling the condition of the seed-bed. Irregular silviculture also allows individual retention of trees for other special qualities, such as veterans, elite trees supporting epiphytic flora, and trees of particular historic or landscape value.

Irregular high forest management is now an established management practice for deciduous woodland on four major estates in Dorset and south Wiltshire, and, with careful planning, timber marketing and the use of grant-aid structures, is showing positive economic return, even within ancient semi-natural stands.

There is, however, little scientific evidence as to the effects on biodiversity of such management practices in the UK and it is important to evaluate a potentially economically sustainable approach to the management of broadleaved woodland as an alternative to grant dependant coppicing or non-intervention/neglect.

Monitoring of forest stands in the UK to determine their biological and silvicultural development at the stand level is poorly developed. With regard to the measurement of timber increment and structure in irregular high forest there is established European practice and the Rushmore Estate is part of the Association de Futaie Irrégulière (AFI), a major European irregular high forest research network. This network's methodologies integrate silvicultural and economic data and also records some biological data covering deadwood and specific habitat features relating to individual trees. It does not, however, capture shrub layer structure nor does it currently capture the overall biodiversity value of a particular structure.

PROJECT OBJECTIVES

The proposal is to investigate the relationship between forest structure and biodiversity at the stand-level scale in a range of actively managed, semi-natural woodlands on the Dorset/Wiltshire border.

To undertake innovative research into the ramifications of irregular forest management in potentially enhancing biodiversity in semi-natural woodlands in Britain.

To explore the use of innovate methodologies in the study of woodland birds and invertebrates, including the use of indicator species to allow the development of monitoring protocols which would in due course allow the gathering of data relating to this relationship across a wider area.

PROJECT OUTLINE

The project will focus on two biotic groups: birds and invertebrates and their interaction with woodland vegetation as follows:

1. Birds

The research proposal is to investigate the responses of birds to differing woodland structures, comparing a range of structurally-varied stands in predominantly broadleaved, ancient semi-natural woodland. This will involve:

a. determining the habitat associations of particular woodland bird species by identifying the importance of resource provision within a range of different stand characteristics; and

b. understanding how woodland birds interact with the matrix in respect of foraging and dispersal behaviours in summer and winter.

It is proposed the work should be undertaken as a part time PhD by Danny Alder through Manchester Metropolitan University under the supervision of Dr Stuart Marsden.

A detailed project proposal for this part of the project is attached at Appendix 1.

2. Invertebrate Communities

This part of the research proposal will examine the effects of differing management on invertebrates, using moths as the key biometric indicator to determine any differences between coppice and irregular high forest stands. The aim is to identify patterns within moth assemblages, comparing range of species and abundance between types of woodland management. A variety of stand-types, concentrating on coppice, irregular high forest, and limited-intervention old growth stands, will be sampled using these methods to assess the relative effects of differing management prescription on moth assemblages.

Two methods of sampling will be developed:

1. Sampling the woodland shrub layer across stands within the Rushmore Estate woodlands over two field seasons to examine differences between stand-type. It may also be possible to assess more non-specific invertebrate damage, such as by counting holes or segments chewed in the leaves at the same time as counting leaf mines, as a measure of abundance of external-feeding larvae. Again, comparisons would be made between stand-type.

2. Within coppice and irregular high forest stands in one particular woodland block (Half Hide Coppice), sampling will be undertaken with a view to these stands becoming long-term monitoring stations. In this wood, the leaf-miner assemblage will be compared with moth trapping to determine relationships between leaf-mining moths and larger moths flying to traps. The aim here is to develop leaf miners as a tool for use by non-specialists as indicators of the invertebrate 'health' of woodlands in woodland monitoring and assessment.

It is proposed to engage a Masters-level research student to undertake sampling over two seasons. It is anticipated that the work would be carried out part-time. It will be important to establish feasibility and extent of sampling in the first year, and to refine the sampling effort for the second year.

A detailed project proposal for this part of the project is attached at Appendix 2.

3. Vegetation classification, Structural Complexity and Stand Structure

Underpinning research on birds and invertebrates is the need to determine vegetation composition (ground flora, shrub layer and canopy) within each stand type to be sampled. Other measures of stand composition and structural complexity are also likely to be helpful, including daylight penetration through the canopy. This work will be undertaken by Bryan Edwards of the Dorset Environmental Records Centre and Danny Alder, with assistance from Andy Poore.

4. Monitoring

The above work seeks to establish a relationship between structure and species diversity expressed in terms of key biotic groups related to the survey area. In addition the project will explore the use of indicator species, such as leaf miner moths, as a way of providing a short cut to the evaluation of biodiversity value as part of wider monitoring protocols such as those developed by the Association de Futaie Irrégulière (AFI). As part of this work AFI Research Stands will be set up in a few key stands.

In this way information about the relationship between stand structure, timber production, economic performance and biodiversity value can be obtained and integrated across a wider number of sites.

A description of the AFI Research Network is attached at Appendix 3.

RUSHMORE ESTATE SURVEY AREA

Management of the Rushmore Estate woodlands at Tollard Royal on the Dorset / Wiltshire border is on a grand scale for lowland England, covering 800ha, of which 400 ha is semi-natural woodland, forming one of the largest woodland SSSIs in England. The woods have a long history of management, forming the core of the area subject to the Cranborne Chase forestal rights until the mid-19th century.

The SSSI has been actively managed under a Plan agreed with Natural England since 1990.

Within the woodland there are now stands under a variety of management regimes, including:

- Stands under transformation to irregular high forest: these stands have been managed over the last 20 years by one of the leading UK practitioners in irregular silviculture.
- Active coppice management: the Estate retains the largest area of on-rotation native coppice in the UK and
- Limited-intervention high forest: areas where stand development is not subject to silvicultural interventions but where limited interventions designed to favour key biotic groups, such as lichen communities, are undertaken.

The opportunity is available at Rushmore to undertake monitoring of plants, invertebrates and birds (equating to 3 trophic levels in the woodland ecosystem) to attempt to understand and compare the effects on wildlife of irregular high forest management, coppice, alongside limited-intervention old growth and open high forest. The economic productivity of each stand type is also known, providing a unique chance to relate economic productivity with consequences for wildlife.

Andy Poore has been the forestry consultant at Rushmore since 1988 and is a member of the Association de Futaie Irrégulière (AFI), a major European irregular high forest research network. Research stands within this Network have been established on a number of Andy Poore's managed estates, including Rushmore.

PROJECT ORGANISATIONS & CONTRIBUTIONS

Rushmore Estate, Tollard Royal, Wiltshire: Survey site, supply of personnel & funding.

Dorset Environmental Record Centre: Accountable body for funding purposes & supply of personnel.

Dorset County Council: Supply of personnel & funding.

Manchester Metropolitan University: Supply of personnel & funding.

PROJECT TEAM

Dr Philip Sterling -Team Manager and County Ecologist, Natural Environment Team, Dorset County Council.

Danny Alder - Senior Ecologist, Natural Environment Team, Dorset County Council.

Dr Stuart J Marsden - Reader in Conservation Ecology, School of Science & the Environment, Manchester Metropolitan University.

Dr Jonathon S Ellis – Lecturer in Molecular Conservation Biology, Manchester Metropolitan University.

Bryan Edwards - Dorset Environmental Records Centre

Andy Poore - Forestry Consultant, Rushmore Estate

TIMETABLE

Activity / Calendar Year	Year 1	Year 2	Year 3	Year 4	Year 5
MRes& PhD studentships in place	Autumn 2013				
Establish sampling points representative of stands under investigation; D.Alder + MRes	Autumn 2013	Spring 2014 – revise as required following pilot work on inverts, birds and vegetation			
Habitat sampling – FloristicsB.Edwards	Summer 2013/14 NVC data available for stands under investigation				
Bird sampling – SM2 x10 D.Alder	Winter 2013- field test SM2 recorders and finalise methods	Spring + Autumn 2014 breeding and post-breeding data collected	Spring + Autumn 2015 breeding and post breeding data collected	Spring + Autumn 2016 breeding and post breeding data collected	Final data collection for gaps in bird data spring 2018
Analysis of bird sampling data, paper produced and final write up for PhD	Preliminary- calibration of recorders and finalise methods	Two periods to follow sampling times, paper produced in Forest Ecology and Management by spring 2015 →	Two periods to follow sampling times, paper produced in Ibis – OrnisFennica or Bird Study.	Analyse multitrophic data in relation to bird sampling for thesis preparation and third and fourth papers to be submitted to Biological Conservation, Journal of Wildlife Management, Forest Ecology and Management	Write up and submit PhD Thesis 'Acoustic methods to detect changes in the bird community within an innovative forest management regime'.
Leaf Miner sampling –MRes (P.S)	Autumn 2013	Summer 2014 + Autumn 2014; review of sampling methodology in spring 2015	Summer 2015; analysis during 2015; paper preparation following submission of dissertation	2 papers published	

Leaf miner sampling and moth trapping Phil Sterling &Volunteer	Continuation of research in Half Hide Coppice	Continuation of research in Half Hide Coppice	Continuation of research in Half Hide Coppice; paper preparation to match MRes outputs	Continuation of research in Half Hide Coppice	Continuation of research in Half Hide Coppice
Vegetation sampling; timber volume, tree density, vegetation structure-density & complexity D.Alder (A.P, S.M)	Basal area measures, tree height measures	Canopy cover measures and vegetation complexity data collected and analysed spring 2014			
Analysis of vegetation data D.Alder (S.M) paper produced		Autumn 2014 – Paper produced-Bird Study →			
Development & Integration of Monitoring Protocols (AP, PS, DA)				Set up AFI Research Stands with adapted draft methodology	
Dissemination of Results					Production of articles, reports etc
Activity / **Calendar Year**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**

PROJECT COSTS

	Item	Yr1	Yr2	Yr3	Yr4	Yr5	Totals	
BIRDS	D Alder Mileage cost (1200 miles pa @ 0.45p per mile)	500.00	500.00	500.00	500.00	500.00		
	Support services- IT, electronics, acoustics	85.00	85.00	85.00	100.00	100.00		
	D Alder University registration x cumulative increase 10% p/a	1,914.00	2,105.40	2,315.94	2,547.53	2,802.29		
	D Alder Living expenses to cover 3 months unpaid leave each year	5,000.00	5,000.00	5,250.00	5,250.00	5,500.00		
	Field study equipment (acoustic recording units, field loggers etc)	9,754.55						
	Supervision from S.Marsden	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00		
	SUB-TOTAL	18,753.55	9,190.40	9,650.94	9,897.53	10,402.29	**£57,894.71**	
INVERTEBRATES	All personnel: Mileage cost (1200 miles pa @ 0.45p per mile)	1,500.00	1,500.00	1,000.00	1,000.00	1,000.00		
	Support services- IT	85.00	85.00	85.00				
	M Res University registration x cumulative increase 10% p/a	1,914.00	2,105.40					
	M Res student Living expenses to cover 3 months each year	3,000.00	3,000.00					
	Field study equipment (e.g. spherical densiometer, moth traps/ batteries)	680.00	680.00	380.00	380.00	380.00		
	Supervision costs MMU	500.00	500.00					
	P Sterling: Project management & implementation	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00		
	SUB-TOTAL	11,679.00	11,870.40	5,465.00	5,380.00	5,380.00	**£39,774.40**	
VEGETATION, SILVICULTURE & MONITORING	Vegetation Survey Bryan Edwards DERC	3,000.00						
	Silvicultural research input: Andy Poore	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00		
	Establishment of AFI research network plots				7,500.00			
	Integration of results into monitoring methodologies/ management guidance initiatuves				2,000.00	5,000.00		
	SUB-TOTAL	4,500.00	1,500.00	1,500.00	11,000.00	6,500.00	**£25,000.00**	
PROJECT ADMINISTRATION		1,000.00	1,000.00	1,000.00	1,000.00	1,500.00	**£5,500.00**	
GRAND TOTALS		**£35,932.55**	**£23,560.80**	**£17,615.94**	**£27,277.53**	**£23,782.29**		**£128,169.11**

OUTPUTS & OUTCOMES OF THIS RESEARCH

- Four published papers in ecology journals e.g. Biological Conservation, British Wildlife.
- Article in the Continuous Cover Forestry Group Newsletter.
- National dissemination to policy makers through the Forestry Commission, Continuous Cover Forestry Group, Manchester Metropolitan University.
- Production of non-specialist interpretative material for local dissemination through the Rushmore Estate and Dorset County Council.
- Collaboration with the Association de Futaie Irrégulière over the development of their research network methodology.
- Contribute to local studies into the effects on biodiversity of continuous cover forestry by Forestry Consultant Mr Andy Poore.
- Collaboration with the Forestry Commission and feedback to the regional and national offices
- Influence on the policy and management guidance issued by the Forestry Commission on the environmental benefits of irregular forest management regimes in the context of semi-natural woodlands in Britain.
- Influence over emerging woodland management policy in Natural England.
- Ecological monitoring protocols that can be rolled out in part or fully across all the irregular research stands in Western Europe.

A. Poore/ P.Sterling/ D. Alder

18th March 2013

APPENDIX 1

Irregular forestry and the avian community; emerging silvicultural and acoustic sampling methods for semi natural woodlands

Danny Alder

Introduction

Since 1945, a number of woodland bird species sensitive to changes in woodland structure are experiencing declines (Hewson *et al* 2007). Causes are varied e.g. shading, reduction of structural complexity due to lack of any woodland management and increasing effects of deer browsing which intensifies the simplification of vegetation structure (Fuller *et al* 2005). Despite the absence of primeval woodland in Britain, the development of structural heterogeneity through irregular or 'close to nature' management of woodlands has the potential to increase bird species richness in structurally homogenous stands (Wesolowski 2007).Within the European Forestry sector there is growing support for the use of irregular silviculture, (as opposed to even-aged high-forest management), where the aim is to create permanently irregular structures at stand level and where management seeks to use natural woodland processes (Susse *et al* 2011). Harvesting is selective and on an individual tree basis. This management approach has the potential to alter habitat quality for a range of woodland birds and other taxa, yet there is a distinct lack of ecological evidence on the effects (positive and negative) of irregular silviculture (Mason 2007). It is plausible that woodland management which improves habitat quality can lower area thresholds for maintaining viable populations of some woodland birds, e.g. Alderman *et al* (2005).

Behavioural responses to habitat characteristics

There are substantial gaps in our knowledge of the ecological effects of irrregular silviculture on woodland birds (Quine *et al* 2007). Understanding the behaviour of individual species is essential on several counts relating to conservation management (Sutherland 1998) e.g. species area requirements, and foraging activity. Behavioural constraints are likely to determine how species respond to stand management (Robertson and Hutto 2007) as some bird species are reluctant to cross forest gaps (Creegan and Osborne 2005, Harris and Reed 2002), predation risk may increase around woodland edges (Thompson 2007), or foraging behaviour is influenced by habitat cues (Alder and Marsden 2010) with birds possibly missing food resources present in significantly modified woodland (Rolstad *et al* 2000) and by dispersal into suboptimal habitats (Gilroy and Sutherland 2007). There is a paucity of relevant evidence to inform woodland management policy in these respects (Dolman *et al* 2007, Fuller *et al* 2007), which is becoming increasingly urgent in respect to our preparedness for the effects of climate changes (Bailey 2007), future projections of woodfuel demand (Fuller and Rothery 2010) and trends in the population dynamics of wild deer (Fuller and Gill 2010). The effect of irregular silviculture in ameliorating negative effects to, and potentially enhancing, biodiversity in general and woodland birds particularly requires research in Britain (Fuller *et al* 2007).

Stand management: opportunities for woodland birds.

Exploring fine-scale habitat relationships can be especially informative in woodlands, e.g. Broughton *et al* (2010) and Holt *et al* (2010), particularly for our understanding of how management interventions at the stand level affect bird distribution and abundance (Hewson *et al* 2011, Nikolov 2009). Knowledge of the way individuals use woodland habitat structures to identify thresholds of use or avoidance is especially valuable for developing conservation prescriptions (Fuller *et al* 2007). Stand management provides opportunities to develop heterogeneity within and between stands creating a broad range of structures from open patches to old growth (Quine *et al* 2007). Yet the ecological relationships existing within irregular high forest stands have received little attention by researchers in the UK (Fuller *et al* 2007 and A. Poore pers.comm). Apart from studies in even-aged, upland plantations (Petty 1989), much of the information which exists comes from studies in North America (Robinson and Robinson 1999, Hayes *et al* 2003, Heltzel and Leberg 2006, Twedt and Somershoe 2009) or Scandinavia (Virkkala and Liehu 1990). Simon (unpubl) highlighted the importance of abiotic influences upon stand characteristics and arthropod biomass, and the ways these affected songbird populations in Labrador, Canada (A.Diamond. pers.comm.). It is important to identify those factors which influence habitat structure and species composition in relation to foraging resources e.g. Holt *et al* (2011). As such, understanding habitat influences upon woodland birds at the stand level will be crucial as the subtleties of habitat use differ between closely related species (Hewson *et al* 2011).

Academic Aim

The aim of this MPhil/PhD is to identify the fine scale and multi-trophic features of woodland stands that determine the distribution and abundance of key woodland bird species within a working UK woodland mosaic. The goal is to investigate the avian responses to different woodland structures comparing a range of structurally varied stands in predominantly broadleaf ancient semi-natural woodland. This will involve; (1) determining the habitat associations by identifying the relative importance of resource provision of a range of different stand characteristics to woodland birds and (2) understanding how woodland birds interact with the matrix in respect of foraging and dispersal behaviours in summer and winter. Novel acoustic sampling methods will be used to provide measures of avian occupancy.

The proposed research stands will be semi-natural deciduous and deciduous mixed woodlands at the Rushmore Estate at Tollard Royal, on the Dorset - Wiltshire border. The woodlands comprise stand types of differing density, size classes, and degrees of canopy openness and under storey complexity. They include stands undergoing transformation to irregular high forest with a developing irregular structure, stands with even-aged elements resulting from shelterwood interventions, simple coppice systems and stands with old growth and even-aged mature high forest. It will be important to identify spatial patterns and gradients of habitat variation across these woodland stands in order to determine habitat resource thresholds above or below which changes in use by woodland birds are detected (Butcher *et al* 2010). For instance in Finland Suorsa *et al* (2003) found a negative relationship between territory size in the treecreeper *Certhia familiaris*, and decreasing timber volume which in part was related to lower diameter of tree stems. Another study on marsh tit, *Poecile palustris*, showed that this species was largely absent from areas with dense tree canopy and undeveloped shrub-layer, (Hinsley *et al* 2007).

Objectives

1. To identify the habitat features which most strongly influence variation in the woodland bird community, in particular relating to the management of stands in respect of stand type, tree species composition, tree basal area and the matrix around them e.g. edge to stand area ratios, under storey density and especially complexity (Marsden *et al* 2002).
2. To identify threshold values for different bird species in habitat elements in different woodland stand types. The principal measures will be woodland bird presence/absence, bird species richness/diversity and relative abundance relating to stand characteristics, tree architecture and microhabitats e.g. Vuidot *et al* (2011), and deadwood volume e.g. Smith (2007). A structural gradient which relates these factors to silvicultural management across the different stands will be identified. Invertebrate biomass will be considered, especially leaf mining moths and how these relate to the other biotic and abiotic factors that have strong influences on woodland bird habitat characteristics. A priority will be to develop predictive models which identify thresholds of stand structure and/or composition for woodland specialist birds and their foraging resources.
3. To build upon the results of 2, it will be important to explore in more detail, microhabitat characteristics and heterogeneity within and between stands using behavioural observations of targeted woodland birds. Foraging and movement behaviour of selected woodland specialists e.g. marsh tit, treecreeper, tawny owl and nuthatch, will be studied across the woodland stands and associated matrix habitats. This will help to identify the key habitat features that influence foraging behaviour and promote dispersal during the breeding season and post and pre -breeding period during winter.

Methods

1. To meet with objective one, stratified sampling across stands will be undertaken to identify the communities of woodland birds using ≥ 200 location points chosen from a 150m grid. Woodland stands will be categorised according to size, semi natural habitats and plant communities (NVC or Phase 1), floristics, i.e. plant species richness/diversity will be sampled. Physical characteristics will be measured including soil type, pH and soil moisture, along with litter depth, vegetation/under-storey density, complexity and height. Stand characteristics will be quantified using proportional values of timber basal area along with estimates of canopy cover (Hale 2004), deadwood volume and tree size/age classes and tree architecture. The collection of invertebrate data by ecologists will be undertaken and will be related to the woodland bird communities across different stand types. For a suggested invertebrate sampling method see Holt *et al* (2011). A relative index of browsing impacts by wild deer will be used to examine any differences between woodland stands.

2. Woodland bird communities will be surveyed in both winter and summer and abundance estimates calculated using acoustic sampling (Venier *et al* 2012). These will be representative of the vegetation communities recorded across the different woodland stands from 1 above and derived using an acoustic richness measure (e.g. Celis-Murillo *et al* 2008). This will permit a model to be developed which captures the ecological gradient along which threshold values may be derived for bird abundance related to woodland attributes. Acoustic studies of forest birds are increasingly

becoming more valuable as computational power has developed, and song recognition tools allow for better detection of species using large data-sets from automated recording, (Brandes 2008).Methods are being refined which allow acoustic surveys to inform biodiversity assessments at both alpha and beta scales of diversity in temperate wooded landscapes, (Depraetere *et al* 2012). Bird distribution and species richness measures can be derived from parameters of calls and song types identified visually in spectrograms and using song recognition software (Blumstein *et al* 2011). Studies have shown how acoustic recording units compare favourably with standardised mist-netting and visual point-count methods (Acevedo and Villanueva-Rivera, 2006). Recent improvements in the collection of density estimates using acoustic recordings show considerable promise, with benefits of avoidance of disturbance by the observer and further analysis of recordings long after field work has ended (Dawson and Efford 2009).

3. Selected resident bird species e.g. marsh tit *Poecile palustris* an understorey forager, nuthatch *Sitta europaea* a bark and canopy gleaner and tawny owl *Strix aluco* a principle woodland predator of small mammals will be studied in detail within a sub-sample of the woodland stands. These are species which maintain year round territories but respond to changes in habitat quality. Tawny owls are known to be sensitive to changes in vegetation structure affecting their prey (Petty 1989), while marsh tit shows a strong association with dense shrub layer (Hinsley *et al* 2007) and may benefit from a more open canopy associated with selective felling in continuous cover stands. Nuthatch has a strong affinity with mature deciduous trees (Matthysen 1998). Using microphone arrays to obtain localised fixes on these birds (Blumstein *et al* 2011, Menhill*et al* 2012), and possibly observations of colour ringed individuals, detailed foraging habitat measures will be made in the habitats immediately surrounding each foraging site and compared to ≥ 120 randomly selected plots within the woodlands across the study area. At the feeding site scale bird foraging behaviour will be recorded, alongside data on feeding substrate and prey species where possible e.g. Alder and Marsden (2010). Bird research will be linked to the research on lepidoptera being undertaken separately in the same study plots with measures of leaf mining moth abundance/biomass (see objective 2 above). Comparison will be made between the sites used by the birds and those that were not, yet were assumed to be available to them, from random sample points with selection explored at different levels; A. within home ranges; and B. within the study woodland stands. It should be possible to identify the important stand characteristics where specialist birds become more or less frequent in their habitat selection. Using the above data a multivariate analysis e.g. canononical correspondence analysis will illustrate the gradients and relationships between different taxa and habitat features. More specific models can be constructed which predict the likelihood of particular species being present depending upon the detailed stand characteristics identified.

Table 1. Timetable – Summer and winter columns shown while green cells denote extension to study for PhD if resources permit.

Year	One		Two		Three		Four		Five	
Literature review	■									
Field research 1		■	■	■						
Preliminary analysis			■							
Field research 2					■		■	■		
Analysis / write up					■	■		■	■	
Field research 3									■	
Analysis/write up									■	■

Collaboration and Training

The Director of Studies for the PhD will be Dr Stuart Marsden of Manchester Metropolitan University who will oversee training in sampling for bird density estimates, forest structural complexity assessment (e.g. FRAGSTATS) and statistical analysis. Access to larger core woodlands will be provided by Mr Andy Poore, Forestry Consultant to the Rushmore Estate. Andy will be co-supervising the research along with Dr Phil Sterling who will provide support in respect of invertebrate assessment and data collection. The British Library, Wildlife Sound Section will provide reference calls of woodland birds for use in analysis. Environmental data on woodlands across the study area will be supplied by Dorset Environmental Records Centre.

Short *Curriculum Vitae*

Danny Alder has more than 20 year's working knowledge of nature conservation mostly with Dorset County Council. Since 2004 Danny has worked as an ecologist undertaking field surveys of habitats and protected species as part of an advisory role to the local authority. Current activities include collaborating with colleagues in developing a woodland management project particularly relating to woodfuel. In 2008 he completed a Master of Science degree with Manchester Metropolitan University, in Countryside Management by Research, gaining a distinction. The field work on Green Woodpeckers culminated in joint authoring with Dr Marsden in the journal *Bird Study* in February 2010.

References

Alder, D., and Marsden, S. (2010). Characteristics of feeding□site selection by breeding GreenWoodpeckers Picusviridis in a UK agricultural landscape. *Bird study*, *57*(1), 100-107.

Alderman, J., McCollin, D., Hinsley, S.A., Bellamy, P.E., Picton, P.and Crockett, R. (2005).Modelling the effects of dispersal and landscape configuration on population distribution and viability in fragmented habitat.*Landscape Ecol*. **20**: 857–870.

Acevedo, M. A., and Villanueva-Rivera, L. J. (2006). Using automated digital recording systems as effective tools for the monitoring of birds and amphibians.*Wildlife Society Bulletin*, *34*(1), 211-214.

Bailey, S. (2007) Increasing connectivity in fragmented landscapes: an investigation of evidence for biodiversity gains in woodlands. *For. Ecol. Manage*. 238: 7–23

Blumstein, D., Mennill, D., Clemins, P., Girod, L., Yao, K., Patricelli, G., Deppe, J., Krakauer, A., Clark, C., Cortopassi, K., Hanser, S., McCowan, B., Ali, A. and Kirschel, A. (2011) Acoustic monitoring in terrestrial environments using microphone arrays: applications, technological considerations and prospectus. Journal of Applied Ecology, 48, 758–767.

Brandes, T. S. (2008). Automated sound recording and analysis techniques for bird surveys and conservation. Bird Conservation International 18:S163–S173.

Butcher, J. A., Morrison, M. L. Ransom, Jr. R. D., Slack R. D and Wilkins. R. N. (2010). Evidence of a minimum patch size threshold of reproductive success in an endangered songbird. Journal of Wildlife Management 74:133–139.

Broughton, R.K., Hill, R.A., Bellamy, P.E, Hinsley S.A (2010) Dispersal, ranging and settling behaviour of Marsh Tits *Poecile palustris* in a fragmented landscape in lowland England. Bird Study, 57: 4, 458 — 472

Celis-Murillo, A., Deppe, J. L., & Allen, M. F. (2009). Using soundscape recordings to estimate bird species abundance, richness, and composition. *Journal of Field Ornithology*, *80*(1), 64-78.

Charman, E.C, Smith, K. W.,Gruar, D. J., Dodd, S. and Grice, P. V. (2010) Characteristics of woods used recently and historically by Lesser Spotted Woodpeckers, *Dendrocopos minor* in England. Ibis, 152, 543–555

Dawson, D. K., and Efford, M. G. (2009). Bird population density estimated from acoustic signals. Journal of Applied Ecology, 46(6), 1201-1209.

Depraetere, M., Pavoine, S., Jiguet, F., Gasc, A., Duvail, S., and Sueur, J. (2012). Monitoring animal diversity using acoustic indices: Implementation in a temperate woodland. *Ecological Indicators*, *13*(1), 46-54.

Fuller, R.J., Noble, D.G., Smith, K.W. and Vanhinsbergh, D. (2005) Recent declines in populations of woodland birds in Britain: a review of possible causes. *British Birds* 98: 116–143.

Fuller, R.J. and Gill, R.M.A. (2010) BOU Proceedings - The impacts on Non-native Species. http:/www.bou.org.uk/bouproc-net/non-natives/fuller-gill20100531.pdf (accessed 31/3/2011)

Fuller, R.J. and Rothery, P. (2010) Woodfuel management: prospects for reversing declines in woodland birds. BOU Proceedings – Climate Change and Birds. http://www.bou.org.uk/bouprocnet/
ccb/fullerandrothery.pdf (date accessed 20th November 2010)

Fuller, R. J., Smith, K. W., Grice, P. V., Currie, F. A, and Quine, C. P. (2007) Habitat change and woodland birds in Britain: implications for management and future research. Ibis, 149 (Suppl.) 261-268.

Creegan, H. P. and Osborne, P. E. (2005) Gap-crossing decisions of woodland songbirds in Scotland: an experimental approach. *Journal of Applied Ecology,***42,** 678-687.

Gill, R.M.A. and Fuller, R.J. (2007).The effects of deer browsing on woodland structure and songbirds in lowland Britain.Ibis 149 (Suppl. 2): 119–127.

Gilroy, J. J., and Sutherland W. J. (2007). Beyond ecological traps: perceptual errors and undervalued resources. *Trends In Ecology and Evolution***22**:351–356.

Hale, S. (2004) Managing Light to Enable Natural Regeneration in British Conifer Forests. Information Note. Forest Research, Edinburgh.

Harris, R. J., and J. M. Reed.(2002). Behavioral barriers to non-migratory movements of birds.AnnalesZoologiciFennici 39:275–290

Hayes, J. P., Weikel, J. M. and Huso, M. M. P. (2003).Response of birds to thinning young Douglas-fir forests.*Ecological Applications* 13:1222–1232.

Hewson, C.M, Armur, A, Lindsell, J. A., Thewliss, R.M, Butler, S., Smith, K.W., Fuller, R.J (2007) Recent changes in bird populations in British broadleaved woodland Ibis, 149 (Suppl. 2), 14–28.

Hewson, C.M, Austing, G.E, Gough, S.J and Fuller, R.J (2011) Species-specific responses of woodland birds to stand-level habitat characteristics: The dual importance of forest structure and floristics.Forest Ecology and Management. Vol.261 Issue 7, 1 April 2011.

Heltzel, J. M., and Leberg P. L. (2006) Effects of selective logging on breeding bird communities in bottomland hardwood forests in Louisiana. Journal of Wildlife Management 70:1416-1424.

Hinsley, S.A., Carpenter, J.E., Broughton, R.K., Bellamy, P.E.,Rothery, P., Amar, A, Hewson, C.M and Gosler, A.G. (2007).Habitat selection by Marsh Tits *Poecilepalustris* in the UK. Ibis 149 (Suppl. 2): 225–234.

Holt, C.A., Fuller, R.J. and Dolman, P.M. (2010) Experimental evidence that deer browsing reduces habitat suitability for breeding Common Nightingales *Lusciniamegarhynchos*. *Ibis*152: 335-346.

Holt, C.A., Fuller, R.J. and Dolman, P.M. (2011). Breeding and post-breeding season responses of birds to modification of habitat structure by deer. Biological Conservation 144: 2151-2162.

Lee, D. C. and Marsden, S. J. (2008). Adjusting count period strategies to improve the accuracy of forest bird abundance estimates from point transect distance sampling surveys. *Ibis*.150: 315-325.

Marsden, S.J., Fielding, A.H., Mead, C., Hussin, M.Z.,(2002). A technique for measuring the density and complexity of understorey vegetation in tropical forests.Forest Ecology and.Management. 165, 117–123.

Mason, W. **(**2007).Changes in the management of British forests and future trends.*Ibis* **149** (Suppl. 2): 41–52.

Mennill, D. J., Battiston, M., Wilson, D. R., Foote, J. R., and Doucet, S. M. (2012). Field test of an affordable, portable, wireless microphone array for spatial monitoring of animal ecology and behaviour. Methods in Ecology and Evolution Volume 3 Issue 4, 704-712.

Nikolov, S., C. (2009) Effect of stand age on bird communities in late successional Macedonian pine forests in Bulgaria. Forest Ecology and Management, 257: 580-587.

Petty, S.J. (1989) Productivity and density of tawny owls *Strixaluco*, in relation to the structure of a spruce forest in Britain. Ann. Zool. Fennici 26: 227-233.

Quine, C.P., Fuller, R.J., Smith, K.W. and Grice, P.V. (2007). Stand management – a threat or opportunity for birds in British woodland? *Ibis* 149 (Suppl. 2): 161–174.

Robertson, B. A., and Hutto, R. L. (2007) Is selectively harvested forest an ecological trap for Olive- sided Flycatchers? The Condor 109:109–121

Robinson, W. D, and. Robinson S. K. (1999) Effects of selective logging on forest bird populations in a fragmented landscape. Conservation Biology 13:58–66.

Rolstad, J., Løken, B. and Rolstad, E. (2000). Habitat selection as a hierarchical spatial process: the Green Woodpecker at the northern edge of its range. *Oecologia*124:116–129.

Suorsa, P., E. Huhta, A. Jäntti, A. Nikula, H. Helle, M. Kuitunen, V. Koivunen and H. Hakkarainen, (2005). Thresholds in selection of breeding habitat by the Eurasian treecreeper (*Certhiafamiliaris*).*Biological Conservation*, 121: 443–452.

Susse, R, Allegrini, C., Bruciamacchie, M, and Burrus, R. (2011) Management of Irregular Forests: developing the full potential of the forest. Association FutaieIrreguliere.English translation P.Morgan 144pp.

Sutherland**,** W.J.(1998). The importance of behaviouralstudies in conservation biology. Animal Behaviour, 56, 801-809.

Smith, K.W. (2007). The utilisation of dead wood resources by woodpeckers in Britain. Ibis 149 (Suppl. 2): 183–192.

Thompson, F.R. (2007) Factors affecting nest predation on forest songbirds in North America. Ibis 149 (Suppl. 2): 98–109.

Twedt, D.J.andSomershoe S.G. (2009) Bird response to prescribed silvicultural treatments in bottomland hardwood forests. Journal of Wildlife Management 73 (7): 1140-1150.

Venier, L. A., Holmes, S. B., Holborn, G. W., Mcilwrick, K. A., and Brown, G. (2012) Evaluation of an automated recording device for monitoring forest birds. Wildlife Society Bulletin.36(1):30–39.

Vuidot, A., Paillet, Y., Archaux, F., Gosselin, F., (2011). Influence of tree characteristics and forest management on tree microhabitats. Biological Conservation 144: 441-450.

Virkkala, R., Liehu, H., (1990). Habitat selection by the Siberian Tit *Paruscinctus* in virgin and managed forests in N. Finland. OrnisFenn. 67, 1–12.

Wesolowski, T. (2007). Primeval conditions; what can we learn from them? *Ibis* 149(Suppl. 2): 64–77.

APPENDIX 2

Insects and Forest Management
Rapid sampling for leaf-mining moths as a tool for understanding the effects of management on insect communities

Phil Sterling

Woodland management and its effects on invertebrates

Well-structured woodland provides a large number of niches for invertebrates, and in Britain, woodland has the richest invertebrate fauna of any habitat, resulting from the continuity of woodlands over thousands of years, the former abundance of woodland in the country, and the complexity of habitat within. In comparison with post-glacial wildwoods, the woods of today probably exhibit much less structural diversity and very many fewer ancient trees than they did. One of the key aims of nature conservation in woodlands is to retain and rebuild niches that would have been present in wildwoods.

Concerning nature conservation, leaving aside the importance of management for deadwood niches, the concentration of effort has been on trying to re-establish traditional coppice management, and to create and enhance open areas along existing rides (Kirby, 1992). A number of characteristic woodland species, especially a small group of our now rare woodland butterflies, are thermophilous species of woodland edges and glades, which cannot survive under woodland canopy or in deep rideside shade. They have seen catastrophic declines in line with reduction in active management. There is good evidence to show that where such species survive, they do much better when coppicing is reinstated, or ride management is carried out for them; numbers of butterflies rapidly increase following open space being provided, reflecting the response of their foodplants and the butterflies to the increase in light and warmth e.g. Warren (1985, 1987). Some deadwood invertebrates living in woodland require flowers as adults from which they gather nectar as an integral part of their life cycle; canopy closure reduces the opportunities for flowering, whilst open spaces ensure continuity of this aspect (Bouget & Duelli, 2004).

From an invertebrate viewpoint, there is limited documentary evidence to show benefits of coppicing or ride management beyond those shown for the thermophilous species; there is an indication that certain groups of moths, those defined as 'Common & Severely Declining', do better within open, actively managed coppice or rides, although this list of moths includes species which are not woodland species (Merckx *et al*., 2012). Importantly, this paper demonstrates that overall macro-moth abundance and species richness was lower at coppiced sites and within wide rides than 'standard' high forest woodland and rides. They also showed that unmanaged high forest supported high numbers and species, and especially for scarce and Red Data Book species. This is backed up by Broome *et al*. (2011), working within coppice woodland up to 20 years old, who found that mature closed-canopy coppice supported a distinctive suite of scarce moth species, as well as greater species richness and abundance than earlier year-classes. Similarly, abundance and species richness of leaf-miner assemblies and spiders (Sterling & Hambler, 1988) and macro-moths (Waring, 1988) were shown to be higher in neglected areas than within actively managed coppice. There is growing evidence, therefore, that unless there is a realistic chance of benefiting thermophilous species, re-coppicing may simply end up damaging what invertebrate diversity remains.

Coppice management is not the only way to manage woodlands to create structural diversity, and variation in light penetration, and open spaces. High forest can be managed to produce a range of structure and habitat conditions and this potential range of options is not widely appreciated; high forest is often visualized as close canopy, mature woodland as in the 'standard' woodland category used in Merckx *et al.* 2012.

Irregular high forest management, a form of Continuous cover forest management, which involves periodically and selectively harvesting individual trees or small groups of trees, creating a permanently irregular structure of mixed size stems e gaps which to allows existing trees with good timber potential to expand in size and which the long-term regeneration and sustension of the stand. It also encourages the majority of stems within a stand to develop good crowns and increased resistance to disease pathogens. Natural regeneration of trees takes place in the gaps sporadically throughout the stands, which is a fundamental aspect of the selection system, creating an intimate mix of different-aged trees and increases the chances of continual adaption to changing environmental or climatic conditions. The irregular silviculture selection system also allows individual retention of trees for other special qualities, such as veterans, elite trees supporting epiphytic flora, and trees of particular historic or landscape value.

Management & Invertebrate communities

Understanding the effects of management on invertebrates within almost any habitat types has long been a difficult topic. There are plenty of techniques available for gathering samples of invertebrates. They include passive trapping using pit-fall traps for ground-living species, and malaise, light, and water traps for aerial species, as well as more active sampling techniques using sweep nets, beating trays and vacuum samplers, and the options are about as diverse as the invertebrate communities to be sampled. Indeed, each technique has its advantages and drawbacks. For example, pit-fall and malaise traps often sample vast numbers and a good species range of invertebrates, mainly insects, but can take considerable time to sort and identify, and the expertise to do so competently is rarely available. Moth traps have advantages and disadvantages: they tend to catch fewer species and adult moths are relatively easy to recognise with practice, but their mobility means that it can be difficult to determine precisely the effects of management treatment on what has been caught, and difficult to control any effect of variation in UV light scatter between treatments.

To analyse effects of management treatment, what is usually required is a degree of certainty about the origin of the invertebrate that has been sampled. Pit-fall traps provide reliable data in this respect; the invertebrate has fallen into the trap, therefore it is reasonable to assume that it was living close by. The more active sampling techniques can provide similar confidence, though controlling sampling effort is more complicated.

One little researched tool, however, is the potential for insect leaf-miner assemblies (groups of species) to provide convenient, fast counts of these tiny insects. It works on the principle of counting the artefacts the insect leaves behind, the track or leaf-mine it made when burrowing through leaf tissue, rather than the insect itself. Leaf miners are present in almost all vegetation types, and especially woodland. They have been used in woodland situations before, demonstrating clear differences between 'treatments' in coppiced woodlands (Sterling & Hambler, 1988; Sterling *et al*., 1992), and they offer considerable potential for understanding the effects of CCF and other management practices in the woodlands at Rushmore.

Background to leaf miners

Leaf miners are insects whose larvae live within the lamina of the leaf, usually burrowing through the parenchyma between upper and lower epidermis, and as they feed they usually leave behind a track, or mine, as evidence of where they have been. As a feeding behaviour, leaf mining occurs in several insect groups, particularly Lepidoptera (moths), Diptera (true flies), Coleoptera (beetles) and Hymenoptera (saw-flies). In total in the British Isles there are many hundreds of species, and examples can be found in most vegetated habitats.

In the British Isles the leaf miners are an extremely diverse group, comprising many hundreds of species, and examples can be found in most vegetated habitats. They are important in their own right as 'biodiversity', and are part of the food web, for example, they are prey for birds, small mammals and predatory invertebrates.

In terms of their use as an assessment tool, they offer considerable advantages over other groups, with only a few inherent problems:

Advantages

- there are many species found in most habitats, exhibiting the full range of distribution from ubiquitous to highly restricted, and of abundance from very common to very rare
- they are found on most vascular plant species, from grasses and herbs to woody shrubs and trees, conifer and deciduous; there are a very few species on pteridophytes
- the mines they form are usually many times larger than the larvae that made them and easily visible to the naked eye
- mines can be assessed in a systematic way, either using quadrat methods in grassland habitats, or by counting numbers of leaves on shrubs or trees
- mines survive for weeks, sometimes months, after the larvae have vacated to pupate, or have died in the mines
- counting mines in the field is usually weather-independent
- on each plant species there is only a small range of species to identify; non-experts could easily be trained to identify selections of species
- many mines can be identified to species level
- the mine is a precise location of where the female insect decided to lay that ovum; this provides certainty of origin of breeding / feeding sites for determining the effects of management on leaf-miner assemblies
- sampling of leaf mines is quick and simple, and with practice can be achieved at a pace on slightly slower than the physical counting of leaves, one-by one, noting each species and abundance as it is encountered

Disadvantages

- leaf-miners are hardly recognised by insect recorders so information on identification is poor in comparison with larger species; there is one good UK-based website, and a few keys for some taxa in the UK and Europe
- they are herbivorous, so do not represent saproxylic, predatory or scavenger insect assemblies; they are unlikely to tell us much about deadwood fauna
- they are all small or very small insects, so may not be representative of larger insects
- some tenanted leaf mines need to be retained and the adult species reared to confirm identity; this is not always easy and emergence of the insect may be months after collection

Academic Aim: studies on leaf-mining and other moths at Rushmore

This research proposal intends to examine at Rushmore the effects of differing management on invertebrates, using leaf-mining moths as the key biometric indicator, and to undertake repeated moth trapping to examine differences between coppice and irregular high forest stands.

The aim is to identify patterns in invertebrate community richness and abundance in relation to woodland management. A variety of stand-types, concentrating on coppice, irregular high forest, and limited-intervention old growth stands, will be sampled using these methods to assess the relative importance of different management prescriptions on invertebrate communities.

Methods of sampling will be developed, particularly looking at the leaf-miner assemblage, and using moth traps. It may also be possible to assess invertebrate damage, holes or segments chewed in the leaves, as a measure of abundance of external-feeding larvae.

It is proposed to engage a field Masters Research student to undertake sampling over three seasons. It is anticipated that the work would be carried out part-time, probably at a 'Research Assistant' level. It will be important to ensure that the RA is engaged for three field seasons to establish feasibility and extent of sampling in the first year, and to refine the sampling effort for the second year.

The proposed research stands will be semi-natural deciduous and deciduous mixed woodlands at the Rushmore Estate at Tollard Royal, on the Dorset - Wiltshire border. The woodlands comprise stand types of differing density, size classes, and degrees of canopy openness and understorey complexity. They include stands undergoing transformation to irregular high forest with a developing irregular structure, stands with even-aged elements resulting from shelterwood interventions, simple coppice systems and stands with old growth and even-aged mature high forest.

Objectives

4. To establish a suite of sampling stands across the woodland complex, in parallel with stands established for the proposed bird research
5. To learn the species of leaf miners involved
6. To undertake repeated samples of the leaf-miners
7. To assess the practicability of assessing leaf damage as a measurement of the activity / abundance of external-feeding larvae
8. To undertake sampling of leaf miners, and moths in light traps, in Half Hide Coppice
9. To analyse the impact of management influencing the distribution and abundance of insect communities.

Methods

1. Objective 1. The stands selected for the bird research will be examined for suitability for the leaf-miner sampling, and adjusted to ensure there is adequate replication built into the experimental design
2. Objective 2. Dr Sterling will provide training to ensure that the student has adequate opportunity to learn to identify the suite of leaf-miner species
3. Objective 3. It is likely that three sample sessions each year will be possible, one late June – late July, the other mid September – mid October. It is anticipated that each stand takes no more than ½ day to complete a sample
4. Objective 4. This will be undertaken in Year 1 whilst counting leaves and looking for leaf mines. It is not known now whether damage to leaves would be sufficient to be meaningful in relation to the number of leaves sampled for miners.
5. Objective 5. To continue the work started in Half Hide Coppice in 2011 by Dr Sterling and Mr David Evans (volunteer), examining abundance and species richness of leaf mines on hazel, and numbers of all moth in moth traps, between coppice and irregular high forest stands, and to continue this work for the next 5 years inclusive. These studies should enable comparison between the two sampling techniques, and to gain understanding of the relative merits of each in measuring the effects of woodland management.
6. Objective 6. Analysis would be concluded by the RA at the end of Year 2, with anticipated publication of results. Analysis of the Half Hide Coppice data would not be ready for publication until 2017, although annual interim reports would be made available.

Table 1. Timetable – Illustration of timing of invertebrate research projects

Year	One		Two		Three		Four		Five	
Literature review										
Field research										
Preliminary analysis										
Analysis / write up										
Field research Half Hide Coppice										
Analysis/write up										

Collaboration and Training

The supervisors of the MRes will be Dr Phil Sterling, MMU and Mr Andy Poore. If Manchester Metropolitan University are able to find a masters student, then Jon Ellis (one of Stuart Marsden's team) would be an academic advisor. If this isn't possible, then a research consultancy in Dorset will be approached to employ the MRes or a Research Assistant equivalent for three years, and would be likely to offer a similar academic advisory role.

Access to the woodlands will be facilitated by Mr Andy Poore, Forestry Consultant to the Rushmore Estate. Andy will also support the research by providing technical support on silvicultural aspects. Additional environmental data on woodlands across the study area will be supplied by Dorset Environmental Records Centre.

References

Bouget, C. & Duelli, P. (2004). The effects of windthrow on forest insect communities: a literature review. *Biological Conservation* **118**, 281-299.

Broome, A., Clarke, S., Peace, A. & Parsons, M. (2011). The effect of coppice management on moth assemblages in an English woodland. *Biodiversity and Conservation* **20**, 729-749.

Kirby, P. (1992). *Habitat Management for Invertebrates: a practical handbook*. RSPB, Sandy.

Merckx, T., Feber, R., Hoare, D., Parsons, M., Kelly, C., Bourn, N. & Macdonald, D. (2012). Towards an effective management policy for the conservation of threatened Lepidoptera in landscapes under intense human land-use. *Biological Conservation* **149**, 32-29.

Sterling, P.H. & Hambler, C. (1988). Coppicing for conservation: do hazel communities benefit? In: K.J. Kirby & F.J. Wright (Eds) *Woodland Conservation and Research in the Clay Vale of Oxfordshire and Buckinghamshire*. NCC, Peterborough.

Sterling, P. H., Gibson, C. W. D. & Brown, V. K. (1992). Leaf miner assemblies: effects of plant succession and grazing management. *Ecological Entomology* **17(2)**, 167-178.

Waring, P. (1988). Responses of moth populations to coppicing and the planting of conifers. In: K.J. Kirby & F.J. Wright (Eds) *Woodland Conservation and Research in the Clay Vale of Oxfordshire and Buckinghamshire*. NCC, Peterborough.

Warren, M.S. (1985). The influence of shade on butterfly numbers in woodland rides, with special reference to the wood white, *Leptidea sinapis*. *Biological Conservation* **33**, 147-164

Warren, M.S. (1987). The ecology and conservation of the heath fritillary butterfly, *Mellicta athalia*. III. Population dynamics and the effect of habitat management. *Journal of Applied Ecology* **24**, 499-513

Phil Sterling
12th February 2013

APPENDIX 3

The Association Futaie Irrégulière Research Network

The Association Futaie Irrégulière (AFI) is a group of French and European private forest managers formed in 1991 to promote the silviculture of irregular forest stands, with an original focus on broadleaved stands. In order to advance this process and to disseminate information, the AFI established a network of research stands to demonstrate how managers were working and what was successful. The methodology of the Network was developed with L'Ecole Nationale du Genie Rural, des Eaux et des Forests (ENGREF), who undertake the mensuration and collate the results from time to time as well as acting as the scientific advisers to the Network. The chief academic is Max Bruciamacchie, a leading authority on irregular silviculture.

A key principle of the Network is that there is no specifically prescribed management; *the Network observes and chronicles the operation of experienced practitioners in irregular silviculture in well-structured forests owned by a range of forest owners across a range of site types.*

As at the September 2012 there are over 80 research stands across France plus seven in Belgium and Luxembourg. Phil Morgan of SelectFor has been appointed by the AFI to undertake the development of the AFI in Britain and Ireland and as of September 2013 three AFI research stands have been established in South West England and seven in Ireland.

The AFI Network consists primarily of stands with a well-developed structure that are regarded as 'showcases'. In addition, stands have been added because they are addressing specific silvicultural issues such as the conversion of even-aged coniferous plantations. Normally stands occur on the basis of one research stand per participating forest, each stand being a compartment between 5 and 15 ha in size.

Site-type varies considerably and the Network has specifically been constructed to investigate the AFI's contention that irregular silviculture is applicable to all site-types. A very wide range of sites is included in the Network both with regard to nutrient status and moisture regime. Climate also varies considerably across the Network, particularly with regard to the summer moisture deficit that can be very severe in Eastern France. Results are therefore also categorised by climate, particularly with regard to the drier site-types where higher deficits have a significant effect on production. Expansion of the Network allows existing results to be affirmed and 'calibrated' with regard to climate and site.

The interaction of site, species, climate and management is often subtle and in interpreting the mensurational data, and deriving the silvicultural implications, stands are grouped by site-type and/ or species. ***The results represent a powerful tool in providing insight and practical management guidance to forest managers.***

The data are collected using repeated measurements on permanent sample plots, generally ten in number across each research stand. The plots are nested, with a wider range of measurements, e.g. seedling and sapling regeneration, being taken in the inner plots. The location of all stems measured is plotted so that removals between measurements can be detected. These measurements are repeated on a five yearly basis irrespective of the felling cycle.

Two types of ***mensurational data*** are collected:

- **overall stand data**: the procedure provides stand level information on the size and increment of the growing stock and its components. Measurements include the trees within the main stand (here defined as being over 17.5 cm diameter at breast height (dbh)) and the smaller stand elements including poles and regeneration.

- **individual tree data**: height; crown dimension, shape and height; quality.

It should be noted here that the management of forests in the Networks strongly directed towards the production of quality timber. Both mensuration and silviculture is focused on this issue and the classification of growing stocks, increment and removals by timber quality class is a key feature of this approach.

In addition to mensurational data, information is also collected about the ***economic performance*** of the stands over time. These data cover the revenue account items; timber, sporting and grant income and detailed costs involved with harvesting, tending, maintenance and management as well as other costs such as taxes and insurance. The data is used to generate information on the evolution of the capital value of the stands. The value increment of each species and size category is calculated and this, when combined with a constant discount rate of 4%, produces a measure of the potential value of the stands. ***These parameters provide is a powerful tool for maximising income from irregular stands.***

Biological data is also recorded. A deadwood transect is recorded and specific habitat features present on the sampled trees are recorded and scored. The latter allows the relationship between the economic and biological value of individual trees to be investigated.

In 2005 a second Synthesis Report was published which provided a wealth of data and silvicultural interpretations of the results from the first 15 years of the Network[1]. In the same year the AFI hosted a visit for Andy Poore and Phil Morgan of SelectFor as part of a research project into the irregular silviculture of oak and ash stands, funded by Woodland Heritage.

[1] Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 *Gestion des peuplements irréguliers: Réseau AFI Synthèse 1991-2005.* AFI, Besançon

Part 2 of the Report of this project presents the AFI Synthesis Report results in detail and considers their implications for CCF in Britain[2].

In 2009 the AFI produced a further publication 'Management of Irregular Forests' which describes the silvicultural, economic and biological aspects of the approach and supports this with more data from the research network. The publication has been translated by Phil Morgan of SelectFor and is available from www.selectfor.com.

[2] Poore, A. (2006) Continuous cover forest management of oak/ash stands in the lowlands: stand dynamics. Part 2: Continuous cover forest management in France & the AFI Research Network: implications for continuous cover silviculture and research in southern England, SelectFor.