TOWARDS DEFINING MINIMUM REQUIREMENTS FOR VIOLET FEEDING FRITILLARIES IN WOODLAND.

Darrell Smith*, **Andrew Ramsey & Owen Nevin**
Centre for Wildlife Conservation, National School of Forestry,
University of Cumbria, Newton Rigg, Penrith, Cumbria. U.K.
* corresponding author: email: darrell.smith@cumbria.ac.uk

University of Cumbria

Introduction

British woodland wildlife is heavily influenced by past management systems; woodland management traditions such as coppice and wood pasture have created complimentary suites of habitat for woodland plants and animals (Peterken, 1993; Sutherland & Hill, 1995). However, butterflies are sensitive to landscape alterations, experiencing greater net losses than either birds or plants in Britain (Thomas et al. 2004). Using a resource-based approach to define habitat (Dennis et al. 2003), we describe key elements of the woodland environment that influence abundance of the five British violet-feeding Nymphalidae fritillary species: high brown (*Argynnis adippe*), pearl bordered (*Boloria euphrosyne*), small pearl bordered (*Boloria selene*), dark green (*Argynnis aglaja*). and silver-washed (*Argynnis paphia*). Key woodland vegetation, structure, physical habitat components and fritillary abundance were quantified at two limestone woodland sites in north-west England (Fig 1). These sites contain core UK populations and are actively managed for fritillary conservation. Management techniques developed in this region have been used nationally as an exemplar for appropriate fritillary management (Ellis & Wainwright, 2008). The identification of key habitat resource requirements is of primary importance as ecological research informs practical conservation management (Dennis, 2004).

Figure 1 Study site locations; ordinance survey maps of the two study site locations within the Morecombe Bay limestone woodlands on the south Cumbria/north Lancashire border of the U.K. (Ellis & Wainwright, 2008)

Method

Both fritillary abundance and habitat characteristics were quantified at two limestone woodland sites: Witherslack Woods, Cumbria, and Gait Barrows National Nature Reserve, Lancashire.

Quantitative component

- Transect sections for research were identified based on aggregated fritillary numbers during the 2007 – 2009 flight seasons, and defined as either 'rich' or 'poor' in population status.
- A random stratified sampling technique, with proportional sampling, measured environment variables that relate to previously described larval and adult resource requirements: vegetation, physical and structural characteristics.

Statistical component

- A primary principle component analysis (Table 1 & 2) informed the grouping of environmental variables for further analysis (Table 3).
- Logistic regression investigates the potential relationships between multiple environmental variables and the fritillary 'rich' and 'poor' status of transect sections.

Table 1 Total variance explained using the PCA extraction method.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.092	25.763	25.763
2	2.504	20.870	46.633
3	1.411	11.755	58.388
4	1.271	10.591	68.979
5	.905	7.542	76.521
Component	**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %
1	2.882	24.013	24.013
2	2.395	19.961	43.975
3	1.499	12.495	56.470
4	1.338	11.148	67.618
5	1.068	8.903	76.521

Table 2 Rotated component matrix. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 38 iterations.

Variable % cover (n=344)	Principle component group				
	1	2	3	4	5
Canopy cover			.704		
Leaf litter			.531		
Moss cover				.719	
Bare ground					-.914
Bare rock			-.755		
Moss covered rock				.722	
Vegetation at 0m		.865			
Vegetation at 0.2m		.884			
Vegetation at 0.4m	.706				
Vegetation at 0.8m	.923				
Vegetation at 1.0m	.918				
Vegetation at 1.5m	.745				

Table 3 Independent variable grouping for enter in to the logistic regression analysis.

	Independent variable
Block 1	Site: WW_GB
Block 2	Bare ground
Block 3	Moss cover Moss covered rock
Block 4	Canopy cover Leaf litter Bare rock
Block 5	Vegetation at 0m Vegetation at 0.2m
Block 6	Vegetation at 0.4m Vegetation at 0.8m Vegetation at 1.0m Vegetation at 1.5m
Block 7	Violet cover

Results

The Aggregated fritillary numbers identified transect sections as being either 'rich' or 'poor' for fritillary population status (mean fritillary population: 'rich' 622.43 ± 61.47 km-1; 'poor' 20.47 ± 4.92 km-1; ANOVA: $F_{1,14}$=109.88, n=15, p<0.001). The logistic regression analysis sought to investigate the relationship between fourteen measured environmental variables and the fritillary 'rich' and 'poor' status within two conservation woodland sites. Six variables formed a final statistically significant model indicating that the environmental indicators, as a set, reliably distinguished between 'rich' and 'poor' areas of fritillary abundance (χ^2=189.722, df=6, n=344, p<0.001). Prediction success overall was 82.0% (Table 4). Table 5 shows the logistic coefficient, Wald test and the exponential of the coefficient.

Table 4 The predicted frequencies for fritillary 'poor' and 'rich' status by logistic regression, with a cut value of 0.50. False 'poor' = 41/(41+158)% =20.6%; false 'rich' =21/(124+21)% =14.48%.

	Predicted frequencies		
	Fritillary status Poor .00	Fritillary status Rich 1.00	Percentage Correct
Fritillaries Poor .00	124	41	75.2
Rich 1.00	21	158	88.3
Overall Percentage			82.0

*Table 5 Results of the logistic regression between fritillary 'rich' and 'poor' status, study site and the fourteen measured environmental variables (n=344). *** significant at the 0.001 level ; * significant at the 0.05 level*

Variable % cover (n=344)	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
							Lower	Upper
Canopy cover	-.034	.005	49.674	1	.000***	.967	.958	.976
Leaf litter	-.017	.007	6.524	1	.011*	.983	.971	.996
Vegetation at 0m	.003	.005	.424	1	.515	1.003	.993	1.013
Vegetation at 0.4m	-.012	.006	3.446	1	.063	.988	.976	1.001
Vegetation at 1.5m	-.007	.010	.478	1	.489	.993	.973	1.013
Violet cover	.507	.104	23.916	1	.000***	1.660	1.355	2.033
Constant	.827	.418	3.921	1	.048	2.286		

The Wald criterion demonstrates that the environmental variables percentage cover of canopy cover (p<0.001), leaf litter (p=0.011) and violet cover (p<0.001) make a significant contribution to the prediction, whilst the environmental variables percentage cover of vegetation at 0.4m (p=0.063), 1.5m (p=0.489) and 0m (p=0.515) contribute to the final model without a demonstration of statistical significance.
Violet cover exerts a strong positive influence whilst canopy cover, leaf litter and vegetation ≥ 0.4m negatively influence fritillary population status.

Conclusion

- Both structure and physical characteristics of the woodland environment influence British violet feeding fritillary population status.
- In association with the positive influence of the larval host plant, *Viola spp*., we establish structural and physical environmental components that influence fritillary population status.
- We identify the potential for an associated vegetation height threshold. These data suggest that, given the requisite violet coverage, woodland structural components of canopy cover and vegetation cover ≥ 0.4m set a 'tipping point' between 'rich' and 'poor' fritillary populations.
- The implications of any height significance may prove beneficial to conservation management strategies. The identification of minimum habitat requirements can act as a guide for intervention and conservation management planning in similar habitats.
- Where environmental management resources are limited there is a clear need for prudent investment in time, manpower and money, especially in the successful implementation of conservation management for conservation dependent species.

References

Dennis, R.L.H., Shreeve, T.G., Van Dyck, H.,2003. Towards a functional resource-based concept for habitat: A butterfly biology viewpoint. Oikos, **102**: 417-426.
Dennis, R.L.H.,2004. Butterfly habitats, broad scale biotope affiliations and structural exploitation of vegetation at finer scales: the matrix re-visited. Ecological Entomology, **29**: 744-752.
Ellis, S. and Wainwright, D., 2008. Conservation of the High Brown Fritillary, *Argynnis adippe,* and Pearl-bordered Fritillary, *Boloria euphrosyne,* butterflies in North West England, Butterfly Conservation Report No. S08-27. Butterfly Conservation, Wareham, Dorset.
Peterken, G., 1993. Woodland Conservation and Management, 2nd Ed. Chapman and Hall, London.
Sutherland, W.J. and Hill, D.A., 1995. Managing Habitats for Conservation. Cambridge University Press, Cambridge.
Thomas, J.A., Telfer, M.G., Roy, D.B., Preston, C.D., Greenwood, J.J.D., Asher, J., Fox, R., Clarke, R.T., Lawton, J.H., 2004. Comparative losses of British butterflies, birds, and plants and the global extinction crisis. Science **303:**1879–1881.