

**UNIVERSITY OF SOUTHAMPTON**  
**ENGINEERING SCIENCE AND MATHEMATICS**  
**SCHOOL OF GEOGRAPHY**



**A GIS-BASED ASSESSMENT OF HABITAT  
PREFERENCES OF THE TWITE**  
*(Carduelis flavirostris pipilans)*

**Iain Turnbull**

A dissertation submitted in partial fulfillment of the requirements for the degree of  
M.Sc. in Geographic Information Systems by Online Distance Learning

December 2010

### **Statement of originality**

Except for those parts in which it is explicitly stated to the contrary, this thesis is my own work. It has not been submitted for any degree at this or any other academic or professional institution.

The copyright of this thesis rests with the author. Information derived from it should be acknowledged.

I agree that the thesis may be made available for reading and photocopying at the discretion of the Head of the School of Geography. Permission for anyone other than the author to reproduce or photocopy any part of the thesis must be obtained from the Head of School who will give his/her permission for such reproduction only to an extent which he/she considers to be fair and reasonable.

Signed.....

Candidate's name: ..... (Block Capitals)

## **Acknowledgments**

I owe a huge amount of gratitude to many individuals and organisations for their assistance and support without which this dissertation would not have been possible. First, I must thank the staff at the RSPB, Nick Wilkinson, Mark O'Brien and David Fouracre for taking the time to discuss my ideas with them and for their advice and of course for permitting me to use their data from South Uist, and Alison MacLennan for her valuable input and advice on twite in crofting areas. Equally, thanks to Peter Lack at the BTO for providing me with the original data from the two breeding bird atlases and for patiently advising me on the data structures and formats. My gratitude also goes to Robin Pakeman and Dick Birnie at the MacAulay Institute for providing, free of charge, the Land Cover Scotland data from 1988. My thanks also to my colleagues at NTS who assisted in planning the project and for allowing me to undertake this course at all. I should also thank the SOC library for copying three articles on twite that would otherwise have been unavailable to me. Also my genuine appreciation goes to Laurie Campbell for allowing me to use his photo of a twite which has pride of place on the title page.

Enormous thanks go to my family for being so patient over the past three years while I tried to persuade my brain that learning was good for it, and especially for coping with me while I tried to understand Java programming, not a pretty sight. I'll be back to normal now!

Thanks also to Jim Wright, my dissertation supervisor, without whom I would not have managed to complete this project. His long-distance guidance was always positive and constructive and our regular long telephone conversations throughout the year served to keep me motivated and focussed, and gave me the belief that I was not heading down blind alleys all the time. Thank you very much.

Finally, I would also like to thank the crofters in South Uist for agreeing to let me wander aimlessly around their crofts this summer, apparently searching the ground for inspiration, and actually finding some, but who could fail to be inspired by that magnificent crofting landscape and the birds.

## Contents

---

<b>Acknowledgments</b>	<b>iii</b>
<b>Contents</b>	<b>iv</b>
<b>List of Figures</b>	<b>vi</b>
<b>List of Tables</b>	<b>viii</b>
<b>1. Introduction</b>	<b>1</b>
1.1 Literature Review	1
1.2 Aims and Objectives	13
<b>2 Methodology</b>	<b>14</b>
2.1 Data Sources	14
2.1.1 Twite data	14
2.1.2 Land cover data	20
2.1.3 Land use data	24
2.1.4 Elevation data	26
2.1.5 Climate data	26
2.1.6 Floristic Value – South Uist	30
2.2 Data Analysis	32
2.2.1 Zonal Statistics as Table	32
2.2.2 Habitat Proximity Estimation	33
2.2.3 Model Development - Logistic Regression	35
2.2.4 Model Development – Habitat Proximity	41
2.2.5 Model Testing – Receiver Operating Characteristic Values (ROC)	42
2.2.6 Model Testing – Independent Data	43
<b>3 Results &amp; Analysis</b>	<b>44</b>
3.1 Floristic Value Results	44
3.2 Zonal Statistics as Table Results	46
3.3 Basic Model	49
3.4 Basic Model Plus Elevation	55
3.5 Basic Model Plus Elevation & Climate	56
3.6 Geographic Zonation Model	57
3.7 Elevation Zonation Model	59
3.8 Inclusion of Habitat Proximity in Models	65
3.9 Land Cover Scotland Models	65
3.10 Model Development Summary	66
3.11 Independent Model Testing	69

<b>4</b>	<b>Discussion</b>	<b>70</b>
4.1	‘Flower Score’ Estimation	70
4.2	Zonal Statistics as Table Analysis	71
4.3	Model Development	72
4.4	Testing the Models against Independent Data	75
4.5	Potential Improvements to the Models	78
<b>5</b>	<b>Conclusions</b>	<b>80</b>
	<b>Bibliography</b>	<b>82</b>
	<b>Appendices</b>	<b>92</b>
Appendix 1	Twite Surveys – Methodology Summaries	92
Appendix 2	LCS88 Land Cover Classification Categories	95
Appendix 3	Description of Agricultural Census Data	97
Appendix 4	Flower Score Survey Methodology	100
Appendix 5	Description of ‘Goodness of Fit’ Measures for Logistic Regression Models	103
Appendix 6	Complete Set of Model Results	106
Appendix 7	Complete Sets of Model ROC Curves	124

## List of Figures

Figure 1	Frequency distribution of breeding twite encountered on moorland in relation to the minimum distance from enclosed farmland, grouped by 400-m bins, from transect surveys in South Uist (2003-05) and South Harris (2005)	4
Figure 2	Relative preference of different habitat types for foraging by twite in the south Pennines	6
Figure 3	Seasonal variation in diet composition of twite nestlings in South Uist in 2003-05.	7
Figure 4	Mean number of Twite recorded for fields in each flower score category	8
Figure 5	10 km Grid Squares with Twite 1968-72	16
Figure 6	10 km Grid Squares with Twite 1988-91	17
Figure 7	Changes in Twite Distribution 1968-72	18
Figure 8	Tetrads with Breeding Twite 1988-91	19
Figure 9	Corine Land Cover 1990 Map for Britain	21
Figure 10	Corine Land Cover 2000 Map for Britain	22
Figure 11	Land Cover Map of Scotland 1988	23
Figure 12	Agricultural Census Data 1988 for Britain	25
Figure 13	Digital Terrain Model for Britain	27
Figure 14	Average (May-August) Monthly Rainfall for Britain	28
Figure 15	Average (May-August) Daily Temperature for Britain	29
Figure 16	Twite abundance in South Uist 2003-05	31
Figure 17	Example of the Zonal Statistics as Table procedure for CLC90 the data	32
Figure 18	Habitat Proximity evaluation procedure	34
Figure 19	Illustration of Logistic Regression Process	39
Figure 20	Geographic & Elevation Zones used for model Development	41
Figure 21	Illustrative Example of a ROC Curve	42
Figure 22	Relative 'Flower Score' for recorded twite locations in South Uist	45
Figure 23	Zonal Stats Analysis CLC90 – Average land cover – top five categories for tetrads with twite	46

Figure 24	Zonal Stats Analysis CLC2000 – Average land cover – top five categories for tetrads with twite	47
Figure 25	Zonal Stat Analysis LCS88 – Average land cover – top five categories for tetrads with twite	48
Figure 26	Zonal Stat Analysis LCS88 – Variation between average percentage land cover for twite tetrads and all Scottish tetrads.	48
Figure 27	Average values for Agricultural Census 1988 categories for Britain and twite tetrads	49
Figure 28	Predicted probability of twite presence (basic model)	51
Figure 29	Predicted distribution of twite (basic model)	52
Figure 30	Map showing residuals for predicted twite probability versus actual distribution	53
Figure 31	Map showing residuals for predicted twite distribution versus actual distribution	54
Figure 32	Predicted probability of twite presence (geographic zones model)	60
Figure 33	Predicted presence of twite presence (geographic zones model)	61
Figure 34	Map showing residuals for predicted twite probability versus actual distribution	62
Figure 35	Map showing residuals for predicted twite presence versus actual distribution	63
Figure 36	Graph showing the relative Model Performance (Area under ROC curve values)	68
Figure 37	Illustration of the variation in survey effort in the BTO88-91 dataset	74
Figure 38	Geographic Zones Model accuracy for North & South Uist	76
Figure 39	Elevation Zones Model accuracy for the Pennines	77

## List of Tables

Table 1	Summary population figures and trends for twite in Britain and Ireland from 1968-72 to 1988-91	2
Table 2	Number of counties in which twite were recorded in 1875-1900 and 1968-72	2
Table 3	Favoured forage plants of twite during the breeding season	5
Table 4	Key food plants for twite during the breeding season	30
Table 5	Moorland Habitat Proximity values and distance to enclosed farmland	33
Table 6	Attributes for Logistic Regression Model Development	37
Table 7	Correlation coefficients between twite numbers and flower scores	44
Table 8	Goodness of Fit statistics for the Basic Model (Britain)	50
Table 9	Goodness of Fit statistics for the Basic Model plus Elevation (Britain)	55
Table 10	Goodness of Fit statistics for the Basic Model plus Elevation & Climate (Britain)	56
Table 11	Goodness of Fit statistics for the Geographic Zones Model (Britain)	58
Table 12	Goodness of Fit statistics for the Elevation Zones Model (Britain)	64
Table 13	Summary of Model Performance	67
Table 14	Summary of Model Testing Results – Area under the ROC curve values	69