

Contents

PREFACE	v
ACKNOWLEDGEMENTS	v
DATASETS USED IN THIS BOOK	vi
CHAPTER 1 OF ZUUR ET AL. (2012A) AND ZUUR (2012B)	vi
COVER ART	vi
CONTRIBUTORS	xiii
1 INTRODUCTION	1
1.1 GAM APPLIED ON STABLE ISOTOPE RATIOS	1
1.2 GAM USING MGCV APPLIED ON THE SQUID DATA	5
1.3 LINEAR SPLINE REGRESSION	7
1.4 LINEAR SPLINE REGRESSION IN JAGS	13
1.5 B-SPLINES IN JAGS	17
1.6 LOW RANK THIN-PLATE REGRESSION SPLINES IN JAGS	19
1.6.1 Using <i>lme</i> to estimate the low rank thin-plate regression spline	22
1.6.2 Using JAGS to estimate the low rank thin-plate regression spline	24
1.7 O'SULLIVAN SPLINES IN JAGS	28
1.8 EFFECTIVE DEGREES OF FREEDOM OF A SMOOTHER	30
2 ADDITIVE MIXED EFFECTS MODELS APPLIED ON POLAR BEAR MOVEMENT DATA	35
2.1 INTRODUCTION	35
2.2 THE VARIABLES	36
2.3. HOUSEKEEPING	37
2.4 DATA EXPLORATION	37
2.4.1 Checking for outliers in the movement data	38
2.4.2 Relationships between movement and the covariates	38
2.4.3 Collinearity	44
2.5 MODEL FORMULATION	45
2.5.1 Distribution	45
2.5.2 Predictor function	46
2.5.3 Link function	48
2.6 FREQUENTIST APPROACH	48
2.6.1 Fitting the additive mixed effects model using <i>mgcv</i>	48
2.6.2 Model validation of the additive mixed effects model	52
2.6.3 Understanding <i>\$lme</i> output from the <i>gamm</i> function	55
2.7 MCMC AND GAUSSIAN ADDITIVE MIXED EFFECTS MODELS	58
2.7.1 Data for JAGS	58
2.7.2 JAGS modelling code	60
2.7.3 Initial values	62
2.7.4 Parameters to save	62

2.7.5 Executing JAGS and obtaining results	62
2.7.6 Mixing of chains	63
2.7.7 Model validation	63
2.7.8 Model interpretation.....	64
2.8 MCMC AND GAMMA GAMM	67
2.8.1 Data for JAGS.....	67
2.8.2 JAGS modelling code.....	68
2.8.3 Initial values	69
2.8.4 Parameters to save	70
2.8.5 Executing JAGS and obtaining results	70
2.8.6 Mixing of Chains.....	70
2.8.7 Model validation	70
2.8.8 Model interpretation.....	71
2.9 DISCUSSION.....	71
2.10 WHAT TO PRESENT IN A PAPER	72
3 ADDITIVE MIXED EFFECTS MODELS APPLIED ON CORAL REEF DATA	73
3.1 INTRODUCTION	73
3.1.1 Coral reefs.....	73
3.1.2 Aim of this chapter.....	73
3.2 THE VARIABLES.....	74
3.3. HOUSEKEEPING.....	74
3.4 DATA EXPLORATION	75
3.4.1 Checking for outliers	75
3.4.2 Relationships	76
3.4.3 Collinearity.....	78
3.5 MODEL FORMULATION.....	79
3.6 FREQUENTIST APPROACH	80
3.6.1 Linear mixed effects model using lme	80
3.6.2 Additive mixed effects model using gamm.....	82
3.6.3 Model validation of the additive mixed effects model	86
3.6.4 Model interpretation.....	86
3.7 MCMC AND GAUSSIAN ADDITIVE MIXED EFFECTS MODELS	88
3.7.1 Data for JAGS.....	89
3.7.2 JAGS modelling code.....	90
3.7.3 Initial values	92
3.7.4 Parameters to save	92
3.7.5 Executing JAGS and obtaining results	92
3.7.6 Mixing of Chains.....	93
3.7.7 Model validation	93
3.7.8 Model interpretation.....	93
3.8 DISCUSSION.....	97
3.9 WHAT TO PRESENT IN A PAPER	98
4 POISSON GAMM APPLIED ON RUDDY TURNSTONE DATA.....	99
4.1 GROUP SIZE EFFECT ON VIGILANCE IN RUDDY TURNSTONES.....	99

4.2 THE VARIABLES.....	100
4.3. HOUSEKEEPING.....	100
4.4 DATA EXPLORATION.....	101
4.5 POISSON GAMM.....	104
4.5.1 GLMM or GAMM?.....	105
4.5.2 GAMM formulation.....	105
4.5.3 Fitting GAMM using <i>gamm4</i>	106
4.5.4 Estimated smoothers.....	109
4.5.5 Model validation.....	110
4.6 USING FLOCK SIZE AS AN OFFSET?.....	110
4.7 UNBALANCED RANDOM EFFECTS; SIMULATION STUDY.....	111
4.8 DISCUSSION.....	114
5 GAMM APPLIED ON PARASITE DATA.....	115
5.1 INTRODUCTION.....	115
5.2 THE VARIABLES.....	116
5.3. HOUSEKEEPING.....	116
5.4 DATA EXPLORATION.....	117
5.4.1 Checking for missing values.....	117
5.4.2 Checking for outliers.....	117
5.4.3 Relationships.....	118
5.4.4 Collinearity.....	119
5.4.5 Zero inflation.....	119
5.5 MODEL FORMULATION.....	119
5.6 POISSON AND NEGATIVE BINOMIAL GLMM FOR TOTAL ABUNDANCE.....	121
5.6.1 Poisson GLMM using <i>lme4</i>	121
5.6.2 Negative binomial GAMM using <i>JAGS</i>	125
5.6.3 Negative binomial-P GLMs and GAMMs.....	136
5.7 GENERALISED POISSON GAMM FOR UNDERDISPERSED SPECIES RICHNESS.....	142
5.8 BINOMIAL GAMM FOR ABSENCE/PRESENCE DATA.....	144
6 ZERO-INFLATED SEA BIRD DATA SAMPLED AT OFFSHORE WIND FARMS.....	145
6.1 COMMON GUILLEMOTS.....	145
6.2 THE DATA.....	146
6.2.1 Importing the data.....	146
6.2.2 Recoding of variables.....	146
6.3 LOADING THE REQUIRED PACKAGES.....	148
6.4 DATA EXPLORATION.....	148
6.5 BUILDING TOWARDS A MODEL.....	153
6.5.1 Poisson GAM with a bivariate smoother.....	153
6.5.2 Applying the Poisson GAM with a bivariate smoother.....	155
6.5.3 Poisson GAM with multiple bivariate smoothers.....	157
6.5.4 Poisson GAMM with multiple bivariate smoothers.....	159
6.6 ZERO-INFLATED POISSON GAMM WITH BIVARIATE SMOOTHERS.....	161

6.7 ZERO-INFLATED NEGATIVE BINOMIAL GAMM WITH BIVARIATE SMOOTHERS	163
6.8 TECHNICAL DETAILS OF FITTING THE TWO-WAY NESTED ZIP GAMM	163
6.8.1 <i>Underlying mixed effects model</i>	163
6.8.2 MCMC code for a two-dimensional smoother for data from one survey	166
6.9 MODEL SELECTION USING DATA FROM SURVEY 1	176
6.10 A MODEL FOR ALL 13 SURVEYS	177
6.11 MCMC RESULTS FOR ALL 13 SURVEYS	179
6.12 ADDING INDICATOR FUNCTIONS	182
6.13 MODEL VALIDATION	182
6.14 DISCUSSION	185
6.15 WHAT TO PRESENT IN A PAPER	186
7 ZERO-INFLATED GAMM APPLIED ON HARBOUR PORPOISE ...	187
7.1 HARBOUR PORPOISE	187
7.2 IMPORTING THE DATA AND HOUSEKEEPING	188
7.3 DATA EXPLORATION	189
7.3.1 <i>Spatial and temporal sampling positions</i>	189
7.3.2 <i>Outliers</i>	192
7.3.3 <i>Collinearity</i>	193
7.3.4 <i>Relationships</i>	194
7.4 BRAINSTORMING	196
7.4.1 <i>Adding correlation to the model</i>	196
7.4.2 <i>Specifying the fixed part of the models</i>	197
7.4.3 <i>Mathematical formulation of the models</i>	198
7.5 ZIP GAMM USING UNIVARIATE SMOOTHERS	199
7.5.1 <i>Implementation of ZIP GAMM with univariate smoothers</i> ...	199
7.5.2 <i>ZIP GAMM results</i>	208
7.5.3 <i>ZIP GLMM results</i>	210
7.6 ZIP GAMM USING TWO-DIMENSIONAL SPATIAL SMOOTHERS	210
7.6.1 <i>Implementation of ZIP GAMM with multivariate smoother...</i>	210
7.6.2 <i>ZIP GAMM results</i>	211
7.7 DISCUSSION	214
7.8 WHAT TO PRESENT IN A PAPER	214
8 GAMMA GAMM APPLIED ON TREE GROWTH DATA	217
8.1 INTRODUCTION	217
8.2 THE VARIABLES	218
8.3. HOUSEKEEPING	218
8.4 DATA EXPLORATION	219
8.5 MODEL SPECIFICATION	221
8.6 FREQUENTIST APPROACH	222
8.7 BAYESIAN APPROACH	226
8.7.1 <i>Schematic overview</i>	226
8.7.2 <i>Data for JAGS</i>	226

8.7.3 JAGS modelling code.....	228
8.7.4 Initial values and parameters to save	231
8.7.5 Running JAGS.....	232
8.7.6 Assess mixing of chains and model fit.....	232
8.7.7 JAGS results.....	233
8.7.8 Model validation	234
8.7.9 Heterogeneous gamma GAMM.....	237
8.8 DISCUSSION.....	238
8.9 WHAT TO PRESENT IN A PAPER	239

9 BERNOULLI GAMM APPLIED ON COWBIRD BROOD PARASITISM

.....	241
9.1 INTRODUCTION	241
9.2 THE VARIABLES.....	242
9.3. HOUSEKEEPING.....	243
9.4 DATA EXPLORATION.....	243
9.5 MODEL FORMULATION.....	245
9.6 FREQUENTIST APPROACH	245
9.7 BAYESIAN APPROACH.....	247
9.7.1 Preparing the data for JAGS.....	248
9.7.2 JAGS modelling code.....	249
9.7.3 Running JAGS and mixing of chains.....	251
9.7.4 Estimated smoothers and fitted values obtained by JAGS.....	251
9.7.5 Differences between fitted values.....	253
9.8 DISCUSSION.....	254

10 GAMM APPLIED ON MAXIMUM COD LENGTH USING INLA...255

10.1 INTRODUCTION.....	255
10.2 THE VARIABLES	256
10.3 DATA EXPLORATION	256
10.4 GAM IN MGCV.....	259
10.5 ADDING SPATIAL CORRELATION TO THE GAM.....	261
10.6 FITTING A GAM USING INLA.....	263
10.6.1 What is INLA?.....	263
10.6.2 Installing INLA.....	265
10.6.3 Applying regression models in INLA.....	265
10.6.4 GAM in inla.....	268
10.7 GAM WITH SPATIAL CORRELATION IN INLA	270
10.7.1 Defining a mesh	270
10.7.2 Projector matrix.....	272
10.7.3 Setting up the model.....	272
10.7.4 Executing inla.....	273
10.7.5 Plotting the spatial random field.....	274
10.7.6 Theoretical and estimated spatial correlation.....	275
10.8 GAM WITH EXTREME VALUE DISTRIBUTION IN INLA.....	278
10.8.1 Generalised extreme value distribution.....	278
10.8.2 Applying gev models using the <i>ismev</i> package in R.....	279

10.8.3 Applying <i>gev</i> models using <i>inla</i> in R	282
10.9 GAM WITH EXTREME VALUE DISTRIBUTION AND SPATIAL CORRELATION IN INLA	283
10.10 DISCUSSION	284
10.11 WHAT TO PRESENT IN A PAPER	284
11 ZERO-INFLATED AND SPATIAL CORRELATED COMMON SCOTER DATA	285
11.1 INTRODUCTION	285
11.2 THE VARIABLES	286
11.3 DATA EXPLORATION	286
11.3.1 Outliers	286
11.3.2 Collinearity	287
11.3.3 Relationships between response and covariates	288
11.4 POISSON GLM	291
11.5 ZERO-INFLATED POISSON GLM USING PSCL AND INLA	295
11.6 ZERO-INFLATED POISSON GAM USING INLA	298
11.7 ZIP GLM WITH SPATIAL CORRELATION USING INLA	303
11.8 ZIP GAM WITH SPATIAL CORRELATION USING INLA	306
11.9 NB GLM WITH SPATIAL CORRELATION USING INLA	308
11.10 THE EFFECT OF A NEW EXCLUSION ZONE	311
11.11 DISCUSSION	317
11.12 WHAT TO PRESENT IN A PAPER	318
REFERENCES	319
INDEX	325
BOOKS BY HIGHLAND STATISTICS	329
UPCOMING BOOKS IN 2014	331