Wildlife Biology

WLB-00733

Liljebäck, N., Bergqvist, G., Elmberg, J., Haas, F., Nilsson, L., Lindström, Å. and Månsson, J. 2021. Learning from long time series of harvest and population data - Swedish lessons for European goose management. – Wildlife Biology 2021: wlb.00733

Appendix 1–2

Appendix 1

Spearman rank correlation coefficients (r_s) and p-values for annual count data for different counts (months). Data for the period 1977–2018 for greylag goose, Canada goose and bean goose respectively.

Greylag goose

	January (following year)	September	October
September	0.8975 < 0.0001		
October	0.9357 < 0.0001	0.9756 < 0.0001	
November	0.9028 < 0.0001	0.8893 < 0.0001	0.9366 < 0.0001

Canada goose

	January (following year)	October
October	0.8352 < 0.0001	
November	0.8428 < 0.0001	0.9183 < 0.0001

Bean goose

	January (following year)	October
October	0.4085 0.0076	
November	0.4628 0.0022	0.2471 0.1146

Appendix 2

Location of breakpoints and regression estimates between breakpoints using the package strucchange in R 3.3.3.

Breakpoints for estimated harvest of greylag goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of estimated harvest for greylag goose, the selected model had two breakpoints. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoints and 95 % confidence intervals are given.

Breakpoints	0	1	2	3	4	5
RSS	6.52e+08	2.20e+08	1.49e+08	1.22e+08	1.09e+08	1.09e+08
BIC	8.26e+02	7.92e+02	7.86e+02	7.89e+02	7.96e+02	8.07e+02

Confidence intervals for breakpoints of optimal 3-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	15	19	20
2	29	33	34

Two breakpoints: 1995 – 1996 and 2009 – 2010

Regression estimates for linear regression line between break points.

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1977 – 1995				
Intercept	-845354 ± 169000[a]	<0.0001		
Year	427 ± 85.1[a]	<0.0001		
1996 – 2009				
Intercept	-1074000 ±318200[b]	0.002	-1919821 ± 254764[c]	
Year	535.6 ± 159.3[b]	0.002	962.8 ± 127.7[c, d]	<0.0001[e]
2010 – 2018				
Intercept	731900 ± 554500[b]	0.195	-113491 ± 409869[c]	
Year	-358.9 ± 275.7[b]	0.201	68 ± 204.0[c, d]	0.748[e]

[a] reference

[b] in relation to reference

[c] estimated as mean = reference + value in relation to reference and

SE = $\sqrt{(\mathrm{SE.reference\hat{}2} + \mathrm{SE.value\ in\ relation\ to\ reference\hat{}2})/2}$

[d] effect of "Year" (slope) was significantly different between segment 2 (1996 – 2009; 962.8 ± 127.7) and segment 3 (2010 – 2018; 68 ± 204.0), p<0.0007

[e] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for estimated harvest of Canada goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of estimated harvest for Canada goose, the selected model find one breakpoint. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoints and 95 % confidence interval is given.

Breakpoints	0	1	2	3	4	5
RSS	2.06e+09	9.40e+08	7.74e+08	5.96e+08	5.32e+08	5.14e+08
BIC	8.74e+02	8.52e+02	8.56e+02	8.56e+02	8.62e+02	8.72e+02

Confidence intervals for breakpoint of optimal 2-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	33	34	35

One breakpoint: 2010 – 2011

Regression estimates for linear regression between breakpoints

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1977 – 2010				
Intercept	-2035212 ± 173348[a]	<0.0001		
Year	1030.2 ± 86.96[a]	<0.0001		
2011 – 2018				
Intercept	4767758 ± 1555938[b]	0.0040	2732547 ± 1107021[c]	
Year	-2375.0 ± 772.5[b]	0.0039	-1344.8 ± 549.7[c]	0.0370[d]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference and

SE = $\sqrt{(\mathrm{SE.\,reference\hat{}2} + \mathrm{SE.\,value\ in\ relation\ to\ reference\hat{}2})/2}$

[d] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for estimated harvest of bean goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of estimated harvest for bean goose, the selected model had two breakpoints. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoints and 95 % confidence intervals are given.

Breakpoints	0	1	2	3	4	5
RSS	4.74e+07	3.44e+07	2.05e+07	1.81e+07	1.67e+07	1.69e+07
BIC	7.16e+02	7.14e+02	7.03e+02	7.09e+02	7.17e+02	7.28e+02

Confidence intervals for breakpoints of optimal 3-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	17	19	20
2	28	29	34

Two breakpoints: 1995 – 1996 and 2005 – 2006

Regression estimates for linear regression line between breakpoints

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1977 – 1995				
Intercept	-222596 ± 62707.2[a]	0.0011		
Year	113.9 ± 31.6[a]	0.0009		
1996 – 2005				
Intercept	-530941 ± 177477[b]	0.0050	-753537 ± 133098[c]	
Year	264.2 ± 88.8[b]	0.0052	378.2 ± 66.6[c, d]	0.0001[e]
2006 – 2018				
Intercept	406239 ± 128731.6[b]	0.0032	183643 ± 101252[c]	
Year	-203.9 ± 64.2[b]	0.0030	-89.9 ± 50.6[c, d]	0.1185[e]

[a] reference

[b] in relation to reference

[c] estimated as mean = reference + value in relation to reference and

SE = $\sqrt{(\text{SE. reference\^2} + \text{SE. value in relation to reference\^2})/2}$

[d] effect of "Year" (slope) was significantly different between segment 2 (1996 – 2005; 378.2 ± 66.6) and segment 3 (2006 – 2018; -89.9 ± 50.6), p<0.0001

[e] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for October counts of greylag goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of October count data for greylag goose, the most parsimonious model gave no breakpoint. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit.

Breakpoints	0	1	2	3	4	5
RSS	1.65e+10	1.34e+10	9.58e+09	7.03e+09	6.57e+09	6.31e+09
BIC	8.09e+02	8.12e+02	8.11e+02	8.11e+02	8.19e+02	8.29e+02

No breakpoints detected. Regression estimates for the linear regression line.

	Estimate ± SE	p
1984 - 2018		
Intercept	-10290328 ± 749346.4	<0.0001
Year	5177.1 ± 374.5	<0.0001

Breakpoints for October counts of Canada goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of October count data for Canada goose, the selected model had two breakpoints. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoints and 95 % confidence intervals are given.

Breakpoints	0	1	2	3	4	5
RSS	1.09e+09	6.07e+08	4.00e+08	3.56e+08	3.50e+08	3.45e+08
BIC	8.48e+02	8.34e+02	8.28e+02	8.34e+02	8.44e+02	8.55e+02

Confidence intervals for breakpoints of optimal 3-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	26	27	28
2	34	35	36

Two breakpoints: 1995 – 1996 and 2009 – 2010

Regression estimates for linear regression line between breakpoints

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1977 – 1995				
Intercept	-904794 ± 163902[a]	<0.0001		
Year	458.2 ± 82.4[a]	<0.0001		
1996 – 2009				
Intercept	-2878401 ± 1045487[b]	0.009	-3783195 ± 748300.5[c]	
Year	1439.8 ± 82.4[b]	0.005	1898 ± 372.9[c, d]	0.0003[e]
2010 – 2018				
Intercept	3790346 ± 1279885[b]	0.009	2885552 ± 912405.8[c]	
Year	-1878.5 ± 635.3[b]	0.005	-1420 ± 453.0[c, d]	0.0165[e]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference and

SE = $\sqrt{(\text{SE. reference\^2} + \text{SE. value in relation to reference\^2})/2}$

[d] effect of "Year" (slope) was significantly different between segment 2 (1996 – 2009; 1898 ± 372.9) and segment 3 (2010 – 2018; -1420 ± 453.0), p<0.0001

[e] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for October counts of bean goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of estimated October count data for bean goose, the selected model had one breakpoint. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoint and 95 % confidence interval is given.

Breakpoints	0	1	2	3	4	5
RSS	4.08e+09	2.94e+09	2.34e+09	1.94e+09	1.67e+09	1.51e+09
BIC	9.03e+02	9.00e+02	9.02e+02	9.05e+02	9.10e+02	9.17e+02

Confidence intervals for breakpoint of optimal 2-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	17	20	22

One breakpoint: 1996 – 1997

Regression estimates for linear regression line before and after breakpoint

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1977 – 1996				
Intercept	-1938323 ± 677834[a]	0.0068		
Year	1004 ± 341.2[a]	0.0055		
1997 – 2018				
Intercept	-234223 ± 901023[b]	0.7963	-2172546 ± 797277[c]	
Year	107.0 ± 451.5[b]	0.8140	1110.7 ± 400.2[c]	0.0196[d]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference and

SE = $\sqrt{(\mathrm{SE.\,reference\hat{}2} + \mathrm{SE.\,value\ in\ relation\ to\ reference\hat{}2})/2}$

[d] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for breeding index of greylag goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of breeding index (TRIM-indices) for greylag goose , the selected model had one breakpoint. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoint and 95 % confidence intervals is given.

Breakpoints	0	1	2	3	4	5
RSS	234.6	139.3	92.5	67.2	41.7	33.1
BIC	119.4	117.6	118.1	120.6	119.7	123.9

Confidence intervals for breakpoint of optimal 2-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	9	10	16

One breakpoint: 2007 – 2008

Regression estimates for linear regression line before and after the breakpoint

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1998 – 2007				
Intercept	-2920.5 ± 631.1[a]	<0.0002		
Year	1.46 ± 0.32[a]	<0.0002		
2008 – 2018				
Intercept	1770.7 ± 836.7[b]	0.0494	-1149.8 ± 741.0[c]	
Year	-0.88 ± 0.42[b]	0.0486	0.576 ± 0.370[c]	0.144[d]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference and

SE = $\sqrt{(\mathrm{SE.\,reference\hat{}2} + \mathrm{SE.\,value\ in\ relation\ to\ reference\hat{}2})/2}$

[d] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for breeding index of Canada goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of breeding index (TRIM-indices) for Canada goose , the selected model had one breakpoint. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, location of the breakpoint and 95 % confidence interval is given.

Fit

Breakpoints	0	1	2	3	4	5
RSS	0.711	0.404	0,269	0.176	0.136	0.122
BIC	-2.36	-5.08	-4.52	-4.32	-0.49	6.31

Confidence intervals for breakpoint of optimal 2-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	10	11	16

One breakpoint: 2008 - 2009

Regression estimates for linear regression line before and after the breakpoint

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1998 – 2008				
Intercept	-65.1 ± 29.46[a]	0.0411		
Year	0.033 ± 0.014[a]	0.0381		
2009 – 2018				
Intercept	57.91 ± 45.13[b]	0.2166	-7.170 ± 38.107[c]	
Year	-0.029 ± 0.022[b]	0.2132	0.004 ± 0.019[c]	0.8378[d]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference and

SE = $\sqrt{(\text{SE. reference\^2} + \text{SE. value in relation to reference\^2})/2}$

[d] test if the effect of "Year" (slope) is significantly different from 0 (zero)

Breakpoints for breeding index of bean goose

The Strucchange package tests six different models with an increasing number of breakpoints (0 to 5), and selects the most parsimonious model (i.e. with the lowest BIC value). In the case of breeding index (TRIM-indices) for bean goose, the selected model had two breakpoints. The statistics present BIC (Bayesian Information Criteria) and RSS (Residual Sums of Squares) for each model in order to facilitate comparisons of model fit. For the most parsimonious model, locations of the breakpoints and 95 % confidence intervals are given.

Breakpoints	0	1	2	3	4	5
RSS	1.330	0.894	0.555	0.405	0.347	0.275
BIC	10.78	11.56	10.69	13.20	19.09	23.37

Confidence intervals for breakpoints of optimal 3-segment partition (position)

Breakpoint	2.5 %	Breakpoints	97.5 %
1	NA[1]	3	NA
2	5	6	7

Two breakpoints: 2000 – 2001 and 2003 – 2004

[1] 2.5 % confidence interval outside data range for breakpoint 1

Regression estimates for linear regression line between breakpoints

			Within segment	
	Estimate ± SE	p	Estimate ± SE	p
1998 – 2000				
Intercept	656.02 ± 271.88[a]	0.0291		
Year	-0.328 ± 0.136[a]	0.0293		
2001 – 2003				
Intercept	-1329.8 ± 384.78[b]	0.0035	-673.78 ± 333.148[c]	
Year	0.665 ± 0.192[b]	0.0035	0.337 ± 0.166[c, d]	0.2924[e]
2004 – 2018				
Intercept	-643.67 ± 272.860[b]	0.0323	12.349 ± 272.369[c]	
Year	0.322 ± 0.137[b]	0.0324	-0.006 ± 0.136[c, d]	0.9654[e]

[a] reference

[b] in relation to reference

[c] estimate as mean = reference + value in relation to reference

SE = $\sqrt{(\text{SE. reference}\text{^}2 + \text{SE. value in relation to reference}\text{^}2)/2}$

[d] effect of "Year" (slope) was not significantly different between segment 2 (2001 – 2003; 0.337 ± 0.166) and segment 3 (2004 – 2018; -0.006 ± 0.136), p = 0.0565

[e] test if the effect of "Year" (slope) is significantly different from 0 (zero)