Supplementary Materials for

Interpreting past trophic ecology of a threatened species, kea (*Nestor notabilis*), from museum specimens

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This pdf file includes:

Figures S1 to S4.

Tables S1 to S5.

Other supplementary materials for this manuscript include the following:

Data S1.

Fig. S1. Feather bulk $\delta^{13}C$ values through time, for kea captured from 1877 through to 2007, showing the increase in $\delta^{13}C$ variance after 1950.

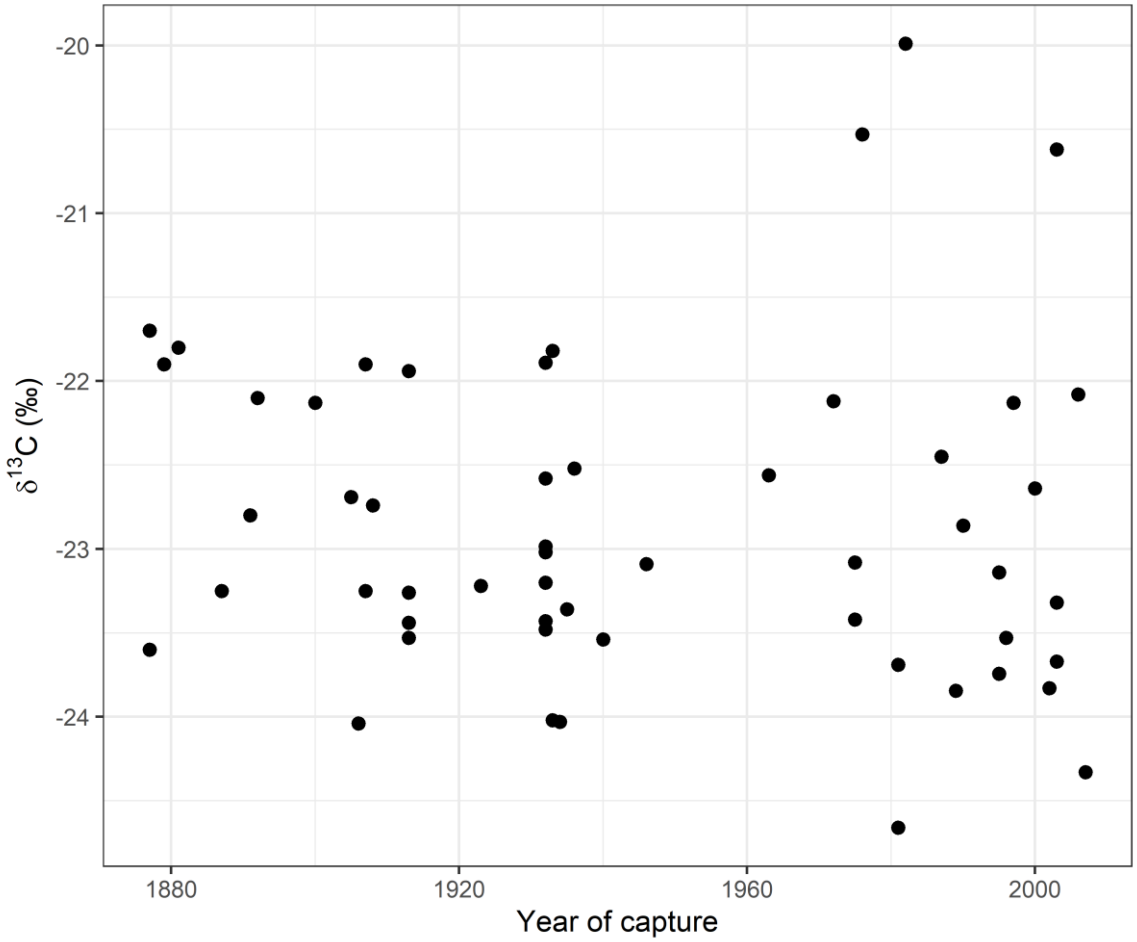

Fig. S2. Biplot of bulk δ15N vs δ13C values with 95% confidence interval ellipses for kea classified as north (black circles, male and female) or south (red circles, male and female). North corresponds to the Canterbury region, and south approximates the Otago region of New Zealand.

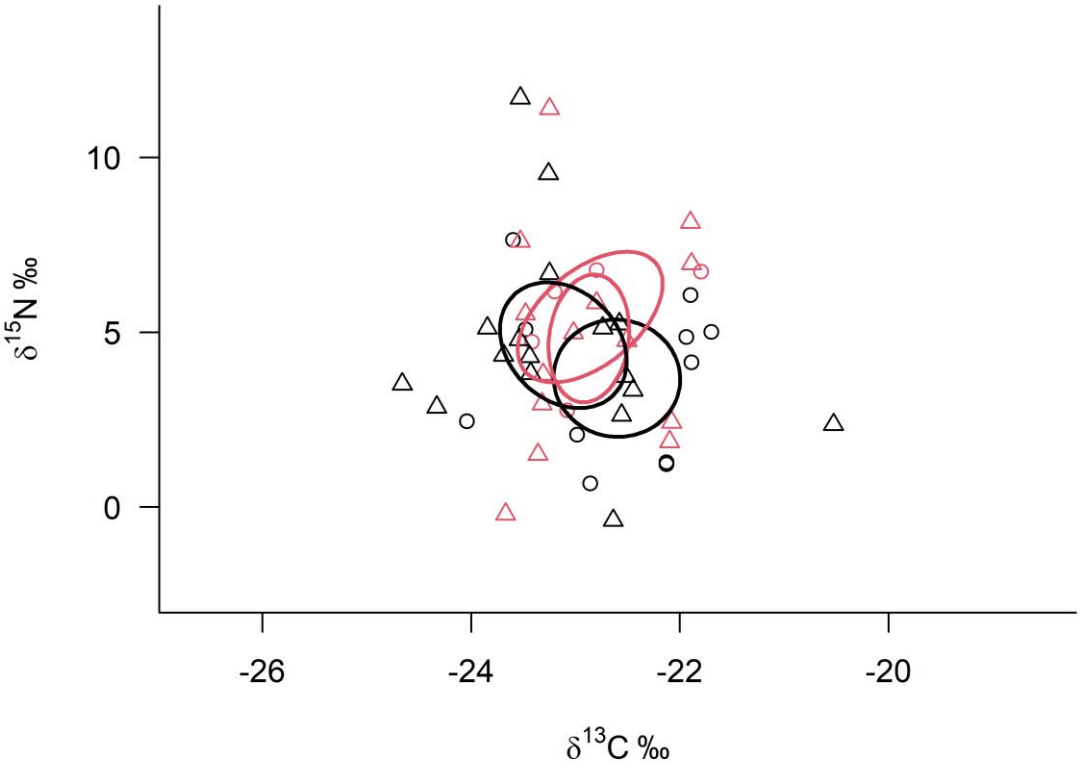

Fig. S3. Relationship of δ^{15}N Phe with bulk δ^{15}N values for feathers from 18 individual kea from museum collections. 95% confidence intervals are shown.

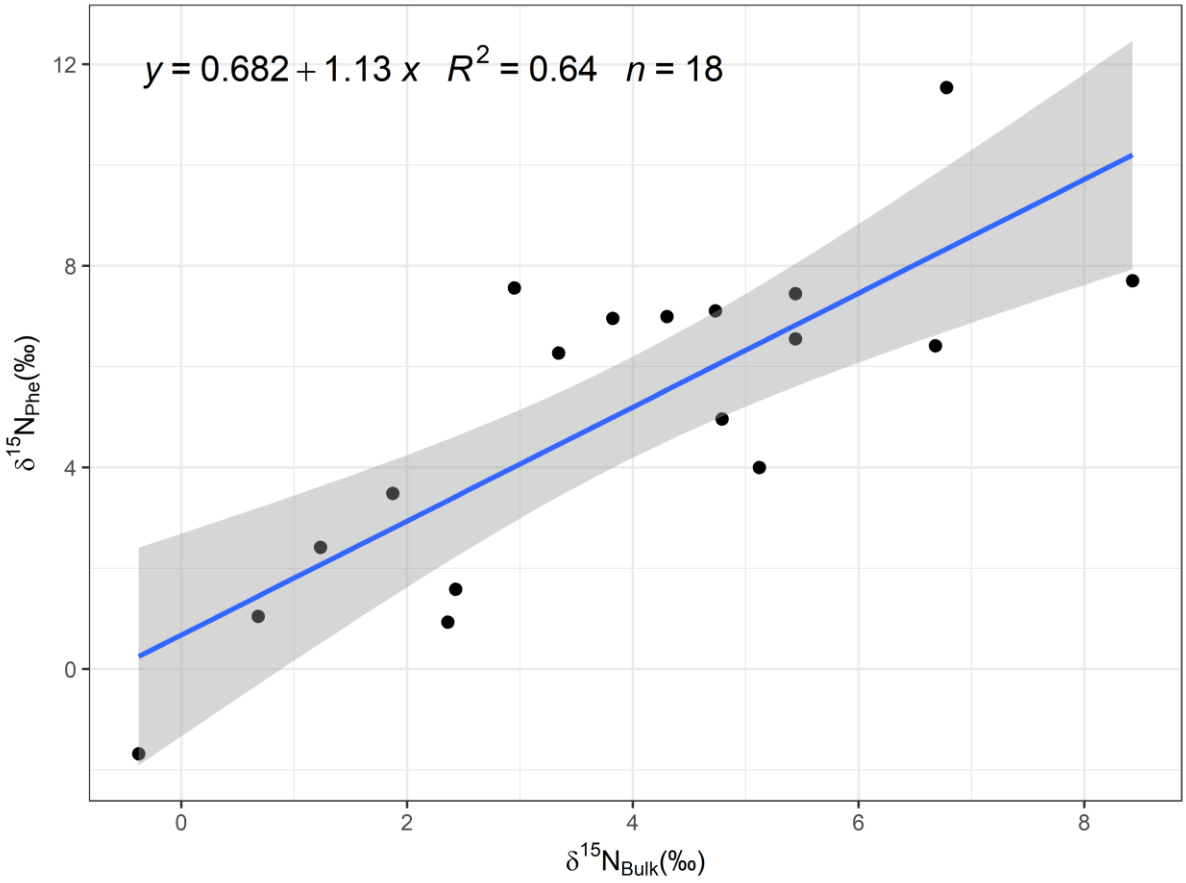

Fig. S4. Trophic position as estimated by the relationship of AA compounds Glx-Phe does not increase significantly through time.

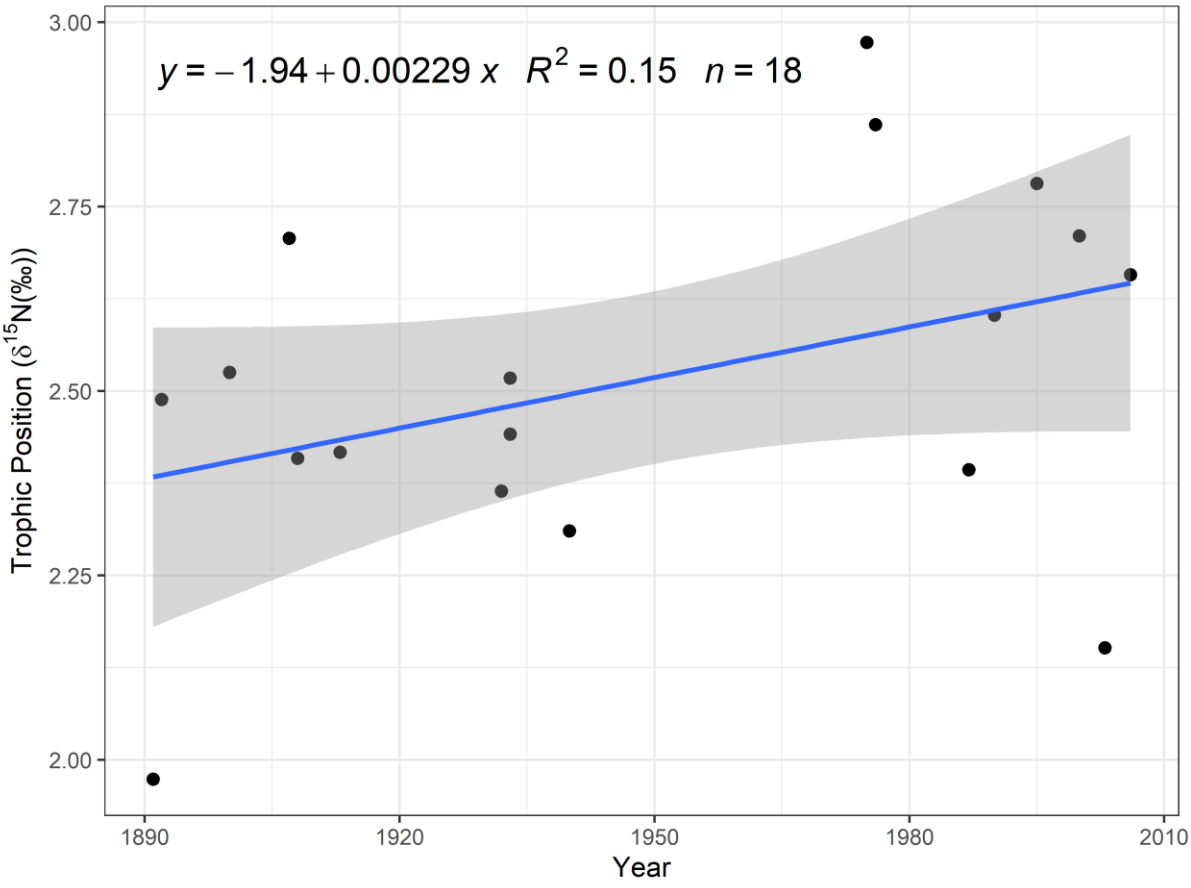

Table S1. Summary statistics for the linear mixed effects model for δ^{15}N values.

Formula: δ^{15}N ~ YearS + CulmenS + EstSex + Region + (1 | TidyLocation)

Linear mixed model fit by REML. t-tests use Satterthwaite's method. REML criterion at convergence: 171.3

Scaled residuals:

Min	1Q	Median	3Q	Max
-1.30667	-0.53481	0.02063	0.37240	1.75116

Random effects:

Groups	Name	Variance	Std.Dev.
TidyLocation	(Intercept)	5.551	2.356
Residual		1.566	1.251

Number of obs: 41, groups: TidyLocation, 25

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	3.618	0.809	31.729	4.471	9.31e-05 ***
YearS	-1.361	0.382	35.628	-3.560	0.001 **
CulmenS	0.036	0.418	28.457	0.087	0.931
EstSexm	0.886	0.790	22.563	1.122	0.274
RegionSouth	0.156	1.070	20.317	0.146	0.886

Signif. codes: 0 ‘***’ , 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘.’, 0.1 ‘ ’ 1

Table S2. Summary statistics for the linear mixed effects model with the primary focus on region and habitat effects - bulk δ^{15}N values and habitat type ("human" and "wild").

Formula: δ^{15}N ~ Region + Habitat + EstSex + Age2 + CulmenS + (1 | Location)

Linear mixed model fit by REML. t-tests use Satterthwaite's method. REML criterion at convergence: 182.5

Scaled residuals:

Min	1Q	Median	3Q	Max
-1.5457	-0.5364	0.1426	0.5020	1.4220

Random effects:

Groups	Name	Variance	Std.Dev.
Location	(Intercept)	4.926	2.220
Residual		1.901	1.379

Number of obs: 44, groups: Location, 27

*Fixed effects***:**

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	1.97336	1.04242	33.83639	1.893	0.067
RegionSouth	0.40817	1.01470	23.19608	0.402	0.691
HabitatWild	3.18239	0.96628	34.35583	3.293	0.002 **
EstSexm	0.63968	0.84645	25.54518	0.756	0.457
Age2young	0.07070	0.77760	19.49723	0.091	0.929
CulmenS	0.01554	0.45801	31.43551	0.034	0.973

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Expected marginal means for each level of the Region and Habitat model. Results are averaged over the levels of: Region, EstSex, Age2. Degrees-of-freedom method: Kenward-Roger, confidence level used is 0.95.

Habitat	**emmean**	**SE**	**df**	**lower.CL**	**upper.CL**
human	2.53	0.787	29.1	0.924	4.14
wild	5.72	0.674	33.0	4.344	7.09

Contrast (difference of means) table between the two habitats. Results are averaged over the levels of: Region, EstSex, Age2. Degrees-of-freedom method is Kenward-Roger.

contrast	**estimate SE**	**df**	**t.ratio**	**p.value**
human - wild	-3.18	1 34.8	-3.171	0.0032

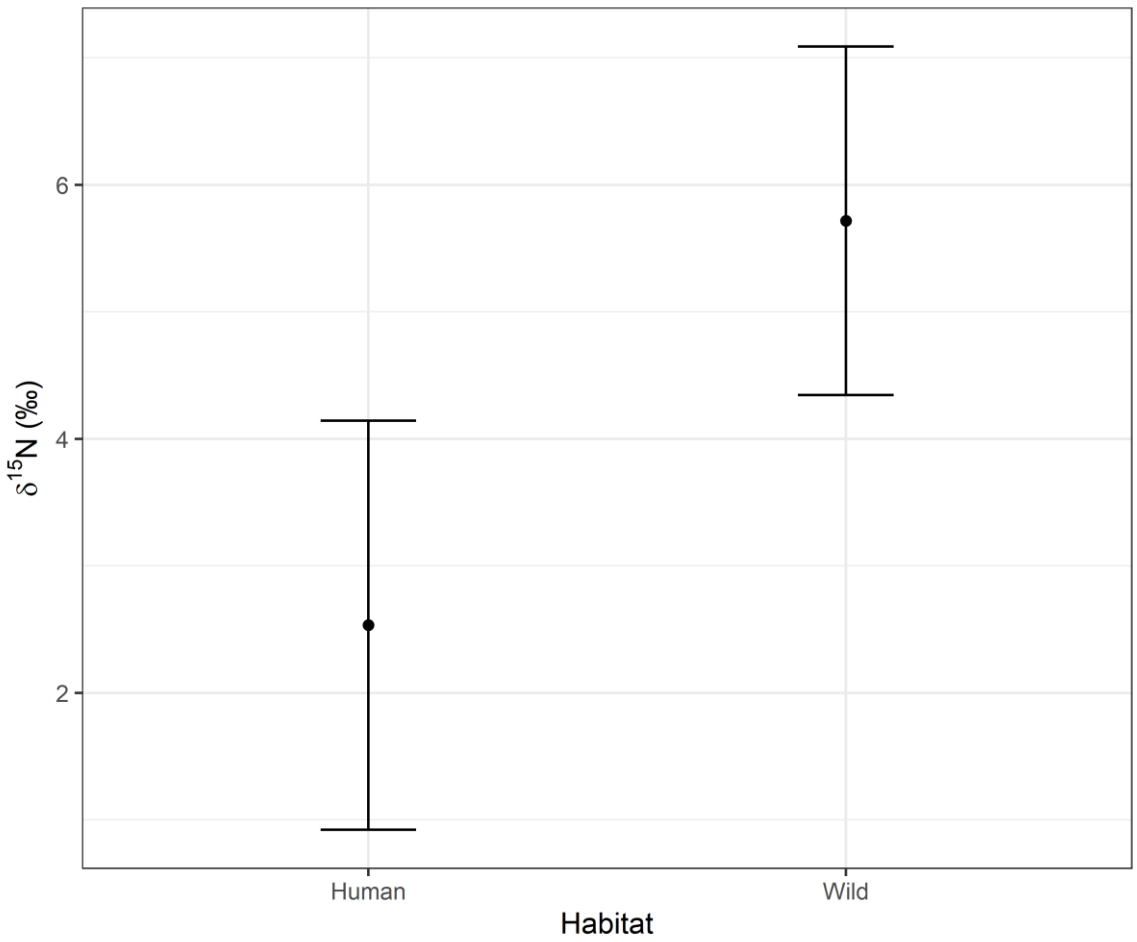

Table S3. Atomic C:N ratios and culmen length. Descriptive statistics and F-test results.

A tibble: 2 x 4

Culmen Class	n	Variance	SD
1	Q1	16 0.117	0.342
2	Q4	15 0.00444	0.0666

F test to compare two variances

F = 26.377, num df = 15, denom df = 14, p-value = 2.189e-07

Alternative hypothesis: true ratio of variances is not equal to 1

95% confidence interval (8.94, 76.27)

sample estimates: ratio of variances 26.37738

Table S4. Descriptive statistics and F-test results comparing δ^{15}N variance before and after 1950.

The F-test tests for equality of variance, with the F-statistic calculated as the ratio of variance: δ^{15}N (Pre-1950) / δ^{15}N (Post-1950).

Year	**n**	**δ^{15}N variance**	**SD δ^{15}N**
pre-1950	35	7.610498	2.758713
post-1950	22	6.307057	2.511386

F test to compare two variances

F = 1.21, num df = 33, denom df = 21, p-value = 0.66

Alternative hypothesis: true ratio of variances is not equal to 1

95% Confidence Interval (0.53, 2.57)

sample estimates: ratio of variances 1.21

Table S5. Stable isotopic values for wild captured birds, by month of death (original data).

Month	**n**	**Var(δ^{15}N)**	**SD(δ^{15}N)**	**Var(delC)**	**SD(delC)**
February	4	3.42	1.85	0.412	0.642
May	3	2.61	1.62	1.54	1.24
June	3	7.86	2.8	1.69	1.3
August	8	6.11	2.47	0.45	0.67
September	10	10.3	3.21	0.696	0.835
October	3	1.31	1.14	0.81	0.9
November	4	9.39	3.06	3.28	1.81
December	3	6.97	2.64	2.4	1.55

Levene's test results for comparing variance across sampling months for $\delta^{15}N$.

Levene's Test for Homogeneity of Variance (centre = median)

	Df	F value	Pr(>F)
group	8	0.4956	0.8499
	31		

Levene's test results for comparing variance across sampling months for $\delta^{13}C$.

Levene's Test for Homogeneity of Variance (centre = median)

	Df	F value	Pr(>F)
group	8	0.5145	0.8362
	31		