

Supplementary Material:

Using population viability analysis and fossil records to inform the conservation of pāteke (*Anas chlorotis*)

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Appendix S1. Latin Hypercube sampling protocol of pāteke demographic parameters for the global sensitivity analysis. Estimates of mean and standard deviations were all drawn from uniform (U) distributions.

Parameter	Mean	SD
Clutch size	U(1, 10)	U(0, 3)
Egg survival	U(0.1, 0.9)	U(0, 0.3)
Duckling survival	U(0.1, 0.9)	U(0, 0.3)
Fledgling survival	U(0.1, 0.9)	U(0, 0.3)
Adult survival	U(0.1, 0.9)	U(0, 0.3)
Parameter	Value	
Proportion breeding	U(0.5, 1.0)	
Extrinsic conditions	U(0.9, 1.1)	
Environmental variability	U(0, 0.1)	

Appendix S2. Global positioning system coordinates for pāteke fossil locations, rounded to two decimal places is a .csv file which can be found in the Supplementary Material .zip file

Appendix S3. Environmental variables used in MaxEnt species distribution models of pāteke across New Zealand.

Variable	Description	Units	Median (25 th and 75 th percentile)	Source
Distance to the coast	Distance in meters to the coastline	km	29.9 (11.2, 55.0)	NZEnvDS* /LENZ ⁺
Minimum winter (July) temperature	Minimum July temperature	°C	0.8 (-1.4, 3.0)	NZEnvDS /LENZ
Topographic wetness index	Quantify topographic controls on hydrological processes. Derived from slope, flow direction and flow accumulation. Low values have low potential to accumulate water, high values are associated with high water accumulation potential	unitless	5.7 (4.6, 7.4)	NZEnvDS /LENZ
Annual water deficit	Annual water deficit based on temperature, rainfall, and solar radiation	mm	6.0 (0.0, 51.0)	NZEnvDS /LENZ
Precipitation driest month	Minimum precipitation in the driest month	mm	88.0 (65.0, 123.0)	NZEnvDS /LENZ
Distance to waterbody	Minimum distance to freshwater source (rivers and lakes)	km	1.0 (0.5, 1.8)	Derived
Soil induration	Measure of soil hardness. Differentiated into five classes ranging from non-indurated (1) to very strongly indurated (5), 0 = no soil present at site.	ordinal scale (0-5)	4 (2, 4)	NZEnvDS /LENZ
Prehistoric vegetation cover	Modelled vegetation cover for 3000 years BP, simplified to six vegetation classes (Appendix 1 - Table S2)	categorical classes	not applicable	LRIS ⁺⁺

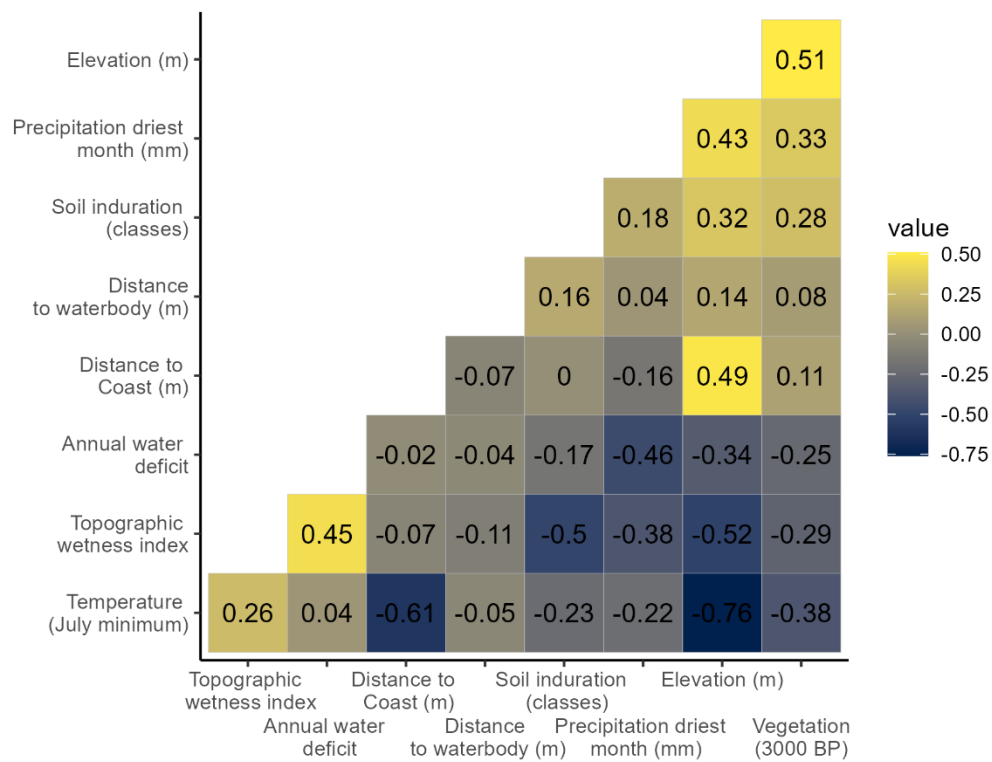
*NZEnvDS is the New Zealand Environmental Data Stack (v1.1; [McCarthy et al. 2021]).

⁺LENZ is Land Environments of New Zealand (Leathwick et al. 2002a, 2002b).

⁺⁺LRIS is the Land Resource Information Systems Portal (<https://lris.scinfo.org.nz>).

Appendix S4. Classes in the prehistoric New Zealand Vegetation land cover layer and the simplified classification used here, following (Wiser and De Cáceres 2013).

Original class	New class
Kauri/northern broadleaved	Broadleaved-podocarp forest alliances
Rimu/tawa-kamahi	Broadleaved-podocarp forest alliances
Kahikatea-pukatea-tawa	Broadleaved-podocarp forest alliances
Matai-kahikatea-totara	Broadleaved-podocarp forest alliances
Kahikatea-matai/tawa-mahoe	Broadleaved-podocarp forest alliances
Matai-totara-kahikatea-rimu/broadleaf-fuchsia	Broadleaved-podocarp forest alliances
Hall's totara/broadleaf forest	Broadleaved-podocarp forest alliances
Hall's totara/silver beech-kamahi-southern rata forest	Beech forest alliances
Hall's totara-miro-rimu/kamahi-silver beech-southern rata forest	Beech forest alliances
Hall's totara-miro/kamahi-southern rata-broadleaf forest	Broadleaved-podocarp forest alliances
Kahikatea-totara forest	Broadleaved-podocarp forest alliances
Rimu-miro/kamahi-red beech-hard beech	Beech forest alliances
Rimu-miro/tawari-red beech-kamahi-tawa	Beech forest alliances
Rimu-matai-miro-totara/kamahi	Broadleaved-podocarp forest alliances
Rimu-miro-totara/kamahi	Broadleaved-podocarp forest alliances
Silver beech	Beech forest alliances
Red beech-silver beech	Beech forest alliances
Black/mountain beech-red beech	Beech forest alliances
Mountain beech	Beech forest alliances
Matai-totara/black/mountain beech	Beech forest alliances
Wetland	Wetland
Dunelands	Dunelands
Scrub, tussock-grassland, and herbfield above treeline	Shrubland alliances
Low forest, woodland and shrubland below treeline	Broadleaved-podocarp forest alliances



Appendix S5. Pairwise correlations between environmental predictors selected for use in the MaxEnt species distribution model of pāteke occurrence. Elevation was highly correlated ($r = 0.76$) with July minimum temperature, so was removed.

Appendix S6. Analysis of varying environmental conditions through time.

In the pāteke PVA, we assumed extrinsic conditions had a mean of 1.0 and environmental variability a value of 0.05. These values act as a multiplier on the demographic rates in the model. During sensitivity analysis, we found the model to be highly sensitive to these values, particularly the value selected for the extrinsic conditions. Given that environmental conditions are likely to change through time under climate change, we explored two additional scenarios relating to the Gaussian noise, i) where the mean is fixed through time, but the SD increases each year (SM Fig. 4A) and ii) where the SD is fixed, but the mean decreases through time (SM Fig. 4B).

Increasing the SD and decreasing the mean in the Gaussian noise through time both resulted in more rapid pāteke extinction (SM Fig. 4C & 4D). Increasing the SD by 0.05 per year resulted in the expected extinction time decreasing from 106 years to 18 years, while decreasing the mean by 0.05 per year resulted in the expected extinction time decreasing from 99 years to 14 years.

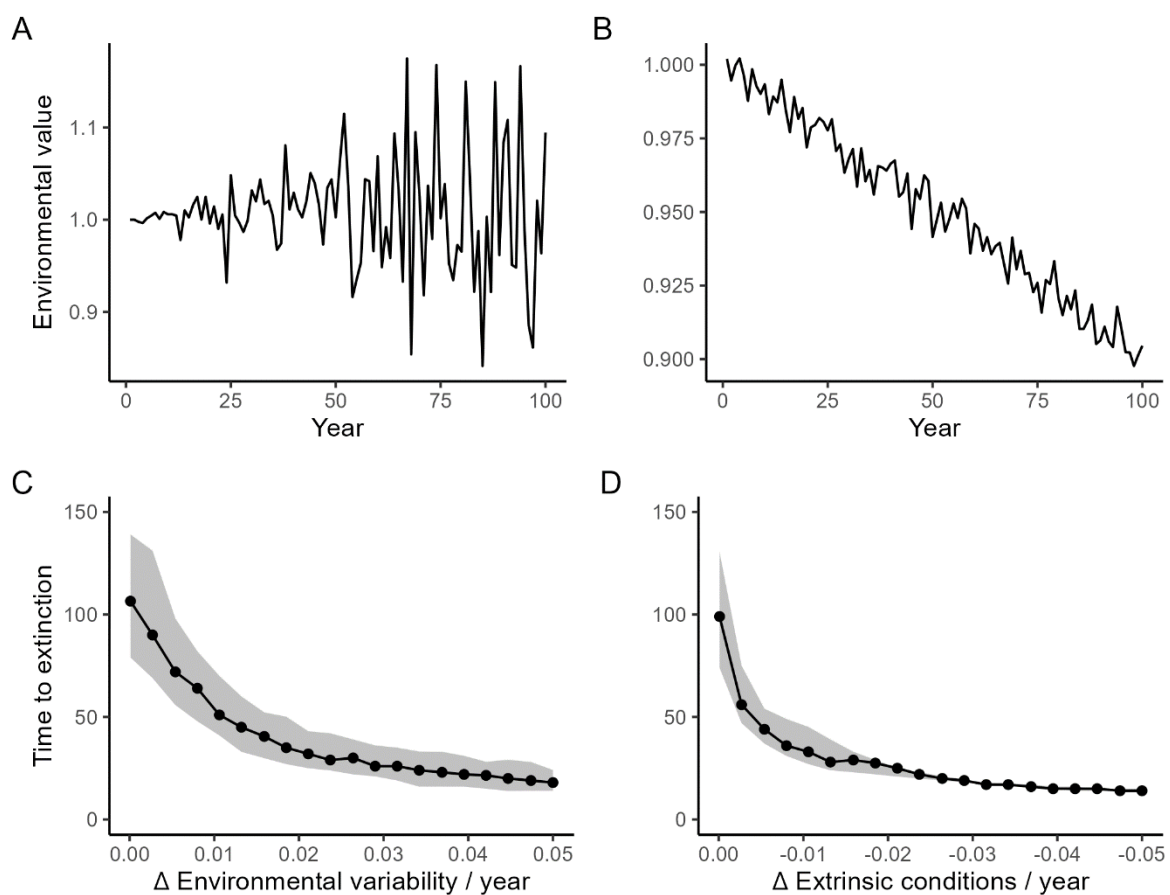
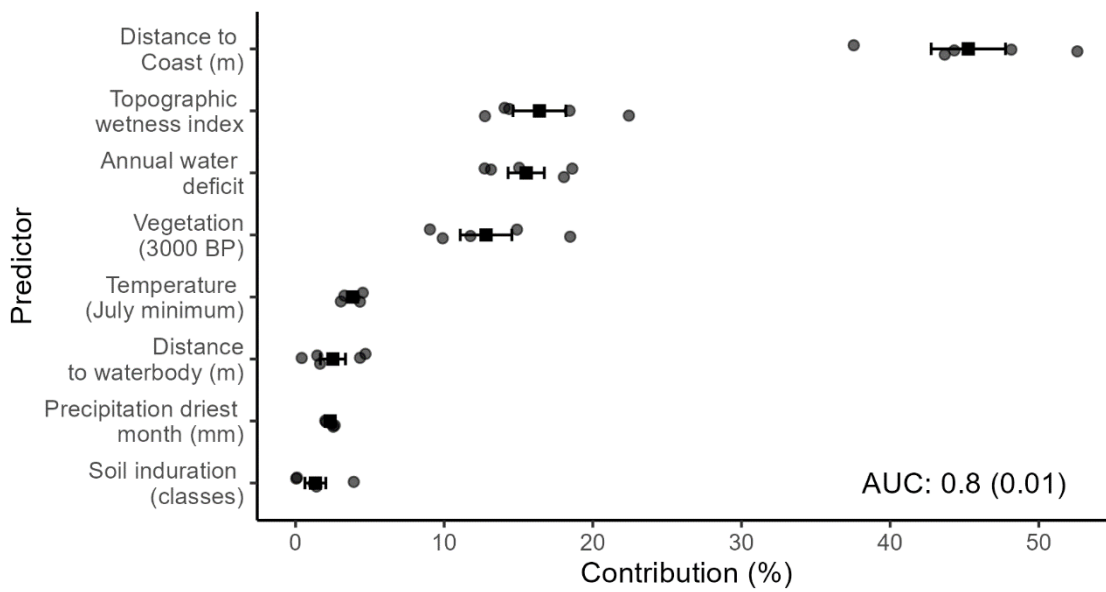


Figure S6. Examples of shifting environmental variability (A) and extrinsic conditions (B) through time and PVA results showing the change predicted time to extinction associated with changes to the environmental variability (C) and extrinsic conditions (D).



Appendix S7. Percent contributions of environmental predictors (based on dilution in performance when the parameter is omitted) to the probability of pāteke occurrence across New Zealand. Points represent individual model runs. The AUC displayed is the mean of the five cross-validated replicates and the standard deviation across these values.

References

Wiser, S. K., and M. De Cáceres. 2013. Updating vegetation classifications: an example with New Zealand's woody vegetation. *Journal of Vegetation Science* 24:80–93.