Using predictive **habitat modelling to locate** unknown nesting areas of the Endangered **Black-capped Petrel** in Hispaniola

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The **Diablotin Black-capped Petrel** (*Pterodroma hasitata*) has a **fragmented and declining population** of ca. 5,000 individuals. The nesting population is estimated at ca. **1,000 breeding pairs**. The only confirmed breeding sites are located in the **mountains of Haiti and the Dominican Republic**, where **habitat loss** and degradation are primary threats and continuing **conservation concerns**.
Black-capped Petrel **nesting habitat** is characterized by **steep ravines** and dense and humid **understory vegetation**. *In situ* **nest searches**, which must be conducted over **expansive geographical areas**, are **laborious and greatly limited** by the undisturbed natural habitat being prospected.

To focus nest-search efforts more efficiently, we predicted suitable nesting areas for Black-capped Petrel in Hispaniola.

Methods*

Habitat characteristics

Presence:
44 Black-capped Petrel nests

Availability:
5,000 random sites
> 1,200 m ASL
in Dominican Republic

50-m buffers
Overlapping buffers merged into **2 types of polygons**:
- presence
- pseudo-absence

Compared environmental variables (presence vs pseudo-absence) with series of **individual GLMs**

Selected **significant variables**
Retained **independent variables**
Removed collinear variables

Habitat suitability

Compared candidate models, including all possible first-level combinations of the **significant environmental variables**.

Ranked candidate models on basis of Akaike's Information Criterion (corrected).

Weight-averaged regression coefficients from models with ΔAICc <2 (scaled AIC weights)

Used **Area Under Curve** to estimate discrimination ability of top models

Computed **regression equation for final habitat suitability model** from weight-averaged coefficients

Applied equation to **GIS rasters of retained environmental variables**

Habitat suitability model map as a **raster of suitability values** ranking from 0 to 1, at a **resolution of 90 m x 90 m.**

Environmental variables

Enhanced Vegetation Index (500m)
Leaf-area Index (500m)
Evapotranspiration (500m)
Primary Productivity (500m)
Wood Biomass (30m)

Altitude (90m)
Distance to coast (90m)
Distance to ridgeline (90m)
Slope (90m)
Slope orientation (90m)
Flow accumulation (500m)

Generalized Linear Model

$ax+b$

Response:
Present/available (Binomial distribution, logit link, weighed)
Predictors:
Mean environmental variables, averaged over polygons

* Adapted from Troy, Holmes, Veech, Raine, & Green. 2014. Habitat suitability modelling for the Newell's shearwater on Kauai. J Fish Wildl Manag.

Results

Table 1. Habitat characteristics of Black-capped Petrel nesting areas

	Petrel sites (n = 16 polygons)			Random sites (n = 4923 polygons)				
Variable	Mean	Sd	Min.	Max.	Mean	Sd	Min.	Max.	p-value
Altitude (m)	**2081.9**	**243.9**	**1641.0**	**2325.0**	**1616.2**	**332.9**	**1180.0**	**2974.0**	**0.002**
Distance to coast (km)	**26.3**	**2.7**	**23.8**	**30.7**	**58.7**	**21.4**	**6.8**	**90.1**	**0.041**
Distance to ridgeline (m)	393.5	182.9	110.6	818.5	473.2	321.2	0.0	1834.9	0.400
Slope (%)	37.2	24.8	7.7	81.5	31.5	16.3	1.1	107.8	0.436
Slope orientation	**74.6**	**45.4**	**1.0**	**128.0**	**35.2**	**42.7**	**1.0**	**128.0**	**0.027**
Flow accumulation	8.0	11.5	1.0	36.5	7.6	22.6	1.0	438.7	0.943
Enhanced Vegetation index [a b]	**2794.9**	**320.1**	**2380.4**	**3474.4**	**3636.7**	**591.9**	**1563.1**	**5260.9**	**0.003**
Leaf-area index [b]	20.4	6.1	11.1	30.5	26.3	12.5	4.2	56.6	0.113
Evapotranspiration (kg m^{-2} 8day^{-1}) [b]	**194.3**	**59.6**	**125.4**	**294.7**	**250.2**	**62.5**	**87.9**	**401.6**	**0.024**
Primary Productivity (kg C m^{-2}) [b]	**9600.0**	**4745.9**	**5949.8**	**16873.3**	**12898.8**	**3883.9**	**1691.6**	**19640.2**	**0.048**
Wood biomass (10^{3}g ha-1)	**167.9**	**16.4**	**136.4**	**198.1**	**130.3**	**58.0**	**0.0**	**268.9**	**0.068**

[a] Dependent; [b] Multi-collinear

Table 2. Ten best models for Black-capped Petrel habitat suitability

Model	Rank	AICc	ΔAICc	AICc weight	Scaled AICc weight	AUC
1 + EVI + DEM + Orientation + Biomass + DistanceCoast	**1**	**-14393.58**	**0.00**	**0.356**	**0.358**	**0.97**
1 + DEM + Orientation + DistanceCoast	**2**	**-14392.69**	**0.89**	**0.229**	**0.230**	**0.96**
1 + EVI + DEM + Orientation + DistanceCoast	**3**	**-14392.62**	**0.96**	**0.221**	**0.222**	**0.97**
1 + DEM + Orientation + Biomass+ DistanceCoast	**4**	**-14392.31**	**1.26**	**0.189**	**0.190**	**0.97**
1 + EVI + DEM + Biomass+ DistanceCoast	5	-14383.22	10.36	0.002	0	0.97
1 + DEM + Biomass+ DistanceCoast	6	-14381.83	11.74	0.001	0	0.97
1 + DEM + DistanceCoast	7	-14381.01	12.57	0.001	0	0.96
1 + EVI + DEM + DistanceCoast	8	-14380.72	12.85	0.001	0	0.96
1 + EVI + Orientation + Biomass+ DistanceCoast	9	-14379.58	14.00	0.000	0	0.97
1 + EVI + Orientation + DistanceCoast	10	-14371.56	22.01	0.000	0	0.96
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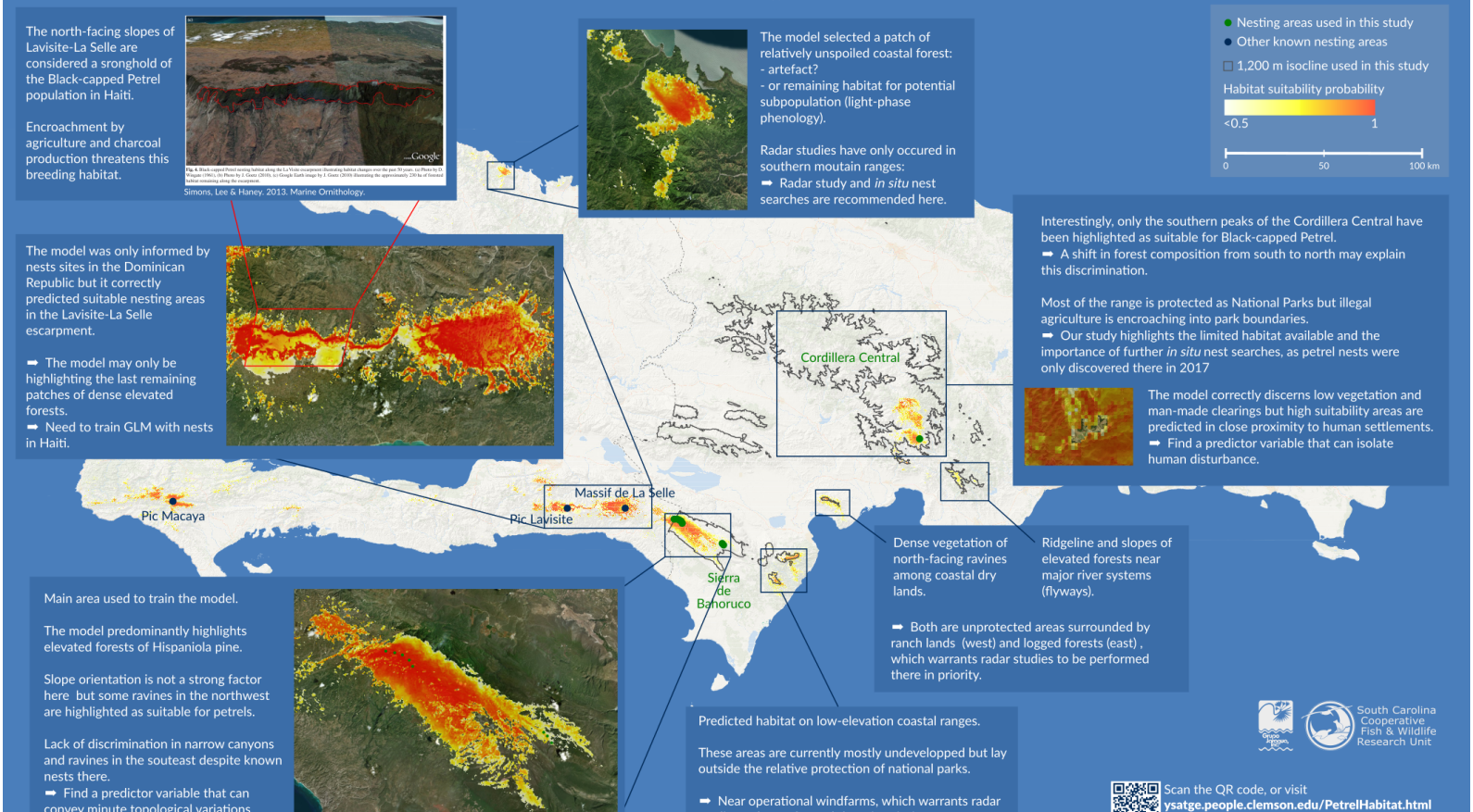
1 (Intercept only)	32	-14307.72	85.85	0.000	0	0.50

EVI: Enhanced Vegetation Index; DEM: Digital Elevation Model (altitude).



The north-facing slopes of Lavisite-La Selle are considered a sronghold of the Black-capped Petrel population in Haiti.

Encroachment by agriculture and charcoal production threatens this breeding habitat.

Simons, Lee & Haney. 2013. Marine Ornithology.

The model selected a patch of relatively unspoiled coastal forest:
- artefact?
- or remaining habitat for potential subpopulation (light-phase phenology).

Radar studies have only occured in southern moutain ranges:
➡ Radar study and *in situ* nest searches are recommended here.

The model was only informed by nests sites in the Dominican Republic but it correctly predicted suitable nesting areas in the Lavisite-La Selle escarpment.

➡ The model may only be highlighting the last remaining patches of dense elevated forests.
➡ Need to train GLM with nests in Haiti.

Interestingly, only the southern peaks of the Cordillera Central have been highlighted as suitable for Black-capped Petrel.
➡ A shift in forest composition from south to north may explain this discrimination.

Most of the range is protected as National Parks but illegal agriculture is encroaching into park boundaries.
➡ Our study highlights the limited habitat available and the importance of further *in situ* nest searches, as petrel nests were only discovered there in 2017

The model correctly discerns low vegetation and man-made clearings but high suitability areas are predicted in close proximity to human settlements.
➡ Find a predictor variable that can isolate human disturbance.

Dense vegetation of north-facing ravines among coastal dry lands.

Ridgeline and slopes of elevated forests near major river systems (flyways).

➡ Both are unprotected areas surrounded by ranch lands (west) and logged forests (east), which warrants radar studies to be performed there in priority.

Main area used to train the model.

The model predominantly highlights elevated forests of Hispaniola pine.

Slope orientation is not a strong factor here but some ravines in the northwest are highlighted as suitable for petrels.

Lack of discrimination in narrow canyons and ravines in the souteast despite known nests there.
➡ Find a predictor variable that can convey minute topological variations

Predicted habitat on low-elevation coastal ranges.

These areas are currently mostly undeveloped but lay outside the relative protection of national parks.

➡ Near operational windfarms, which warrants radar studies to be performed there in priority.

South Carolina Cooperative Fish & Wildlife Research Unit

Scan the QR code, or visit **ysatge.people.clemson.edu/PetrelHabitat.html** for an interactive map of petrel habitat suitability