Predicting suitable nesting sites for the Black caiman (*Melanosuchus niger* Spix 1825) in the Central Amazon basin

Gabriela Paola Ribeiro Banon\(^a\), Gerald Jean Francis Banon\(^b\), Francisco Villamarín\(^{c,d}\), Eduardo Moraes Arraut\(^{a,e,f,g}\), Gabriel Massaine Moulatlet\(^{c,h}\), Camilo Daleles Remô\(^i\), Lise Christine Banon\(^a\), Boris Marioni\(^j\) and Evlyn Márcia Leão de Moraes Novo\(^a\)

\(^a\)Divisão de Sensoriamento Remoto, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, São Paulo, Brazil; \(^b\)Retired from; \(^c\)Universidad Regional Amazónica - Ikiam, Tena, Ecuador; \(^d\)Coordenación de Biodiversidad, Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil; \(^e\)Departamento de Biología Vegetal, Universidade Estadual de Campinas, Campinas, São Paulo, Brazil; \(^f\)Departamento de Recursos Hídricos e Saneamento Ambiental, Instituto Tecnológico de Aeronáutica, São José dos Campos, São Paulo, Brazil; \(^g\)Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, Oxford, Oxfordshire, United Kingdom; \(^h\)Department of Biology, University of Turku, Turku, Finland; \(^i\)Divisão de Processamento de Imagem, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, São Paulo, Brazil; \(^j\)Programa de Conservação de Crocodilianos Amazônicos, Instituto Piagacu, Manaus, Amazonas, Brazil

**ABSTRACT**

After many years of illegal hunting and commercialization, the populations of the Black caiman (*Melanosuchus niger*) have been recovering during the last four decades due to the enforcement of a legislation that inhibits their international commercialization. Protecting nesting sites, in which vulnerable life forms (reproductive females, eggs, and neonates) spend considerable time, is one of the most appropriate conservation actions aimed at preserving caiman populations. Thus, identifying priority areas for this activity should be the primary concern of conservationists. As caiman nesting sites are often found across the areas with difficult access, collecting nest information requires extensive and costly fieldwork efforts. In this context, species distribution modeling can be a valuable tool for predicting the locations of caiman nests in the Amazon basin. In this work, the maximum entropy method (*MaxEnt*) was applied to model the *M. niger* nest occurrence in the Mamirauá Sustainable Development Reserve (MSDR) using remotely sensed data. By taking into account the *M. niger* nesting habitat, the following predictor variables were considered: conditional distance to open water, distance to bare soil, expanded contributing area from drainage, flood duration, and vegetation type. The threshold-independent prediction performance and binary prediction based on the threshold value of 0.9 were evaluated by the area under the curve (AUC) and performing a binomial test, respectively. The obtained results (AUC = 0.967 ± 0.006 and a highly significant binomial test \(P < 0.01\)) indicated excellent performance of the proposed model in predicting the *M. niger* nesting occurrence in the MSDR. The variables related to hydrological regimes (conditional distance to open water, expanded contributing area from drainage, and flood duration) most strongly affected the model performance. *MaxEnt* can be used for developing community-based sustainable management programs to provide socio-economic benefits to local communities and promote species conservation in a much larger area within the Amazon basin.

**CONTACT** G. P. R. Banon. Email: gabrielabanon@gmail.com
Supplementary material
Figure S1. Overview of the ECAD acquisition. (A) Local drainage direction (red arrow) and drainage network points (blue square). (B) Contributing area of the drainage network points obtained by adding the contribution of each local drainage direction to the corresponding drainage network point. (C) Expanded contributing area obtained from the contributing area of the drainage network points.
Figure S2. A simple example illustrating the MaxEnt modeling concept. The MaxEnt distribution is plotted on the $4 \times 4$ scene in blue. Two presence records (pink) and one environmental layer (grey) are depicted assuming two values (light and dark grey). MaxEnt distribution obtained (A) during the initial step and (B) after convergence.
Figure S3. Training omission rate and predicted area for *M. niger* nests in the MSDR plotted as functions of the cumulative threshold averaged over 100 bootstrap replicate runs. The vertical red line indicates the threshold value of 0.9.
Figure S4. Jackknife test conducted for evaluating the isolated and combined effect of each variable on the model performance in terms of AUC values.