4-17-2023

Timing of diversification, dispersal, and biogeography of parrots in thegenus Amazona throughout the Caribbean, visualized in GIS

Christopher Kingwill
Fort Hays State University, cjkingwill@mail.fhsu.edu

Follow this and additional works at: https://scholars.fhsu.edu/sacad

Recommended Citation

Kingwill, Christopher (2023) "Timing of diversification, dispersal, and biogeography of parrots in thegenus Amazona throughout the Caribbean, visualized in GIS," *SACAD: John Heinrichs Scholarly and Creative Activity Days*: Vol. 2023, Article 87.
DOI: 10.58809/XVTN6242
Available at: https://scholars.fhsu.edu/sacad/vol2023/iss2023/87

Christopher Kingwill
cjkingwill@mail.fhsu.edu

Timing of dispersal, evolution, and biogeography of parrots in the genus *Amazona* throughout the Greater Antilles, visualized in GIS

FORT HAYS STATE UNIVERSITY
WERTH COLLEGE OF SCIENCE, TECHNOLOGY AND MATHEMATICS
Department of Geosciences
Forward thinking. World ready.

Abstract

Modern bird diversity for groups in the Greater Antilles, like parrots, is a fraction of what it once was prior to human arrival in the Caribbean. Among parrot groups thought to have been once more widespread are amazons (*Amazona*), a genus with almost 30 species, found across Central and South America. Phylogenetic work on *Amazona* has determined molecularly-dated divergence times for the evolution of different species. Today, the Greater Antilles have many single-island endemic amazon species and only one species, the Rose-Throated Parrot (*Amazona leucocephala*) being found on multiple islands. Divergence times of amazon parrots from molecular phylogenetic dating, can be correlated to known sea-level values from marine isotope stages (MIS) of the Pliocene and Pleistocene. Bathymetric data was altered using raster math (map algebra) to create seascapes – islands/landmasses reflecting sea-level conditions during the Late Pliocene and Pleistocene to determine optimal connectivity between islands which were then made into Routes using Network Analyst in ArcGIS Pro. Exposure vs inundation of the Nicaraguan Rise likely influenced island-hopping for these parrots between the mainland and Jamaica, leading to at least two colonization events, where after which amazons colonized the rest of the Greater Antilles.

Figure 1. An amazon parrot (Rose-Throated Parrot).
Systematics:
Kingdom - Animalia
Phylum - Chordata
Class - Aves
Order - Psittaciformes
Family - Psittacidae
Genus - Amazona

Study Area

Paleo Range of Greater Antillean Amazons, in relation to Modern Geographic Ranges

Greater Antillean Fossil Record Aggregated Range (Pleistocene + Holocene)
Greater Antillean Amazon Species: Modern Ranges

Scale: 1:7,500,000
0 125 250 500 750 1,000 Kilometers
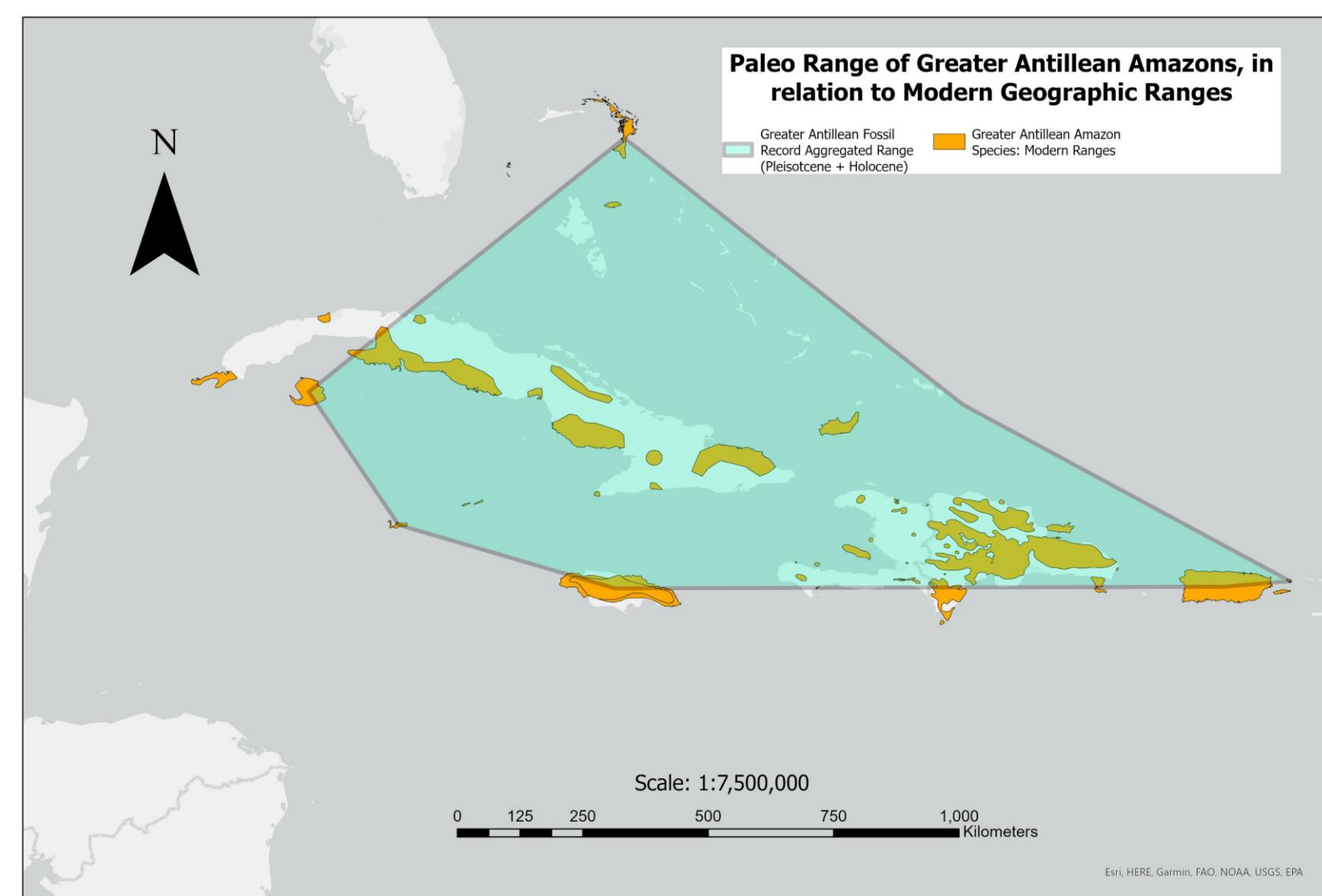Esri, HERE, Garmin, FAO, NOAA, USGS, EPA.

Figure 2. Modern geographic range of the amazon parrot genus across the Greater Antilles with the spatial extent of the Greater Antillean amazon fossil record. The fossil record suggests that amazons were more widespread prior to the arrival of humans to the Caribbean.
• Amazon parrot fossils found in the Caribbean include mandibles, tarsometatarsi, humeri, ulnae, phalanges, ulnare, coracoids, pelvis, etc. Found mostly in caves now submerged by higher sea levels, or at archaeological sites.

Methodology - Results
Late Pliocene & Pleistocene MIS Seascape Networks

A — Network - M2: -65m Below Sea Level / Network Paths — Scale: 1:16,000,000 — 0 125 250 500 750 1,000 Kilometers — Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

B — Network - mPWP +30m Above Sea Level / Network Routes — Scale: 1:16,000,000 — 0 125 250 500 750 1,000 Kilometers — Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

C — Network - MIS 16: -100m Below Sea Level / Network Paths — Scale: 1:16,000,000 — 0 125 250 500 750 1,000 Kilometers

D — Legend:
★ M2 Stops
★ mPWP Stops
★ MIS 16 Stops

Seascape, M2 - Late Pliocene (≈3.3 Ma): -65m Below Sea Level
Seascape, mid-Piancenzian Warm Period - Late Pliocene (≈3.25 – 2.9 Ma) +30m Above Sea Level
Seascape, MIS 16 - Pleistocene (≈625 – 636 ka): -100m Below Sea Level

Marine Isotope Stage M2 - Route: Central America to Jamaica
mPWP - Route: Jamaica to Cuba
MIS 16 Route: Cuba, Bahamas, Cayman Islands
MIS 16 Route: Cuba, Hispaniola, Puerto Rico

Rose-Throated Parrot, *A. leucocephala*; Cuba, Bahamas, Cayman Islands
White-Fronted Amazon, *A. albifrons* (mainland ancestral species)
Yellow-Billed Parrot, *A. collaria*; Jamaica
Black-Billed Parrot, *A. agilis*; Jamaica
Hispaniolan Parrot, *A. ventralis*; Hispaniola
Puerto Rican Parrot, *A. vittata*; Puerto Rico

Scale: 1:8,500,000
0 115 230 460 690 920 Kilometers
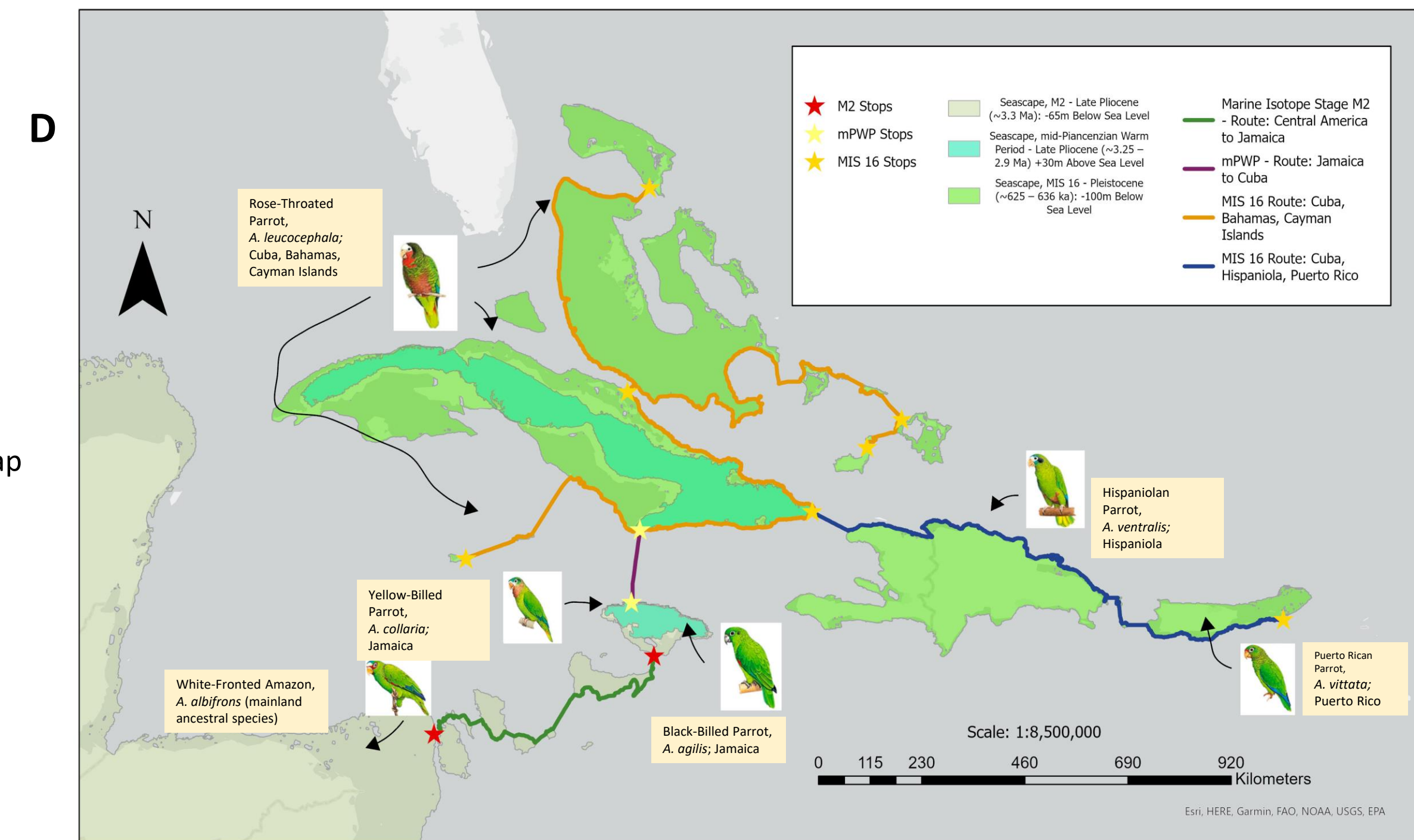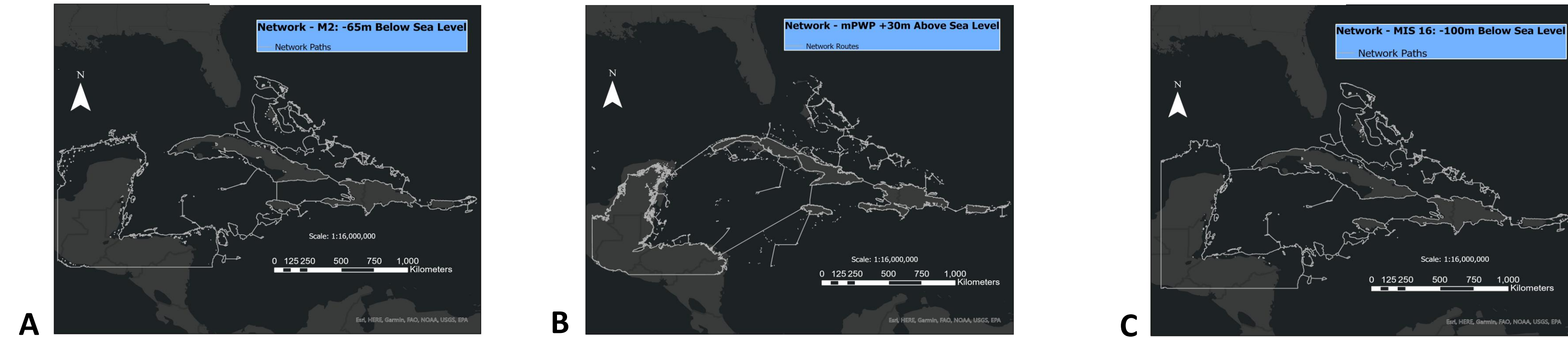Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

Figure 3 A-C: Different islands/landmass extents at different sea-level values, with their polyline boundaries merged to polylines connecting these landmasses from generating optimal region connections, converted to Network datasets.

3 D: Greater Antillean amazon parrot dispersion map in terms of the most optimal Network Routes in relation to sea-level reconstructions according to three MIS and evolutionary divergence times.

Conclusion

Network Analyst can be applied to map paleo routes of birds with only distance as the parameter of measurement and cost. Using modified bathymetric data as the basis for island network routes in reference to fossil data demonstrates island-hopping dispersion. Considering this in the context of previous literature suggests that the avian fossil record in the Caribbean for the Pleistocene and Holocene is still developing.

Reiteration
• By modifying bathymetric data to simulate the Greater Antilles according to sea levels of 3 different MIS – **M2, mPWP, and MIS 16**, each of which were used as estimates for being matched up with phylogenetic divergence times for different endemic species of amazon parrot
• The output landmasses exported from this modified raster data can be used as input regions for generating pathways of optimal connectivity, which can be then used in route operations using Network Analyst to assess potential routes of travel for these birds.

Future
• This project is part of a larger GIS project using feature and raster operations to assess evolution of Caribbean amazon parrots, in relation to their fossil record and known evolution patterns in the Caribbean
• More MIS periods will be used and the Lesser Antilles will be covered as a second region
• In addition to raster math, raster to feature conversion, and Network operations, this larger study will cover raster analysis, specifically Euclidian distance, using modeled maximum flight range distances for amazons