



Utilizing Museum Collections for Conservation Genomics of Endangered Species

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Talk Outline

- Primer to genomics
- Ancestry inference introduction
- VertNet
- Species & Population Sourcing case studies:
 - *Ara* macaws:
 - *Pyrrhura* parakeets





Who Be Me?

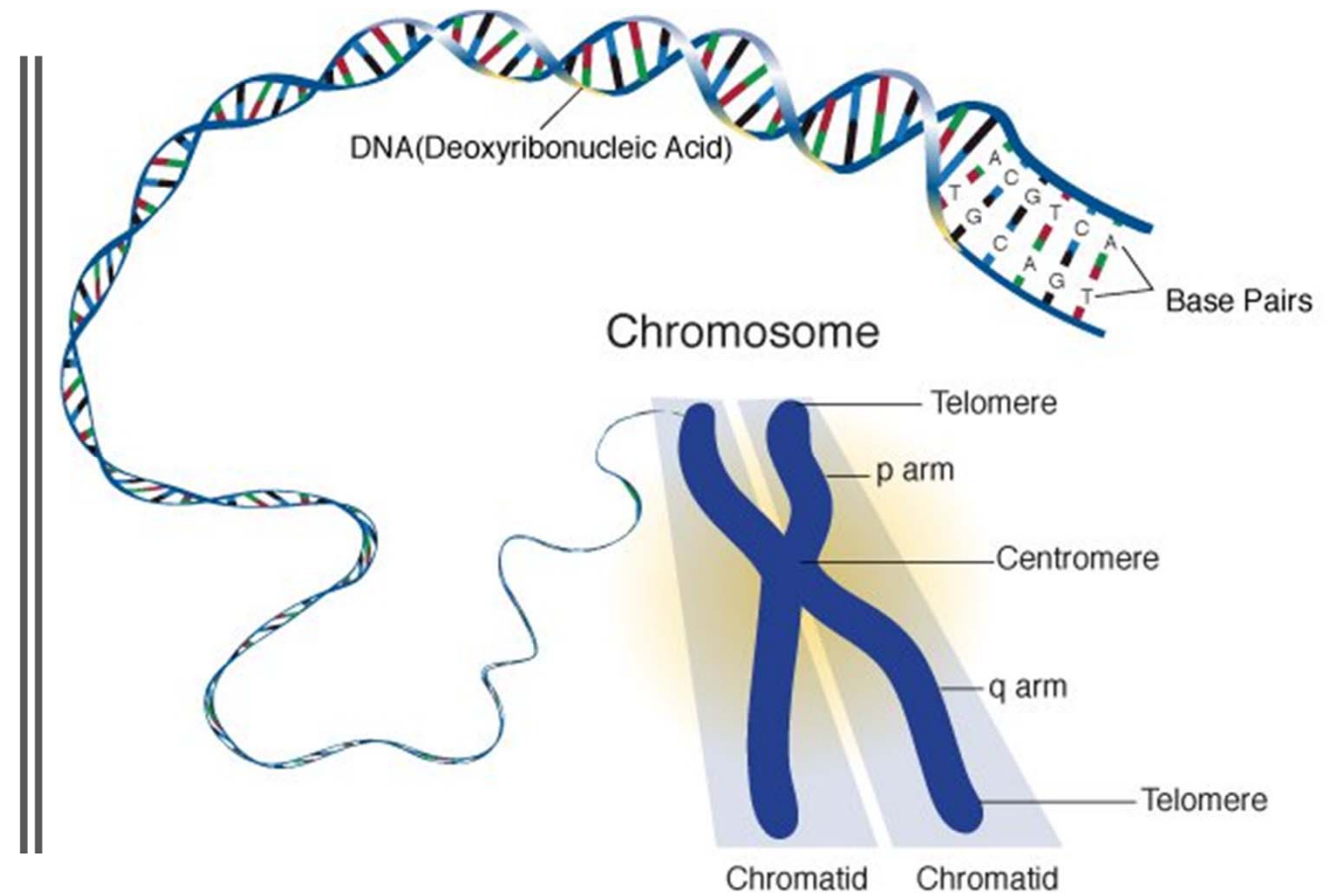
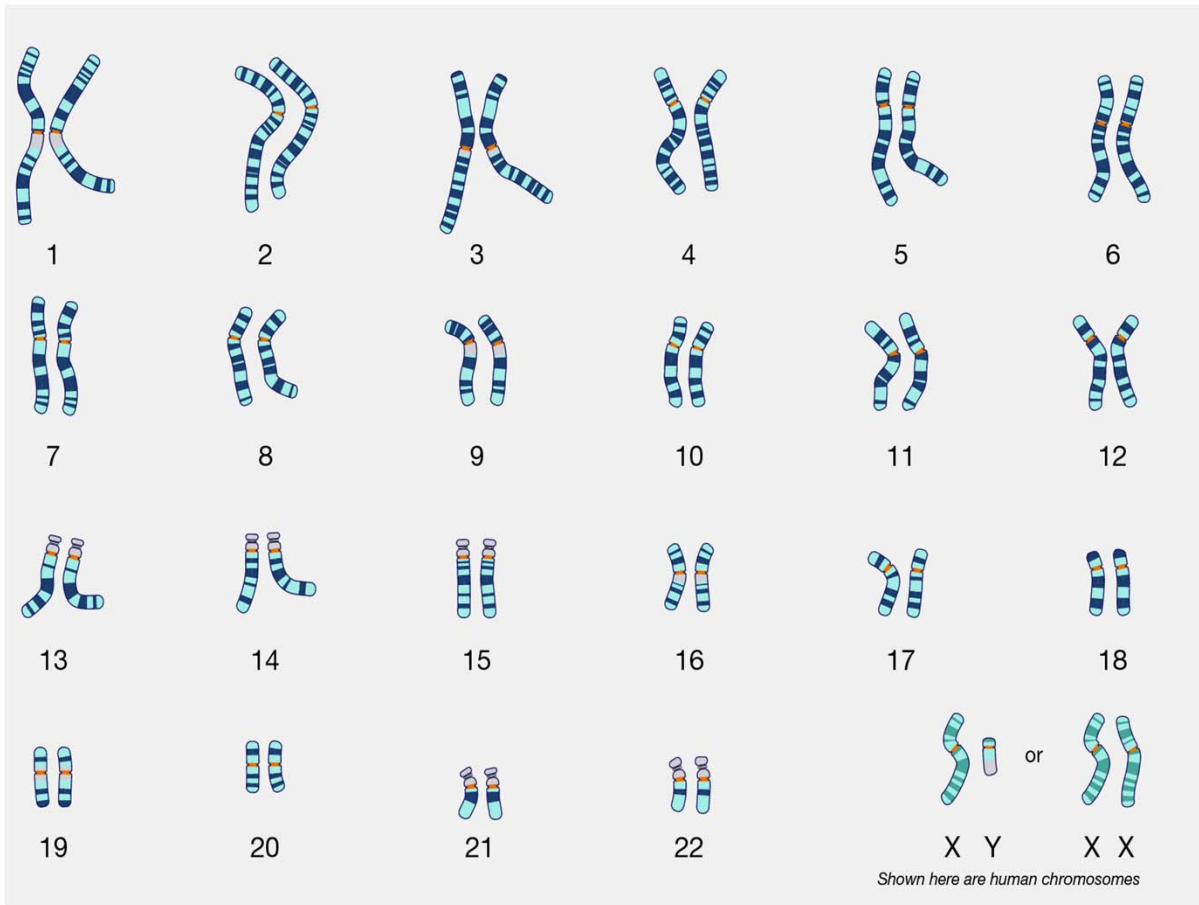
- From Southern California
- Columbia University
 - BA In Environmental Biology
- Johns Hopkins
 - MS in Environmental Science & Policy
- The University of Chicago
 - PhD in Evolutionary Biology

Ornithological Museum Collections

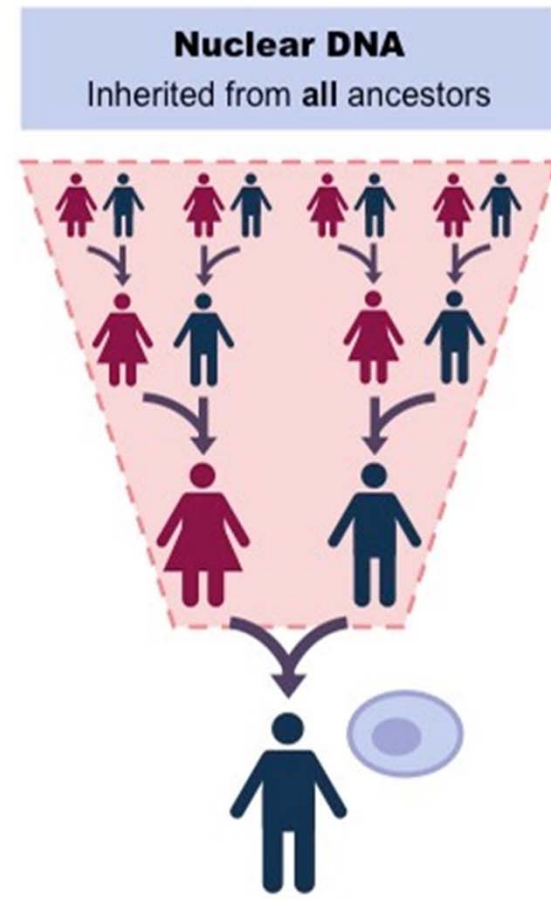
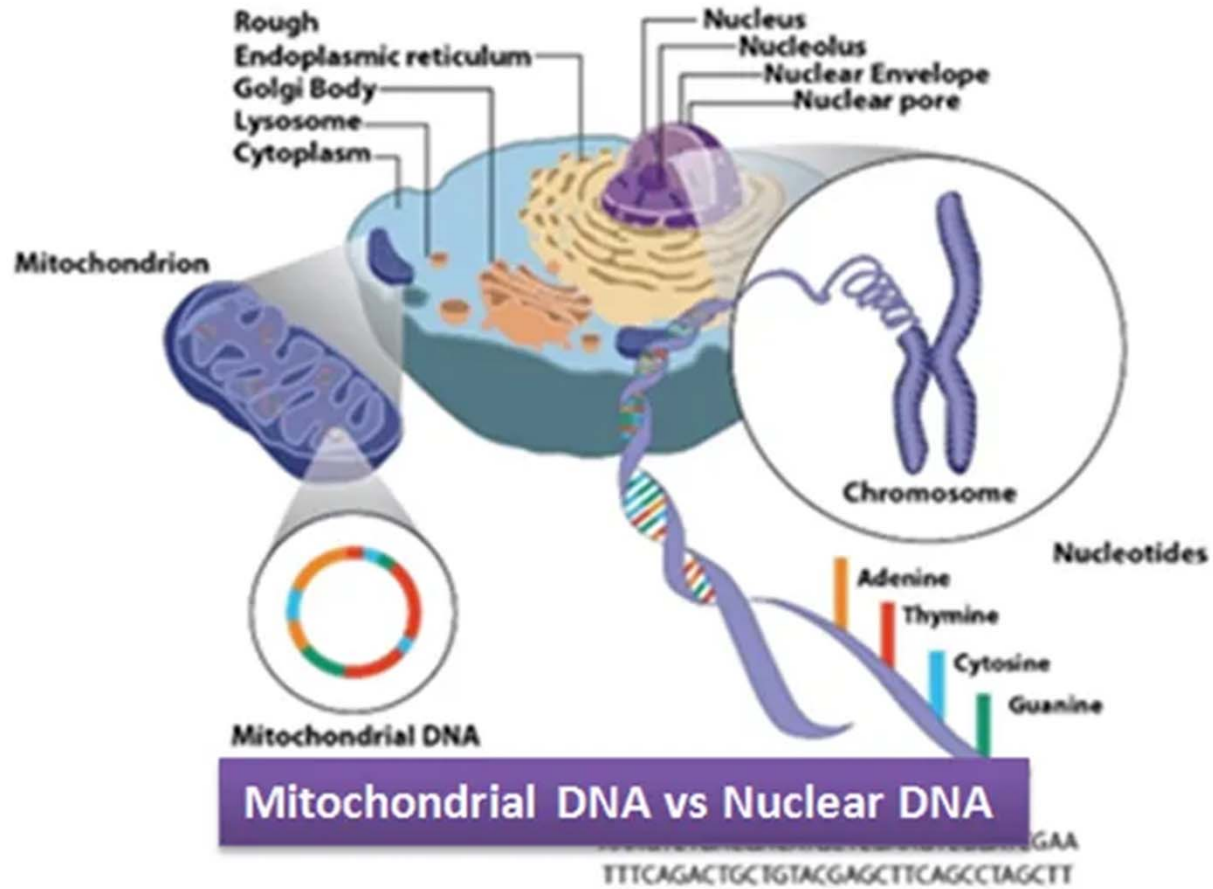
- Natural History Collections house:
 - Skins
 - Round and Flat
 - Genetic samples are taken from the feet and thus referred to as toepad samples
 - Skeletons
 - Tissues
 - Eggs
-



Genomics 101



Genomics 101



What are we trying to create?

whole genome shotgun sequence

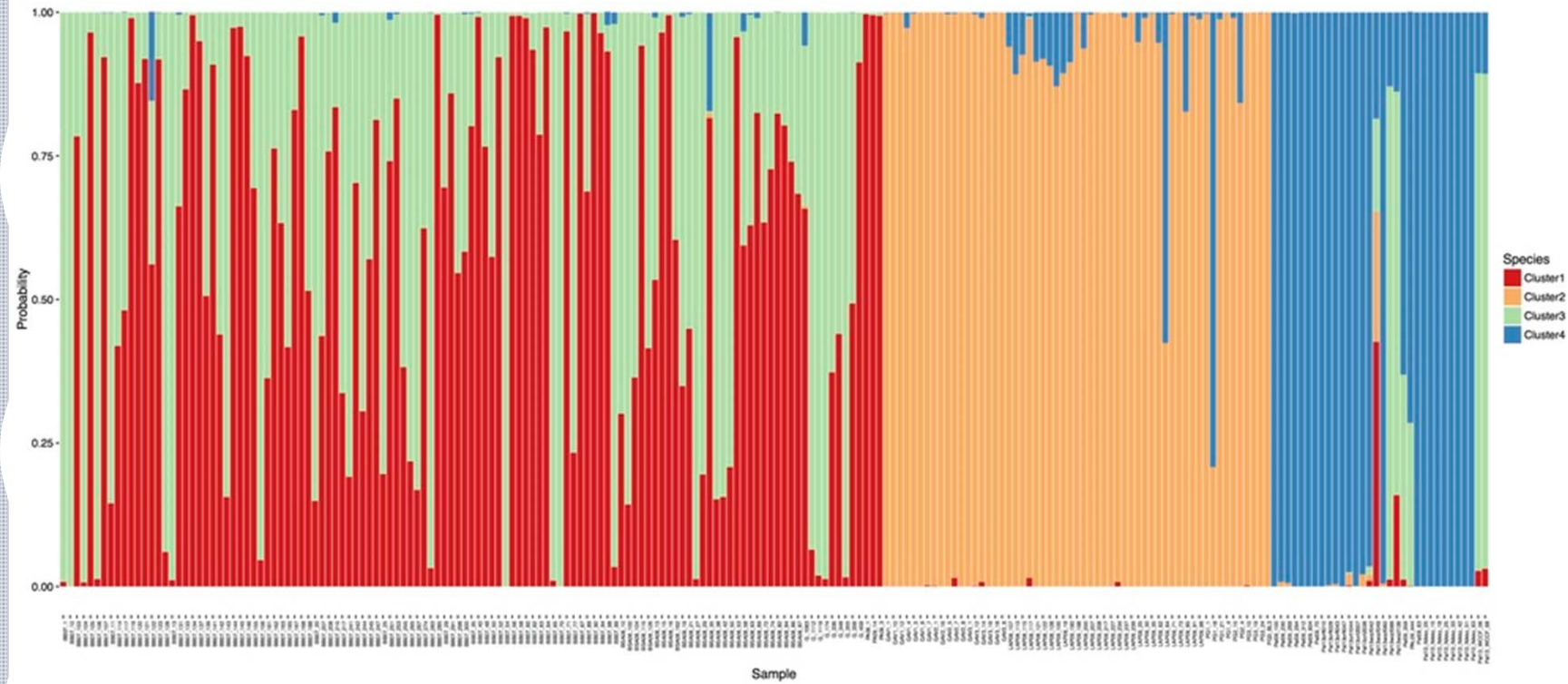
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VARIANT CALL FORMAT

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20	17330	.	T	A	3	q10	
20	1110696	rs6040355	A	G,T	67	PASS	
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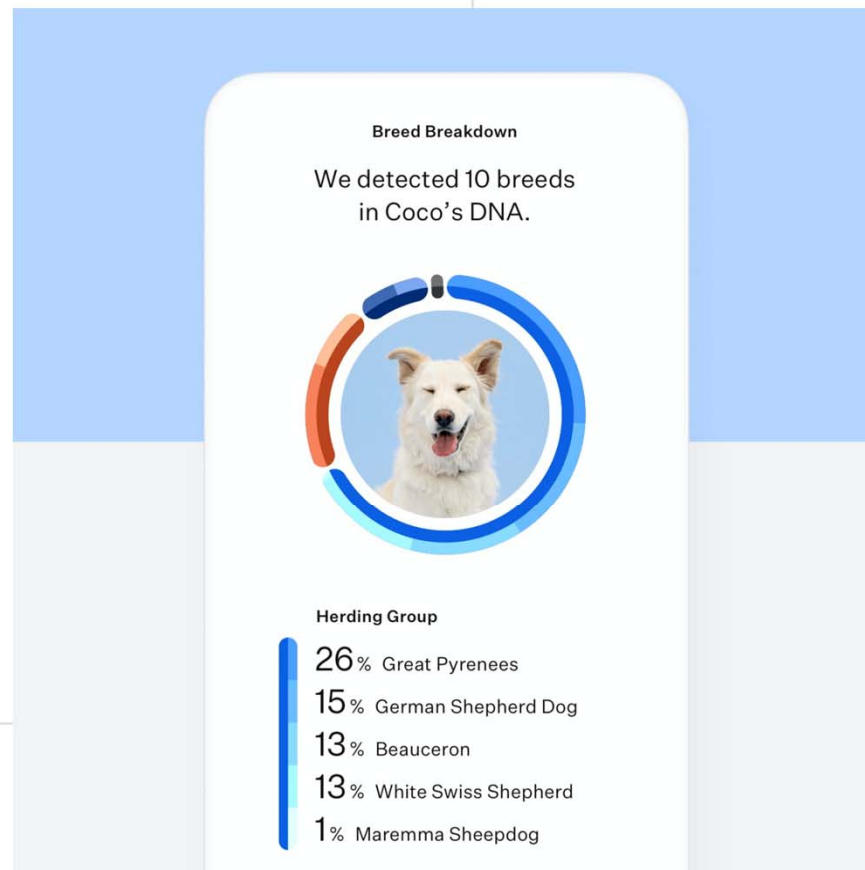
What is ancestry inference?

Using nuclear genetic/genomic markers to infer ancestral genetic clusters/populations

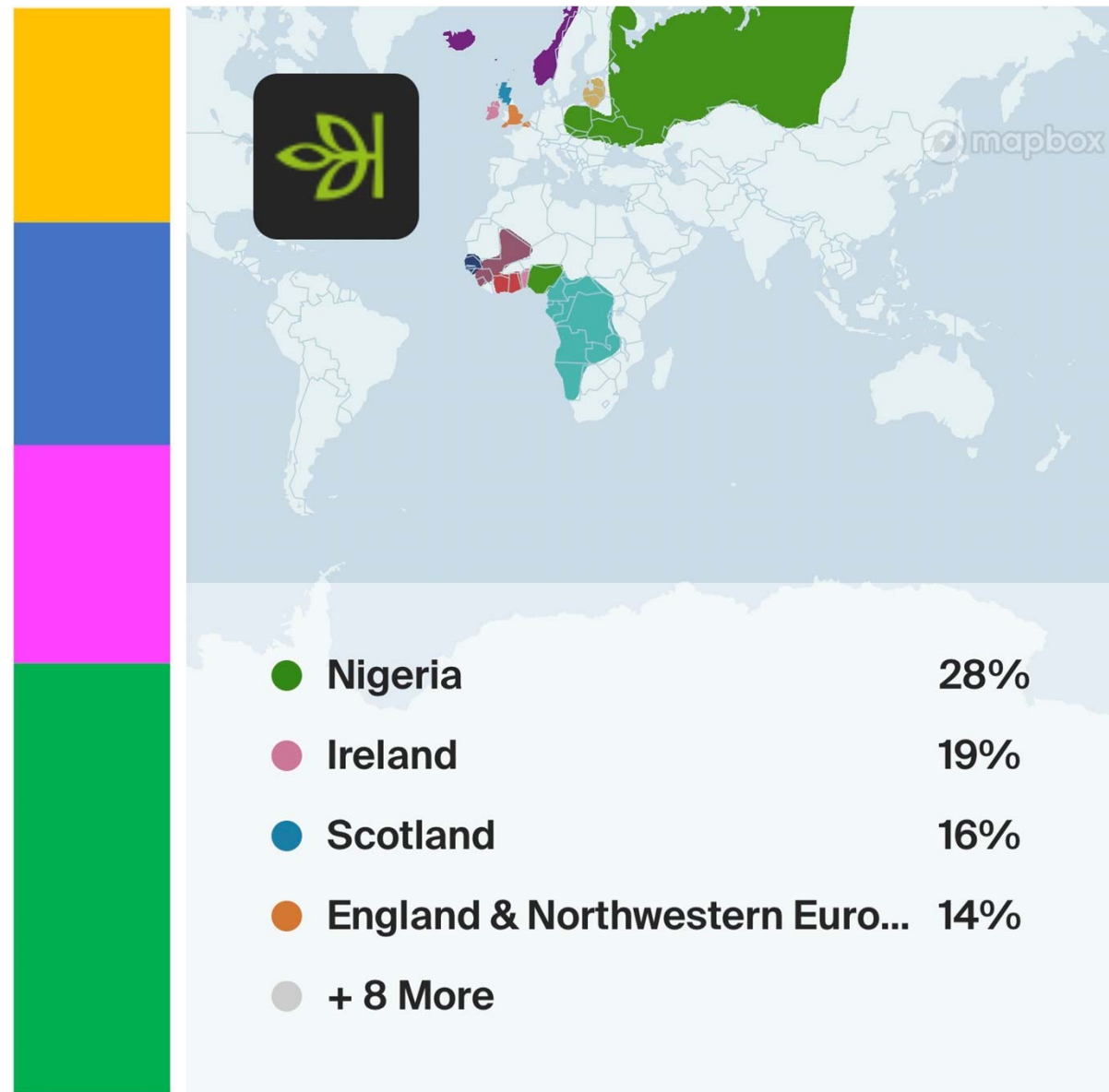


Popular Ancestry Inference Products

- Humans:
 - AncestryDNA
 - 23andMe
- Dogs:
 - Wisdom Panel

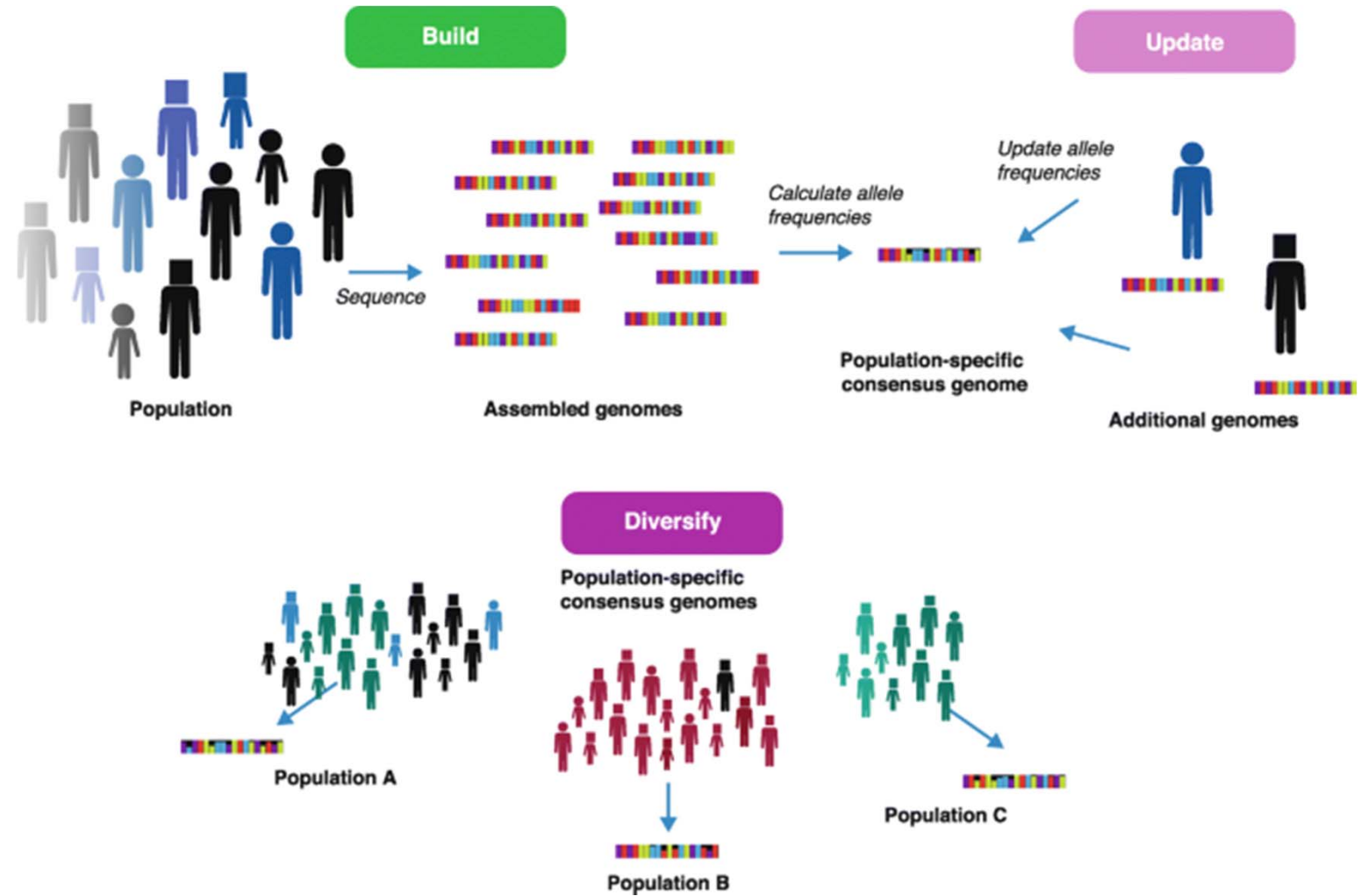


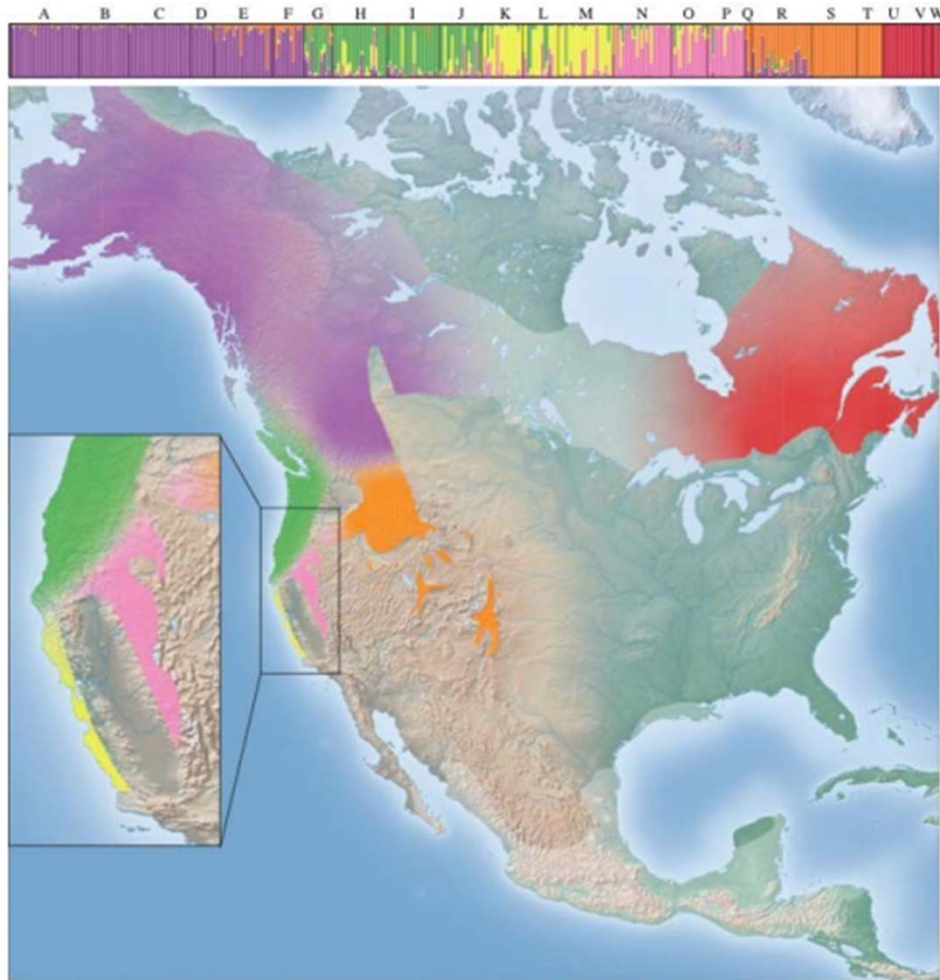
Taylor's ancestry proportions



Reference Panels

- Database of genetic variants by populations across a taxa's distribution



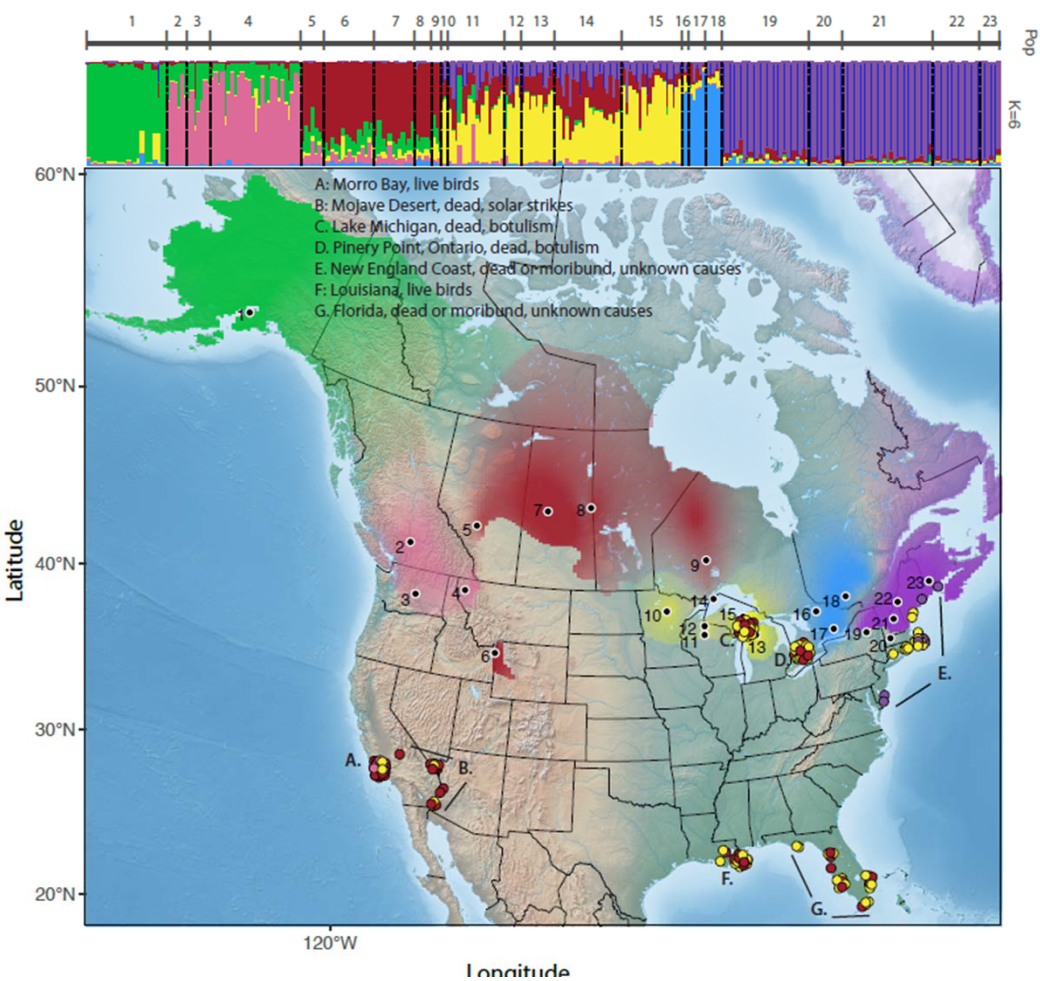
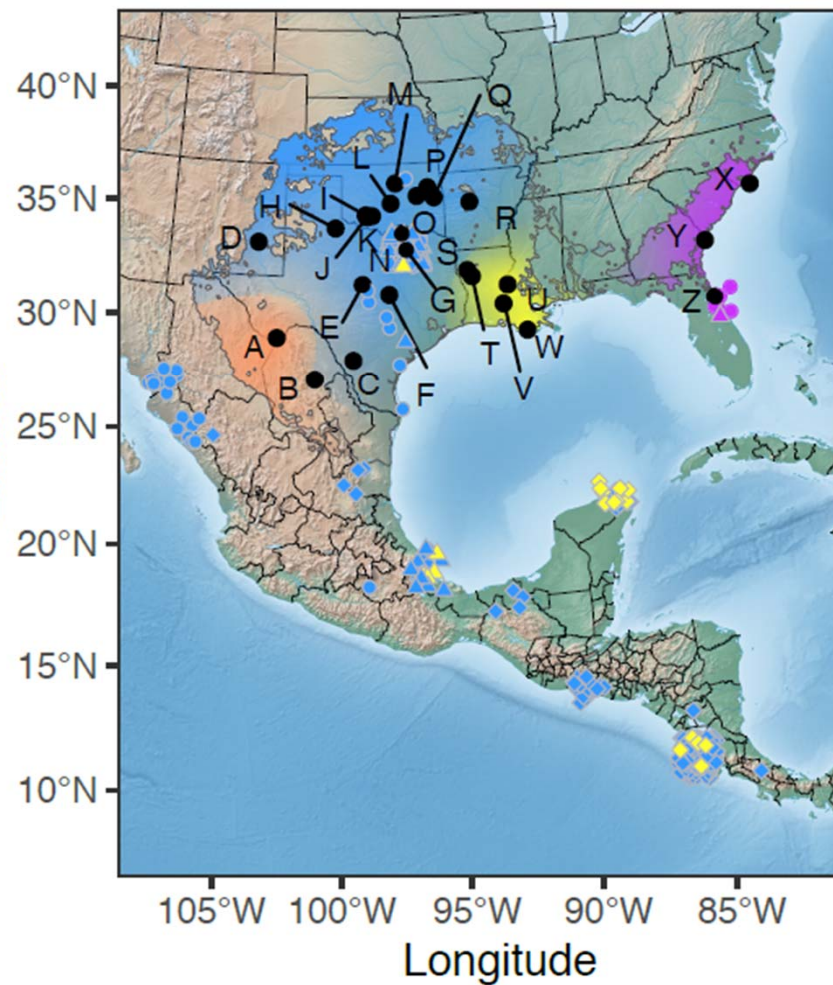
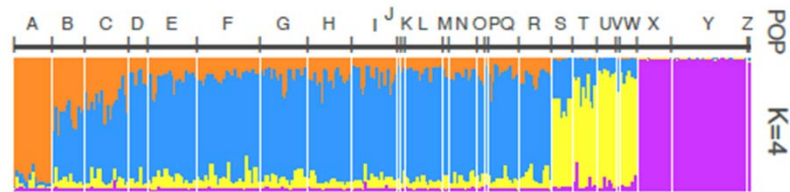


Genoscape

- Map of where populations are geographically and genetically distinct
- Allows for discrete population to be identified and mapped
 - Bird genoscapes have been generated for studying migration



Bird Genoscape Project



VertNet

21,600,262 RECORDS



Search VertNet

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Find records with...

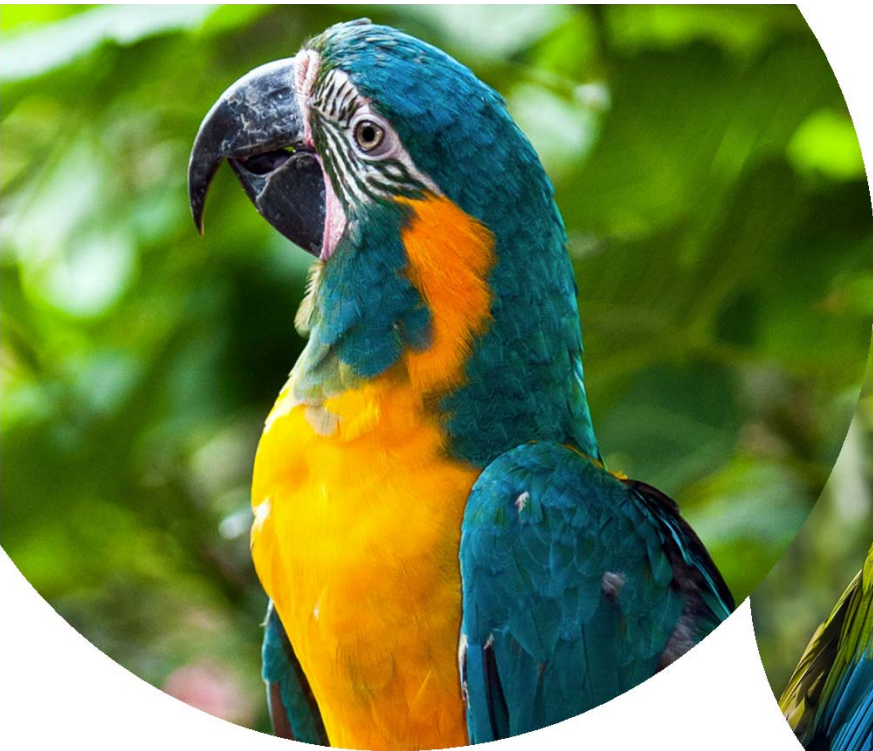
Clear all search terms



Darwin Core terms

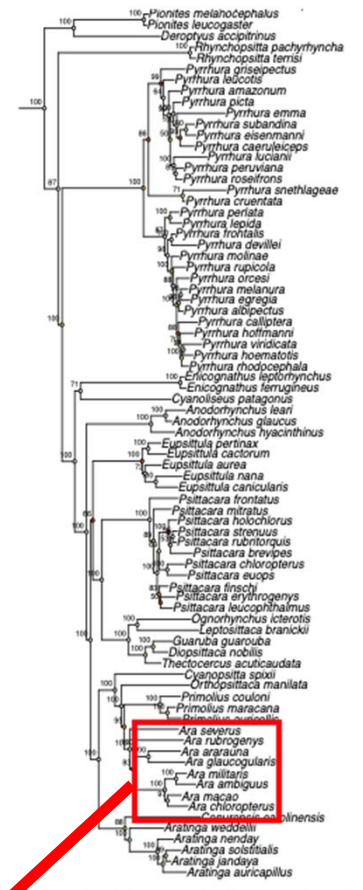
Select institution code

CollectionCode	CatalogNumber	OccurrenceID	FieldNumber	RecordNumber
basisOfRecon ▾	Preparations	Sex	LifeStage	RecordedBy
Continent	Country	StateProvince	County	Locality
Class	Order	Family	Genus	SpecificEpithet
StartDayOfYear	to StartDayOfYear	EndDayOfYear	to EndDayOfYear	

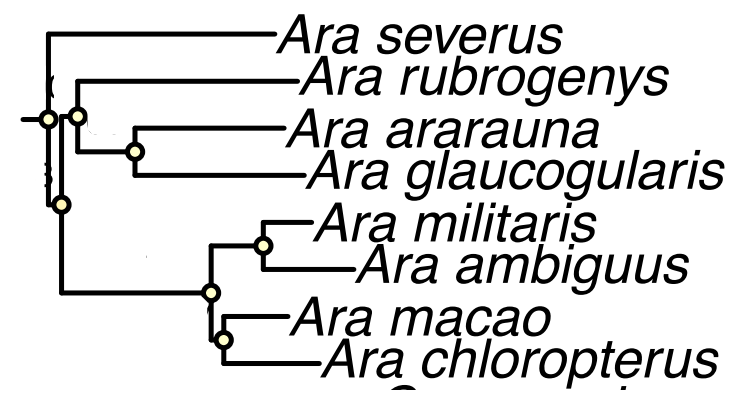


Macaws in the Genus *Ara*

- Very popular as pets worldwide
- 8 species
 - 3 sister species pairs by main plumage coloration
 - Red = *Ara macao* & *Ara chloropterus*
 - Green = *Ara militaris* & *Ara ambiguus*
 - Blue = *Ara ararauna* & *Ara glaucogularis*
 - 1 extinct species & 3 Critically Endangered Species

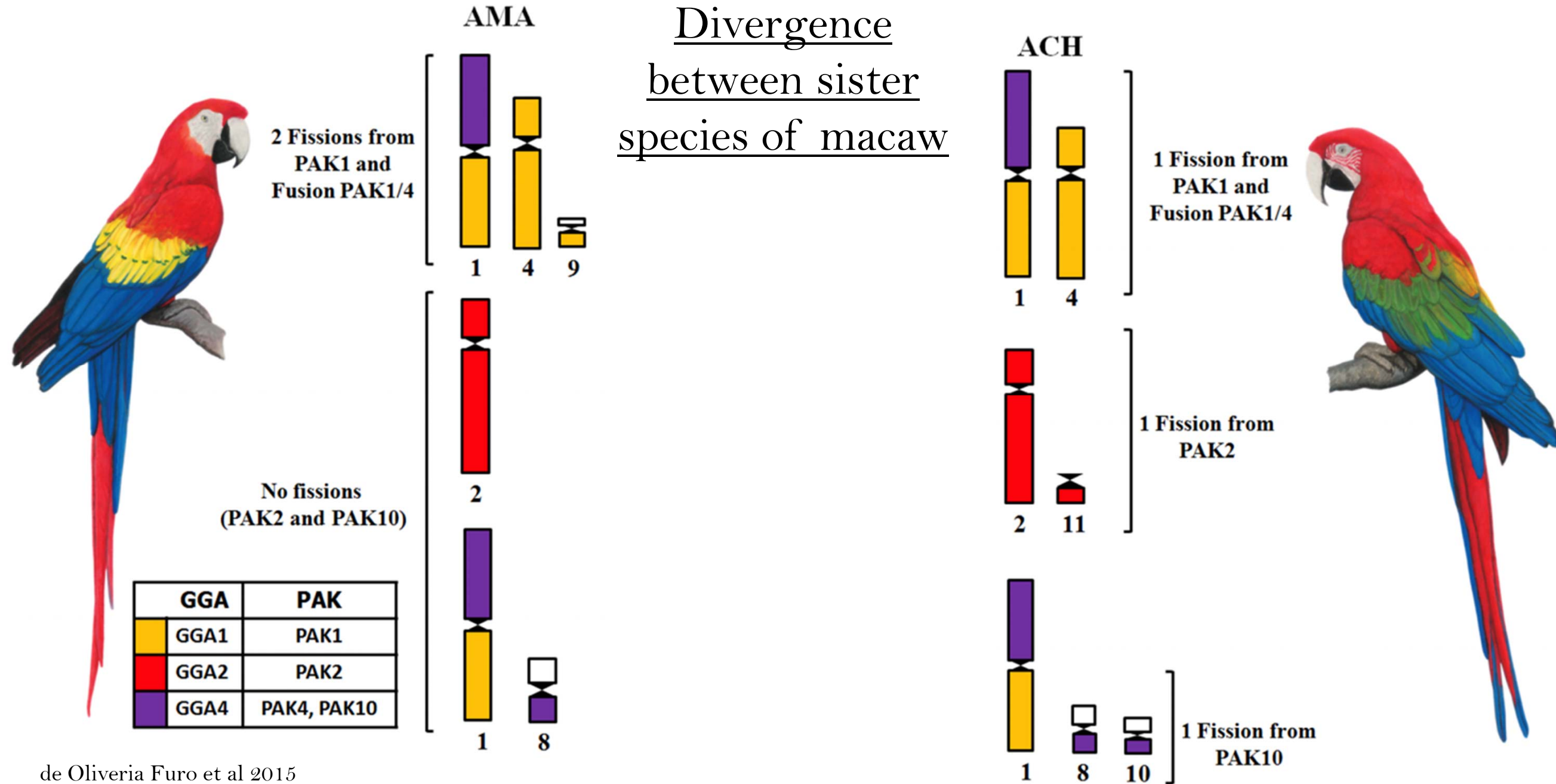


Smith et al. (in review)



Adapted from Smith et al. (2022)

Chromosomal Divergence between sister species of macaw

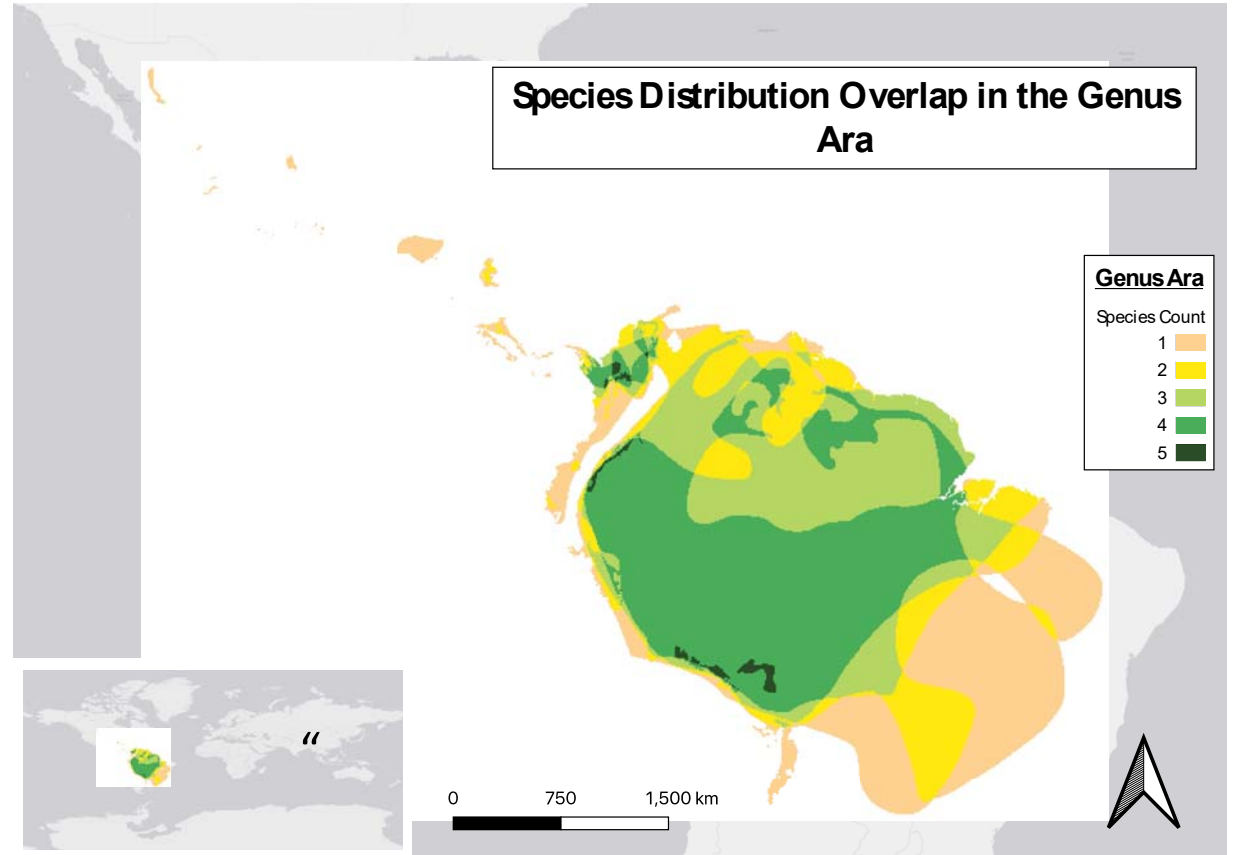


F1 Macaw Hybrids

2019



Dr. Eevin Jennings



Macaw hybridization in Captivity

- Catalina
 - Scarlet macaw (*Ara macao*) x Blue & Gold macaw (*Ara ararauna*)
- Harlequins
 - Green-wing macaw (*Ara chloroptera*) & Blue & Gold macaw (*Ara ararauna*)

Can we identify hybrids down to the generation?

Can we figure out which species, subspecies or ESU the hybrid descends from?

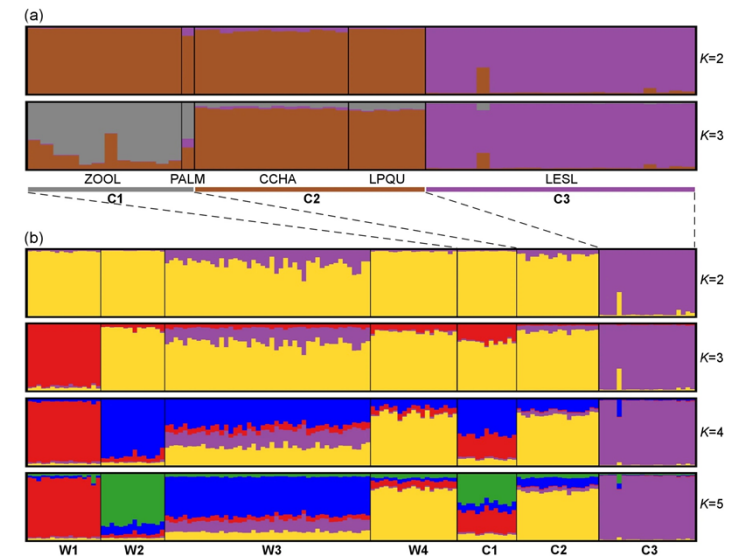
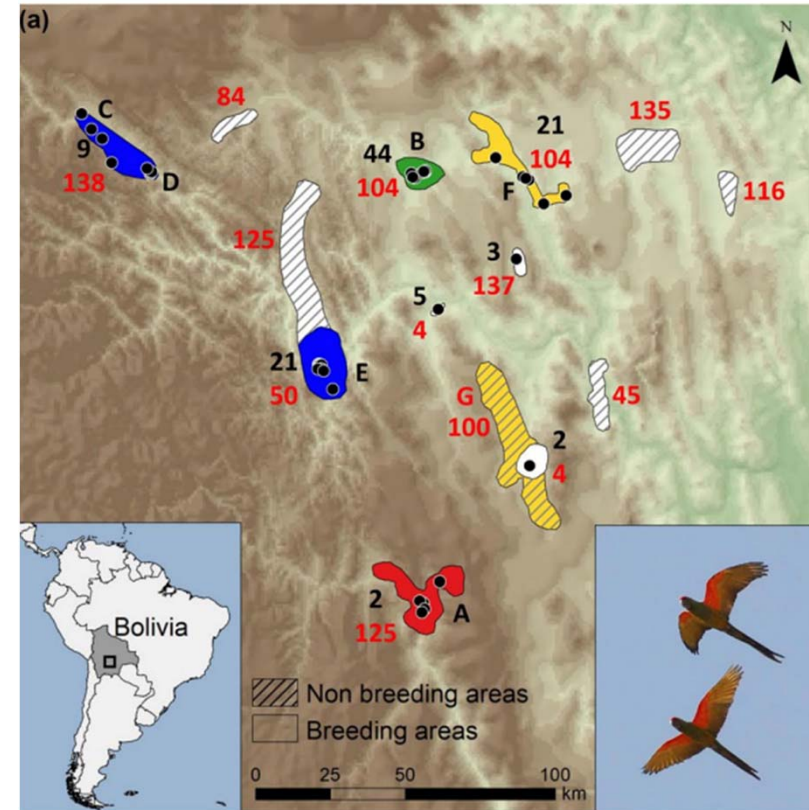


Red-fronted macaw (*Ara rubrogenys*)

- Current Status: Critically endangered
- Restricted distribution in Bolivia

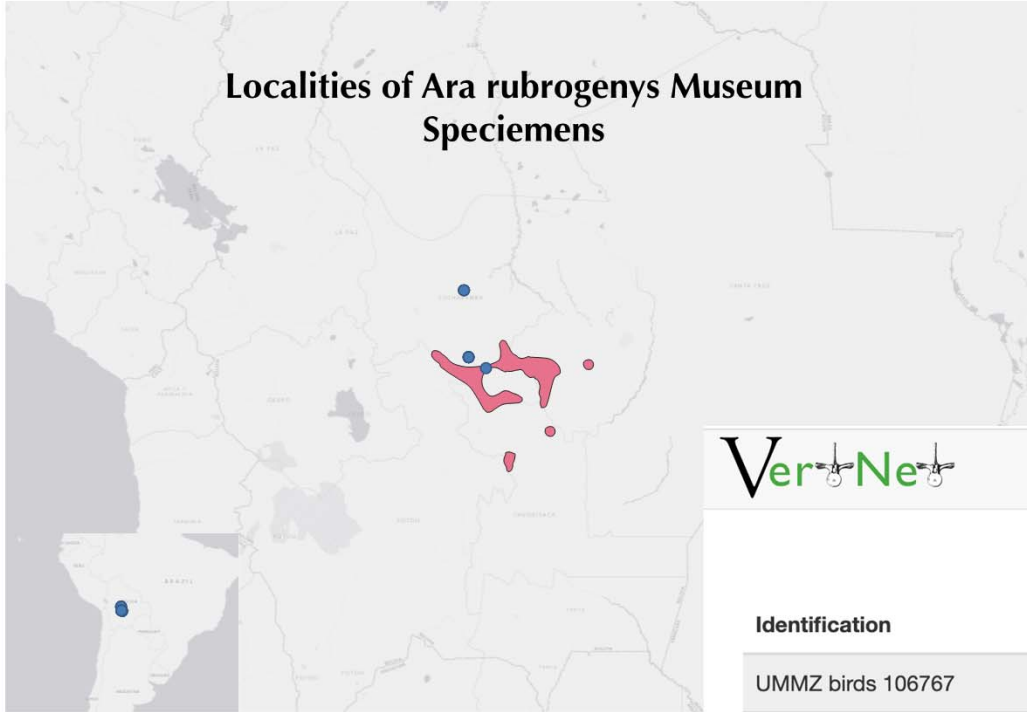


Courtesy of Ebird



Blanco et al. 2021

Localities of *Ara rubrogenys* Museum Specimens



Identification	Taxonomy	Location	Recorded By	Sex	Date	Map	Media
UMMZ birds 106767	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Aiquile	Steinbach, F	female	11-18-1936		
ANSP ORN 143666	undefined: <i>Ara rubrogenys</i>	Bolivia, COCHABAMBA: ELE-ELE; RIO MIZQUE		male	1937-10-13		
CM Birds P120169	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: POJO	STEINBACH, F.B.	female	1926-10-28		
CM Birds P120170	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: POJO	STEINBACH, F.B.	male	1926-10-28		
CM Birds P86176	Aves: <i>Ara rubrogenys</i>	Bolivia, Santa Cruz: EL PALO	STEINBACH, J.	male	1921-07-20		
FMNH Birds 179058	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: El Palmar, Yungas		female	1937-12-28		
FMNH Birds 179063	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Tin-Tin		female	1937-11-23		
FMNH Birds 179061	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Tin-Tin		male	1937-12-28		
FMNH Birds 179065	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Aiquile		female	1936-11-18		
FMNH Birds 179057	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Tin-Tin		male	1937-12-28		
FMNH Birds 110345	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Tin-Tin		male	1932-12-28		
UF Birds 21065	Aves: <i>Ara rubrogenys</i>	Bolivia		female	1984-04-10		
FMNH Birds 179064	Aves: <i>Ara rubrogenys</i>	Bolivia, Cochabamba: Aiquile		male	1936-11-18		



Blue-throated Macaw (*Ara glaucogularis*)

- Current Status: Critically Endangered
- Restricted range in Bolivia
- 3 populations in the wild currently

Blue-throated Macaw distribution

Northwestern population

Northeastern population

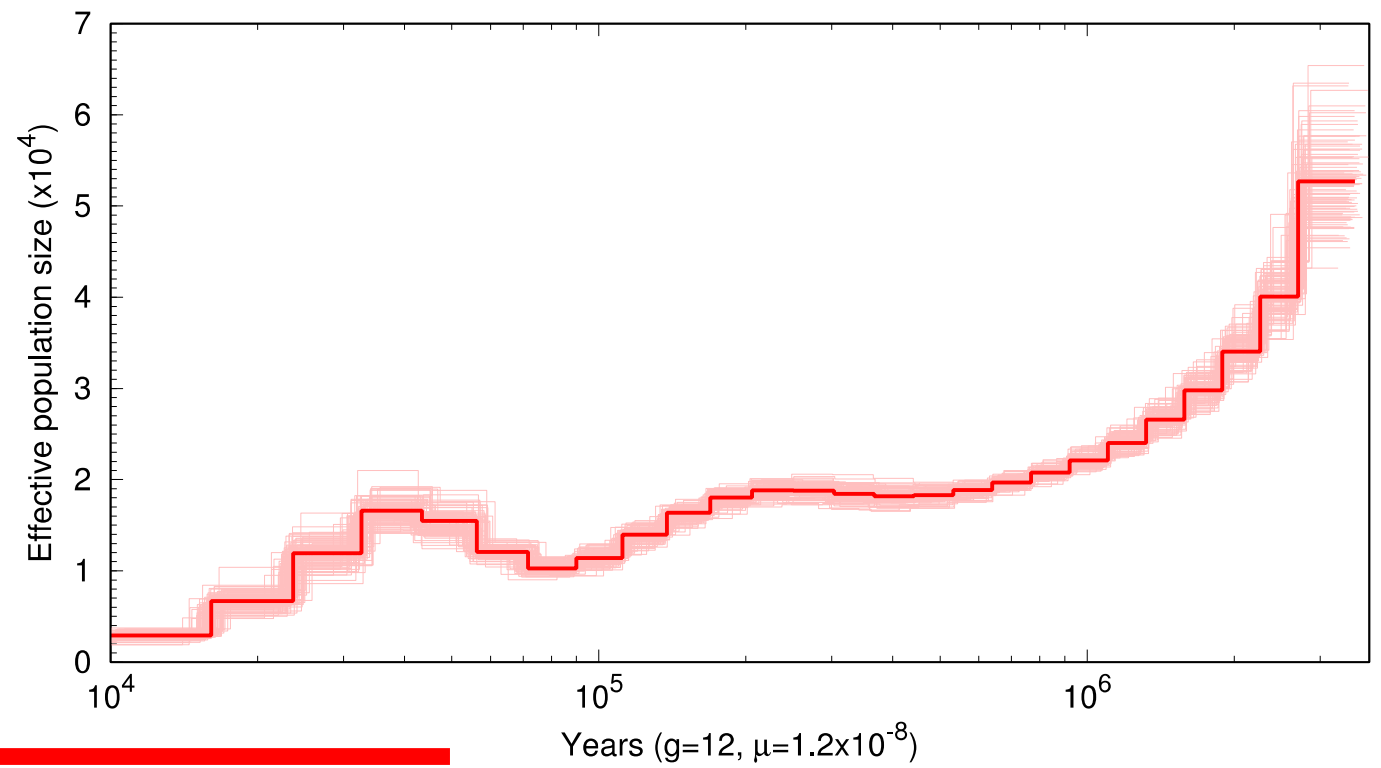
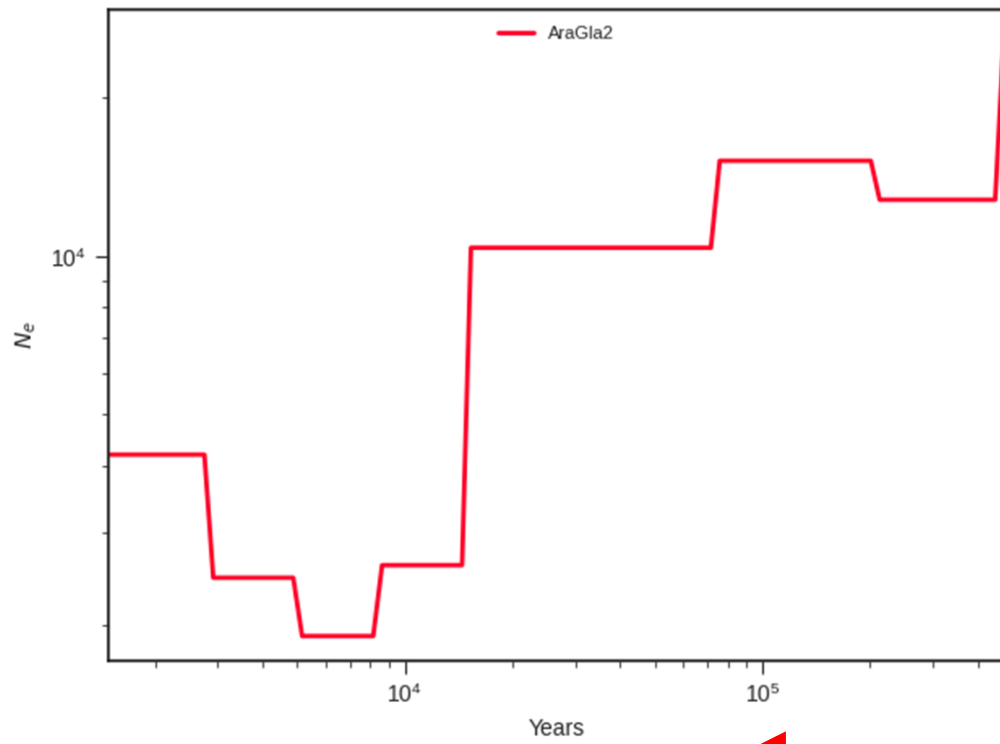
Trinidad (Beni Department Capital)

Southern population





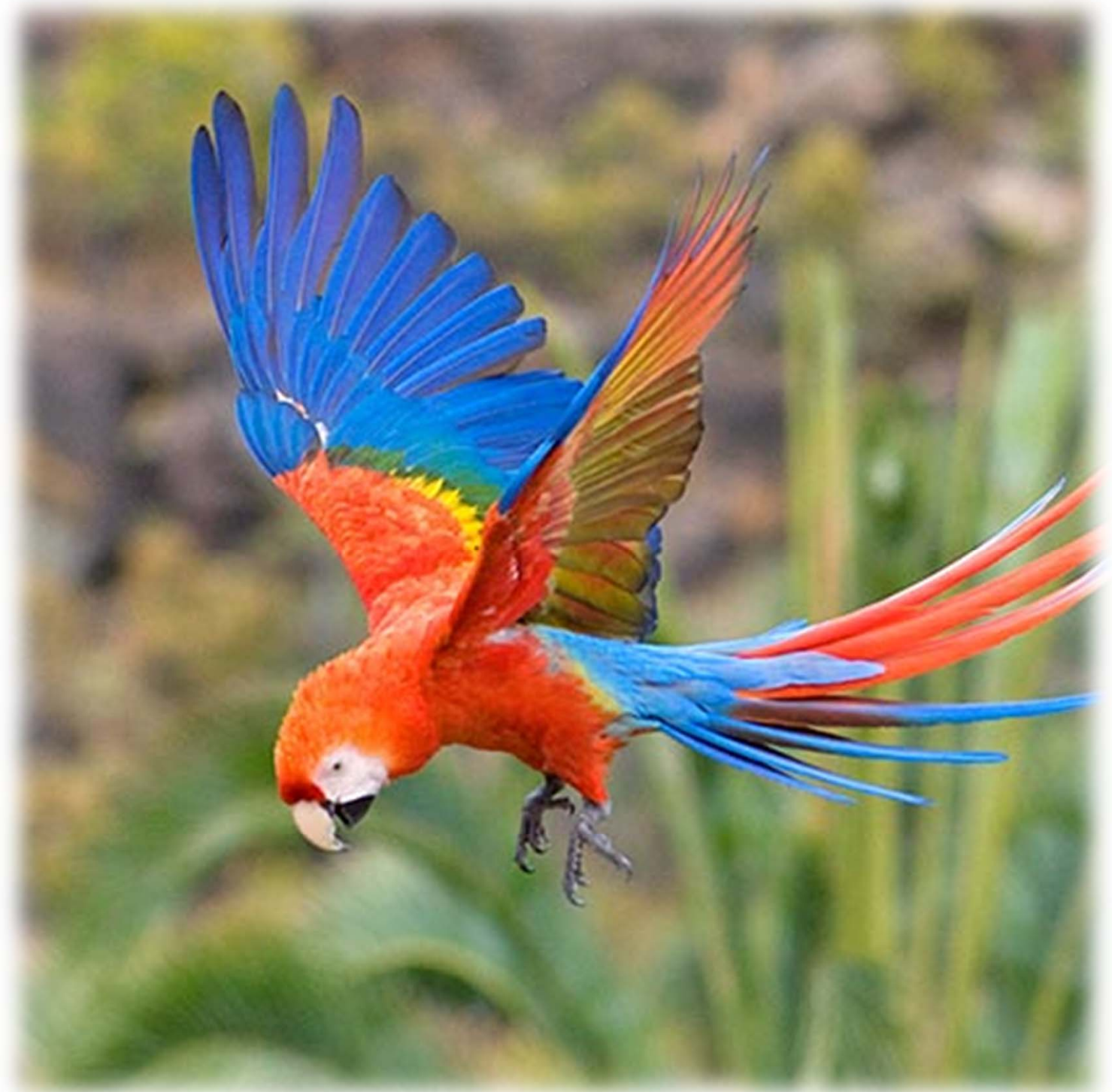
Blue-throated Macaw Historic Population Sizes



← Present Past

Scarlet Macaw (*Ara macao*)

- Two subspecies:
 - *Ara macao macao*
 - Listed as Least Concern according to IUCN
 - *Ara macao cyanoptera*
 - Listed as endangered under the US Endangered species list
- In Costa Rica,
 - Confiscated birds are being released
 - Accidental hybridization of subspecies and release of hybrids into the wild



- *The sampling for this study was largely toepads*

- *A. m. macao*:

- Haplo4

- Haplo7

- *A. m. cyanoptera*:

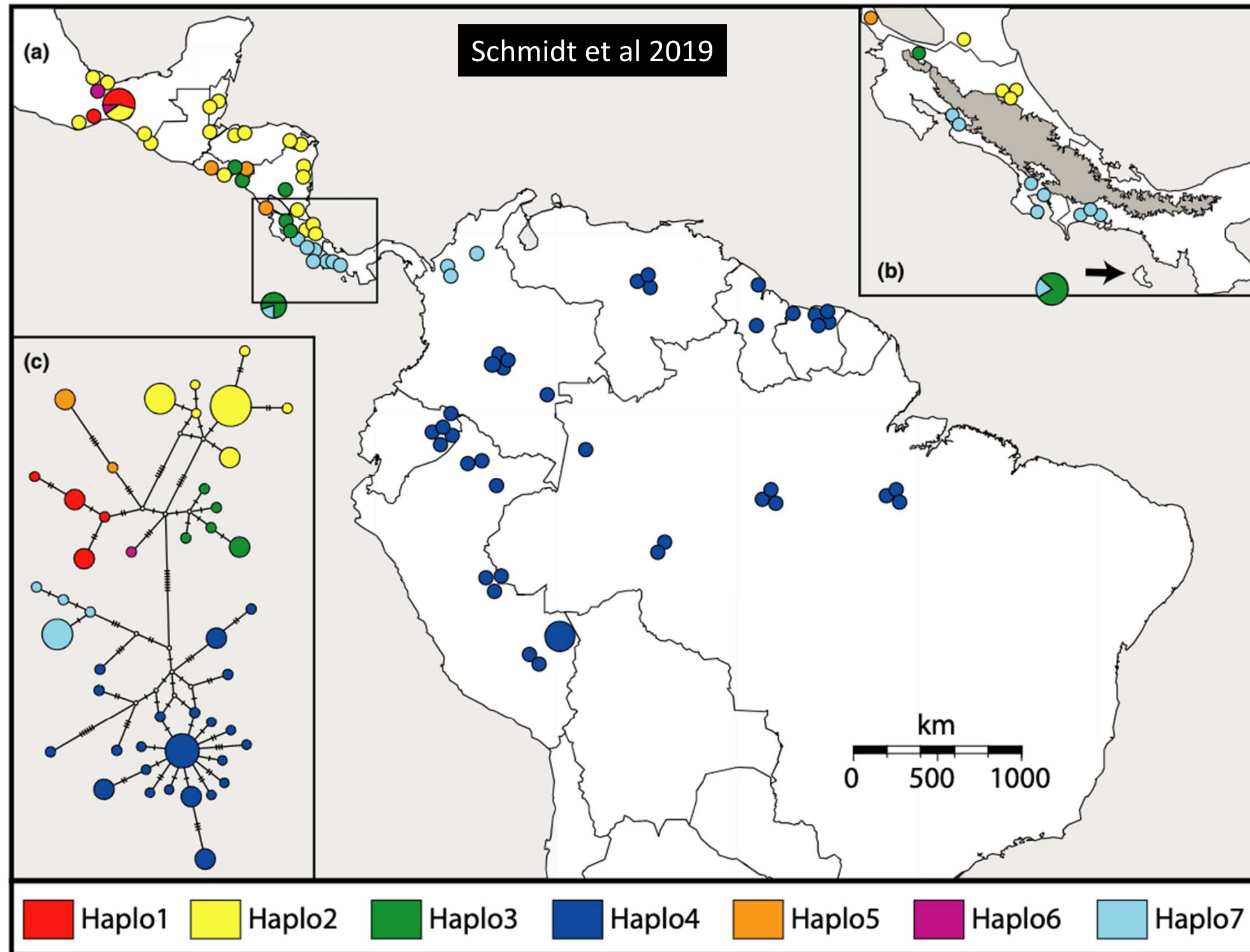
- Haplo1

- Haplo2

- Haplo3

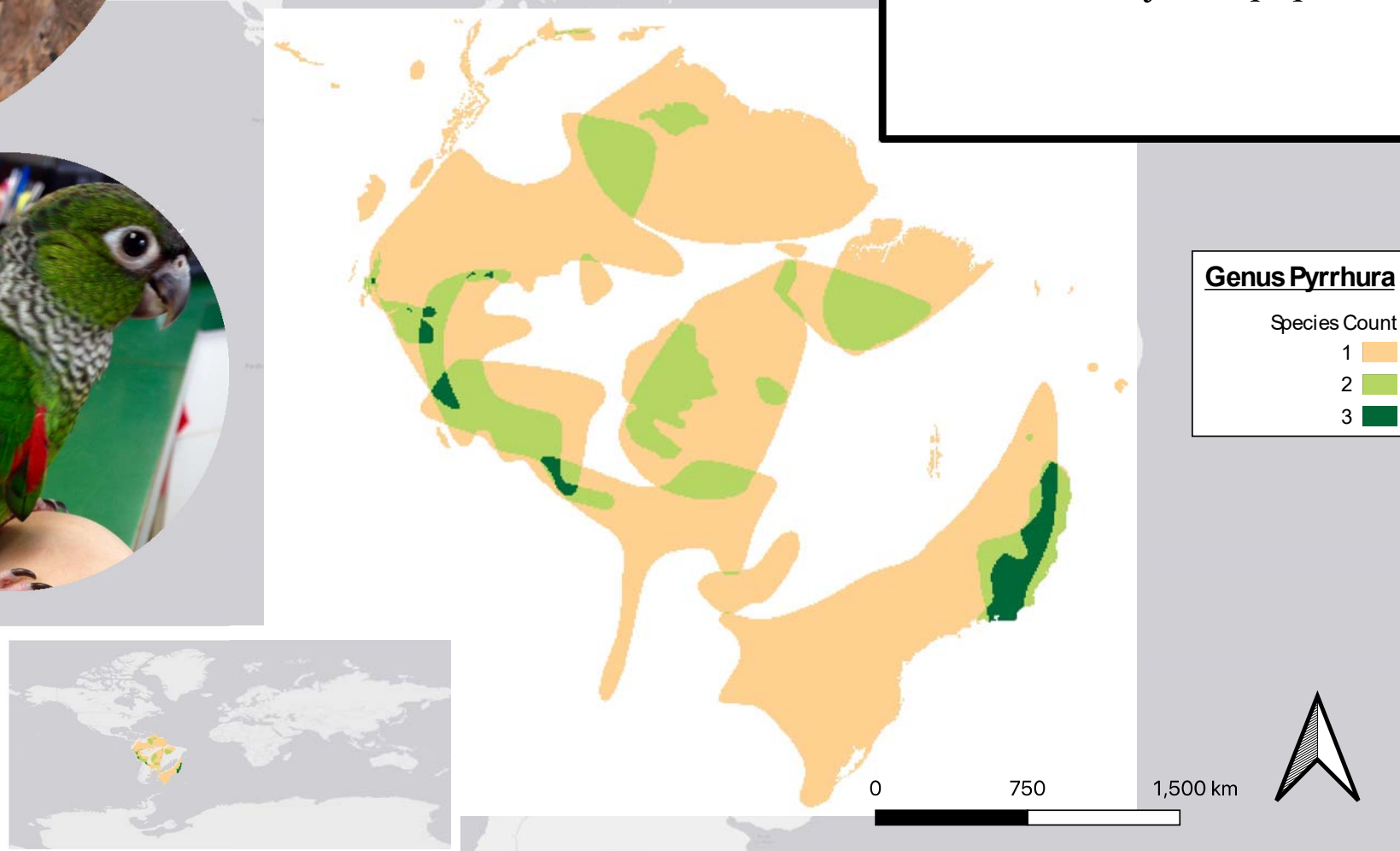
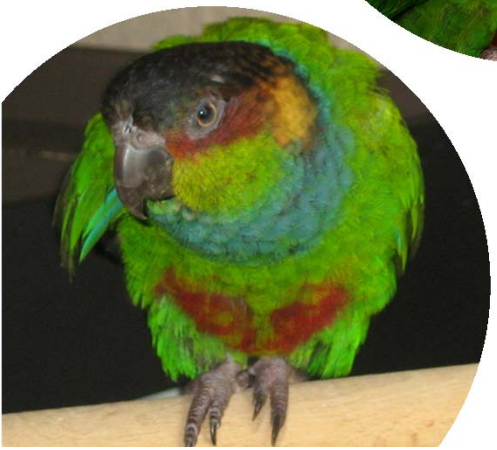
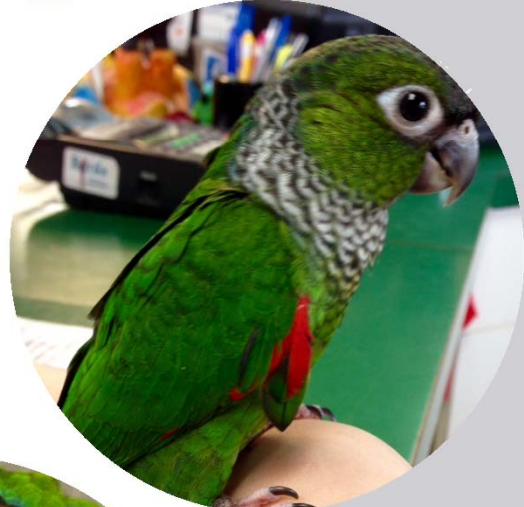
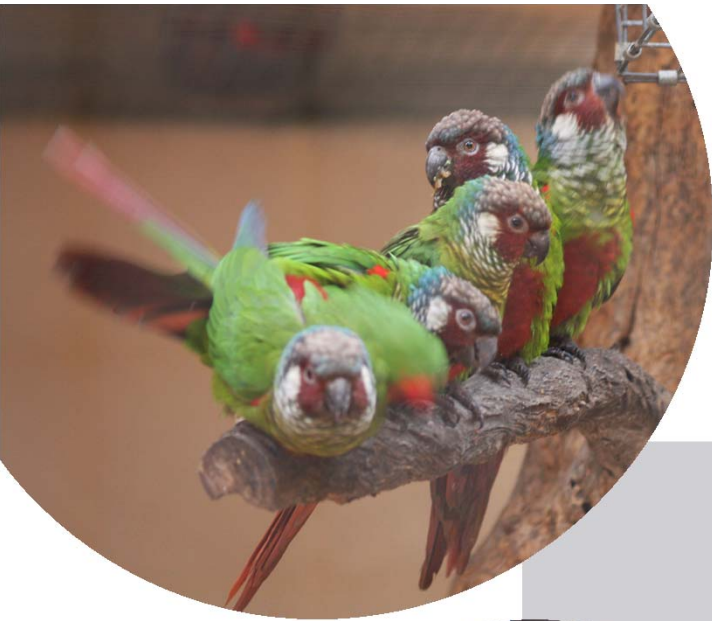
- Haplo5

- Haplo6

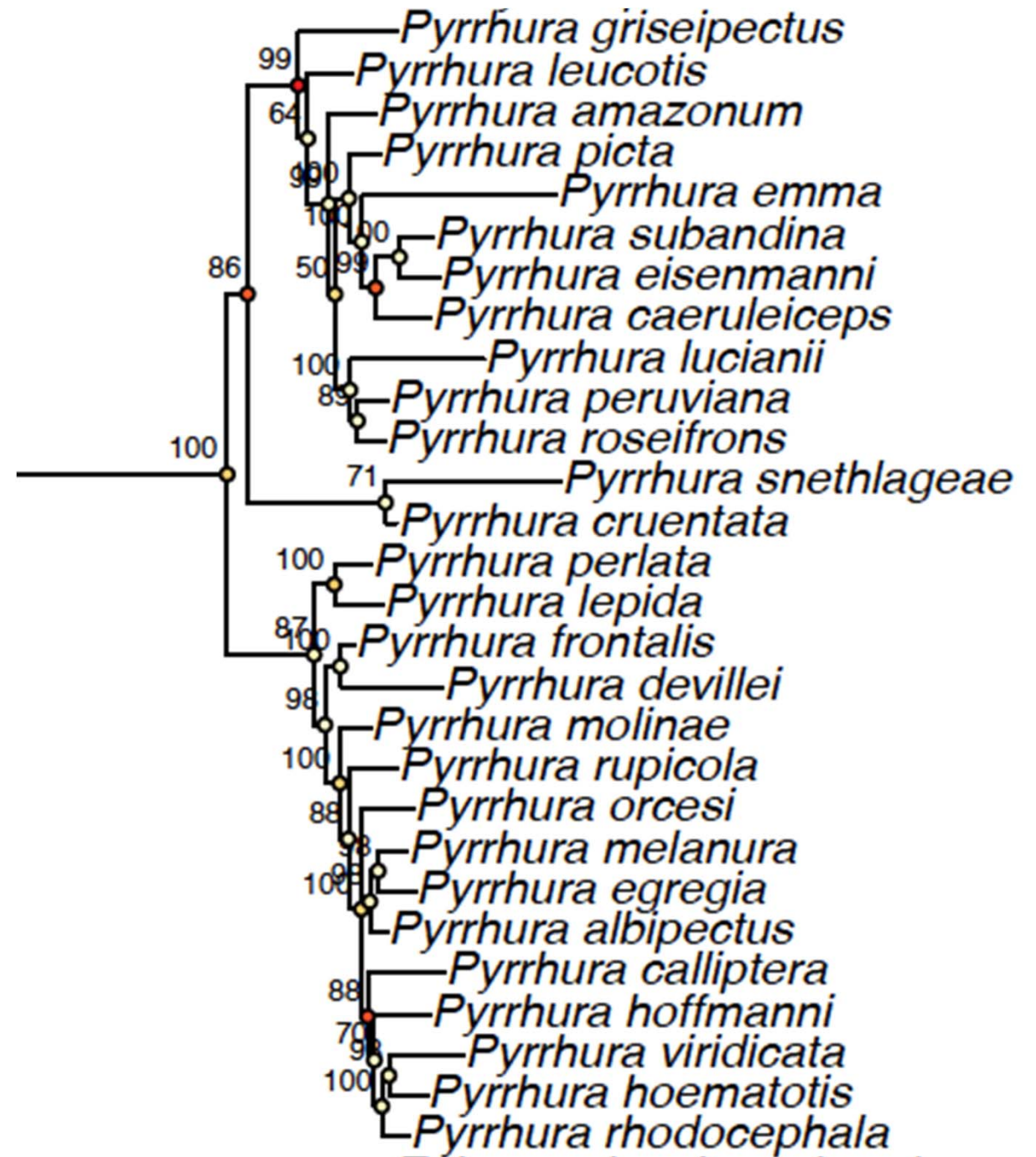


Genus *Pyrrhura*

- Very popular as pets worldwide
- Most speciose genus in Arini with ~28-35 species
- Multiple reports and sources of evidence for hybridization in wild and potential complex evolutionary and population histories



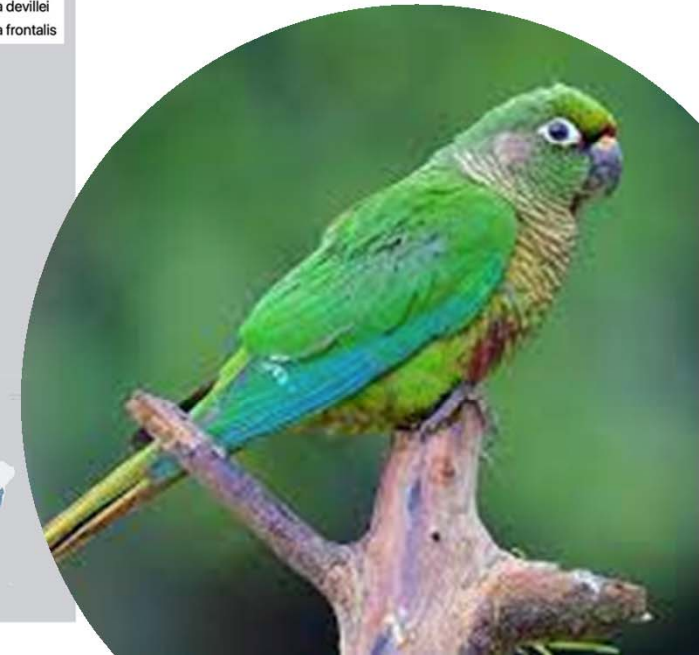
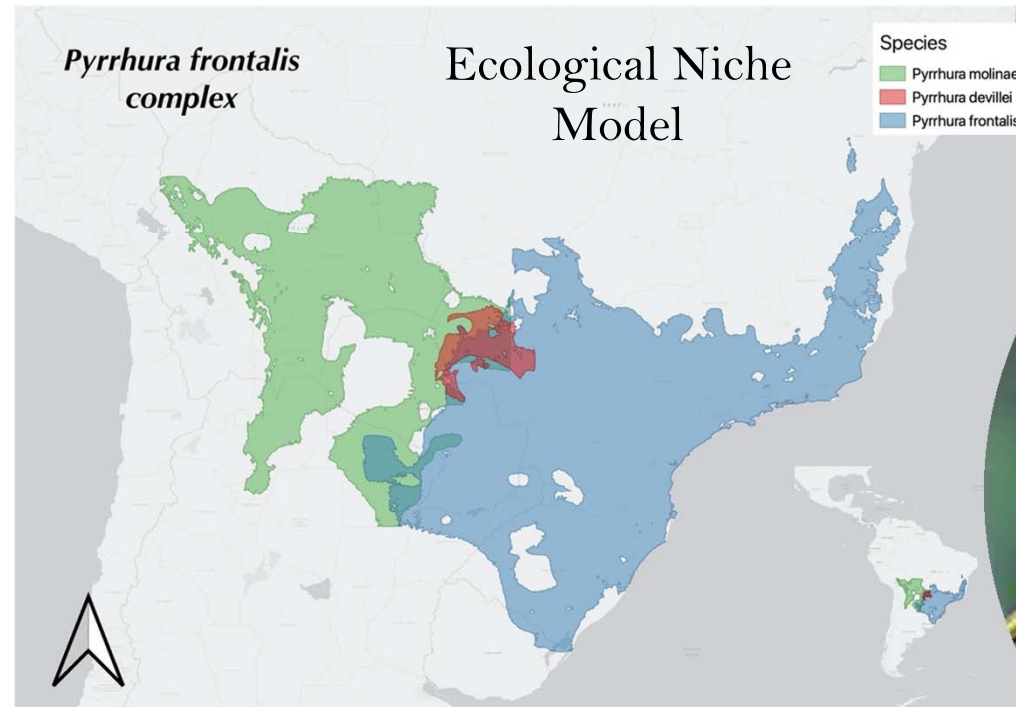
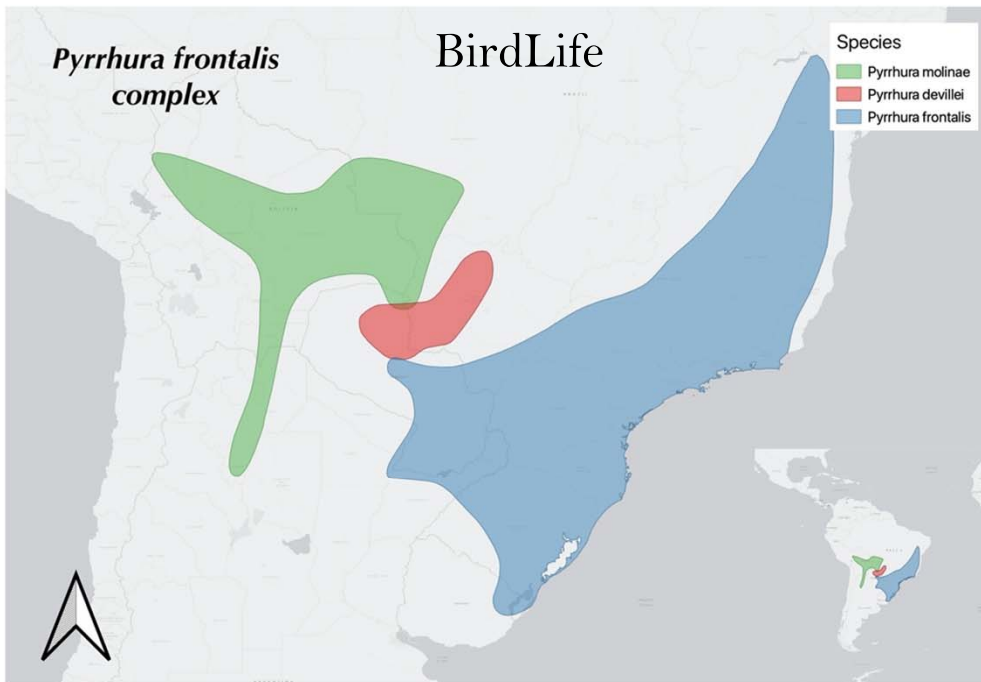
Pyrrhura Tree of Life

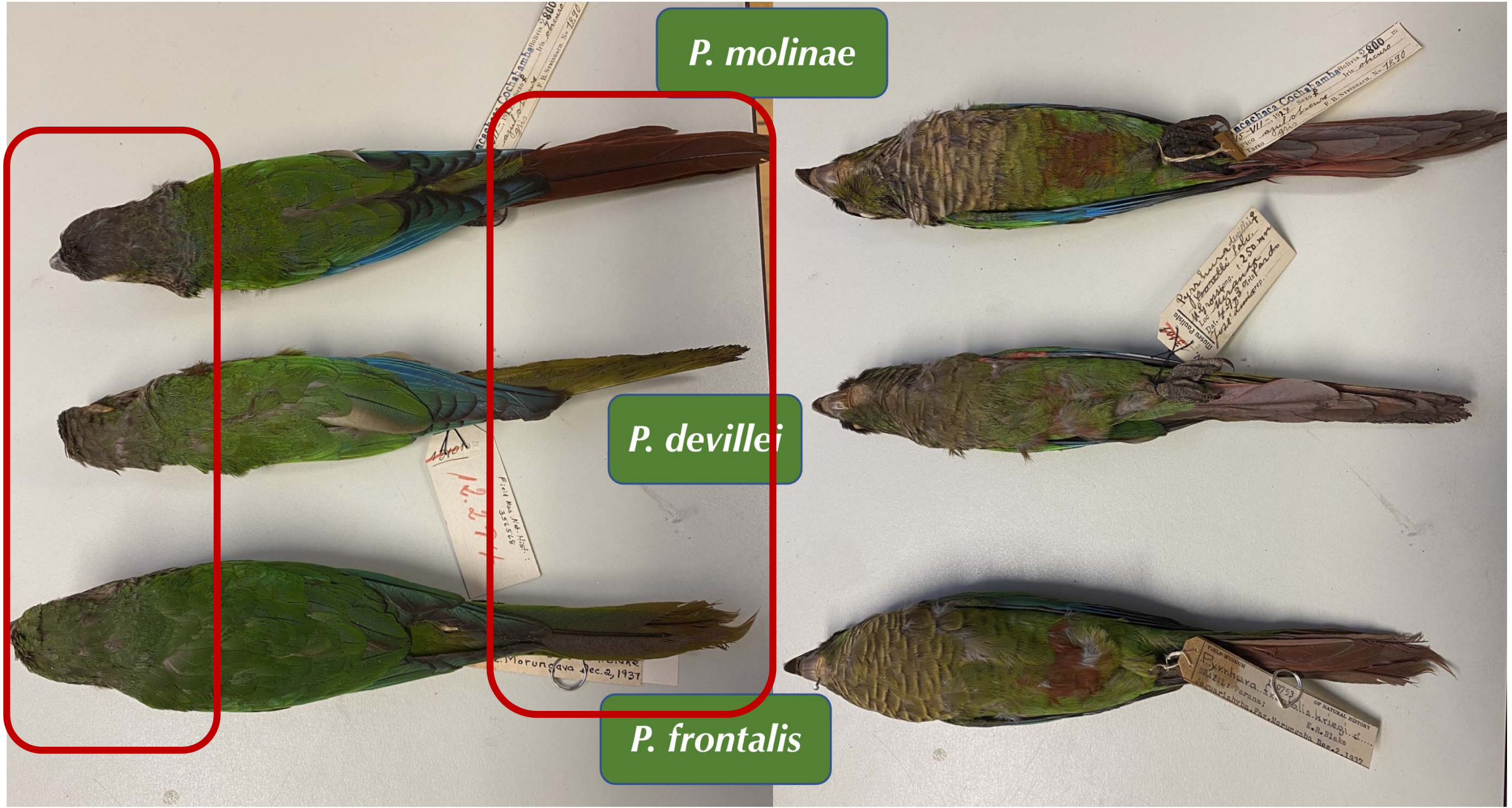


Adapted from Smith et al. (2022)

Green-cheek Conure Complex: Taxonomy & Systematics

- *Pyrrhura molinae* (IUCN: Least Concern)
 - (Green-cheek conure/parakeet)
 - 5-7 subspecies/populations
- *Pyrrhura frontalis* (IUCN: Least Concern)
 - (Maroon-bellied conure/parakeet)
 - 2-3 subspecies/populations
- *Pyrrhura devillei* (IUCN: Near Threatened)
 - (Blaze-winged conure/parakeet)
- *Pyrrhura rupicola* (IUCN: Least Concern)
 - (Black-capped/Rock conure/parakeet)
 - 2-3 subspecies/populations





P. molinae

P. devillei

P. frontalis



COCHABAMBA
18-VI-1917
F. B. STEINMAN No. 2800

COCHABAMBA
18-VI-1917
F. B. STEINMAN No. 2800

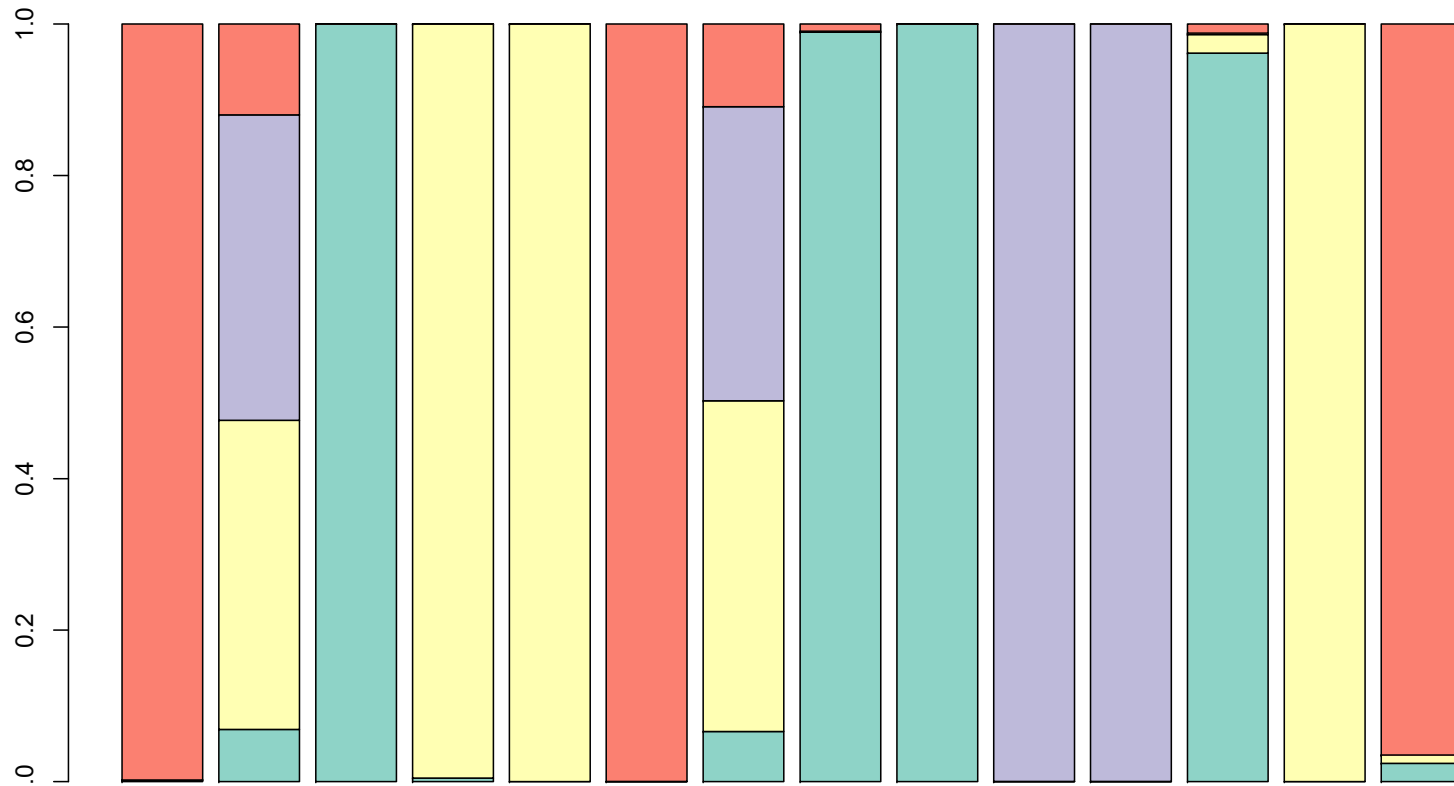
Pyrhura devillei
18-VI-1917
F. B. STEINMAN No. 2800

12.2.1911
F. B. STEINMAN No. 2800

Morungaba
Dec. 2, 1937

OF NATURAL HISTORY
E. A. BLAKE
Morungaba
Dec. 2, 1937

Ancestry of Captive Green-cheek Conures

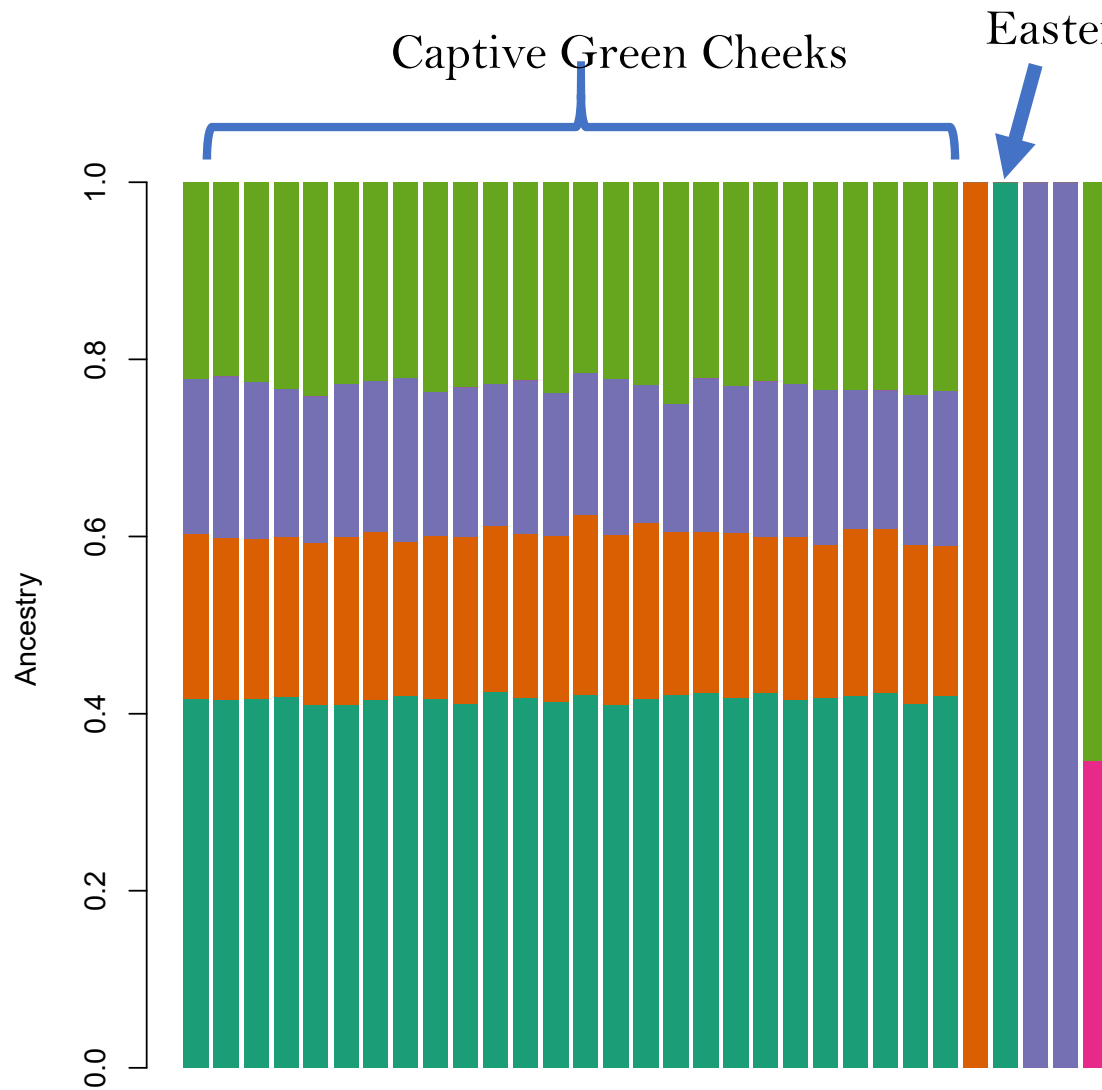


↑
Captive Green-cheeks
~40% wild Green cheek
~40% Black-capped
~12% Maroon-bellied
~8% Crimson/Pearly

↑ ↑
Eastern Bolivian Green-cheeks

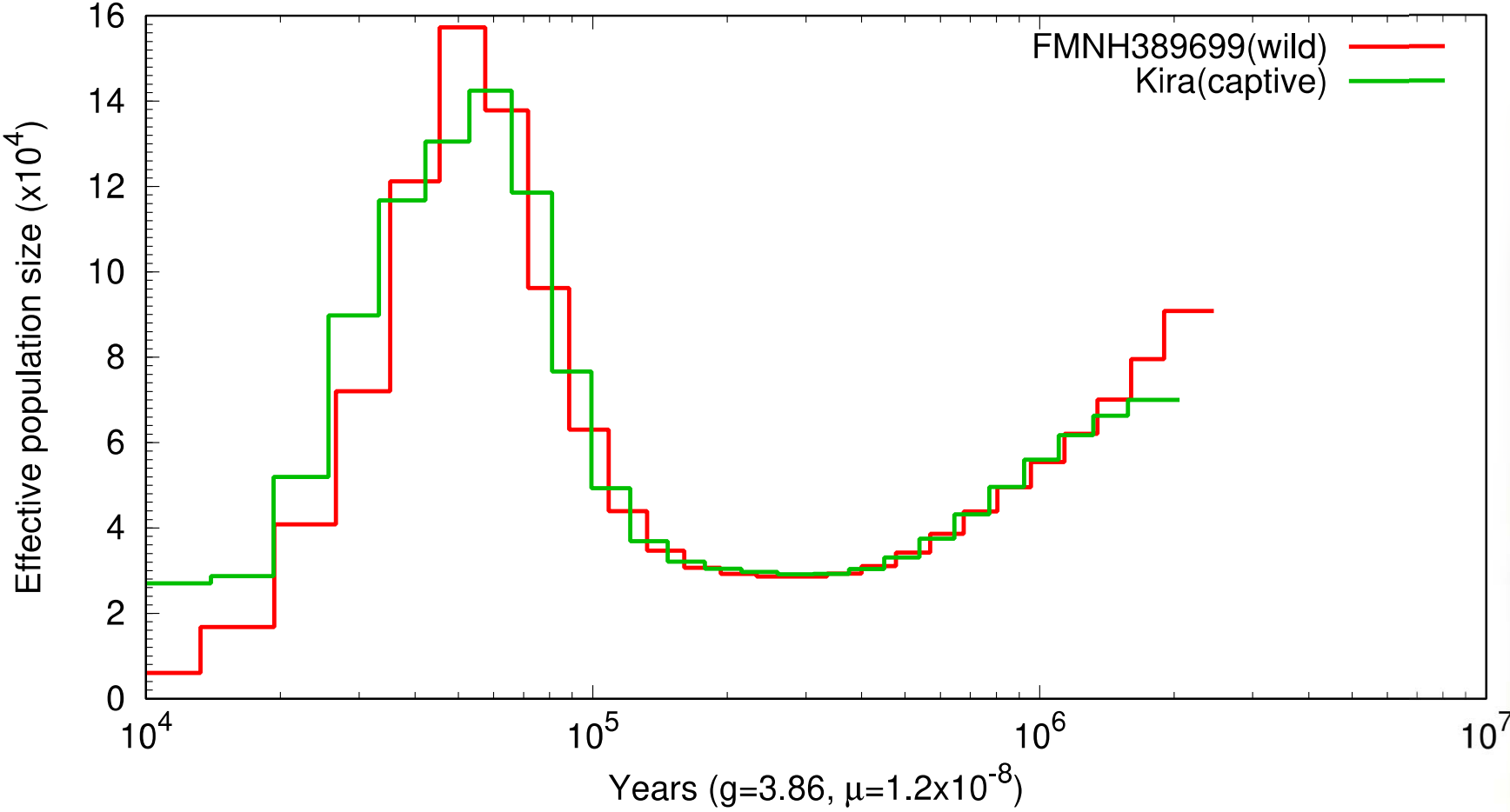
- Red – Maroon-bellied Conure (Brazil)
- Purple – Green-cheek conure (Paraguay)
- Turquoise – Crimson-bellied/Pearly conure (Brazil)
- Yellow – Black-capped Conure (Peru)

Ancestry of Captive Green-cheek conures (continued)



- Using 23 captive individuals from the same aviary sequencing using 3RAD-seq,
 - ~40% Green-cheek conure
 - ~20% Black-capped conure
 - ~20% Crimson-bellied/Pearly conure
 - ~20% of part of Maroon-bellied conures

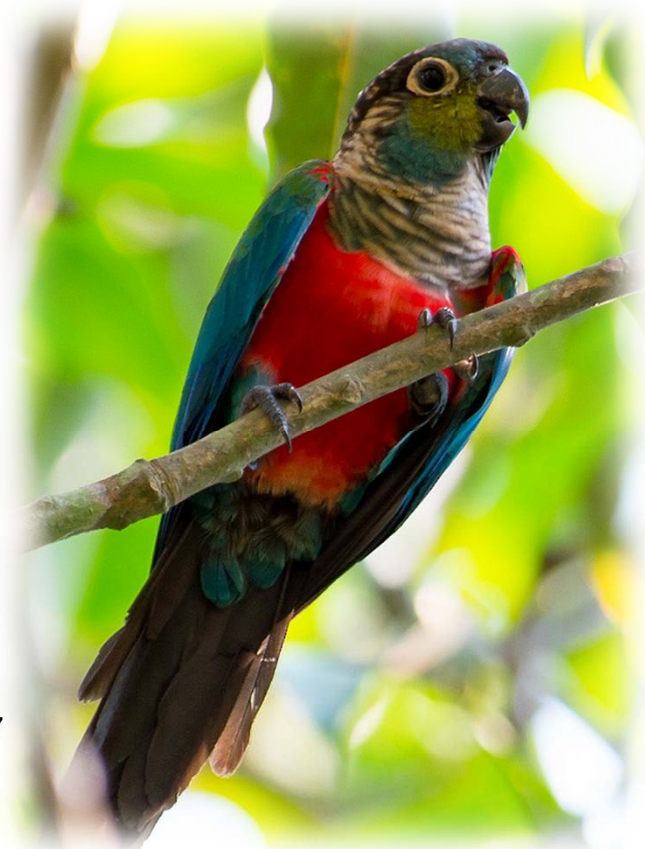
Demographic History of Wild & Captive Crimson-bellied Conures (*Pyrrhura perlata*)



Present



Past



Courtesy of EBird

Grey-breasted Parakeet (*Pyrrhura griseipectus*)

- The illegal trade
- Habitat loss in a very restricted distribution

About 2500 left in the wild



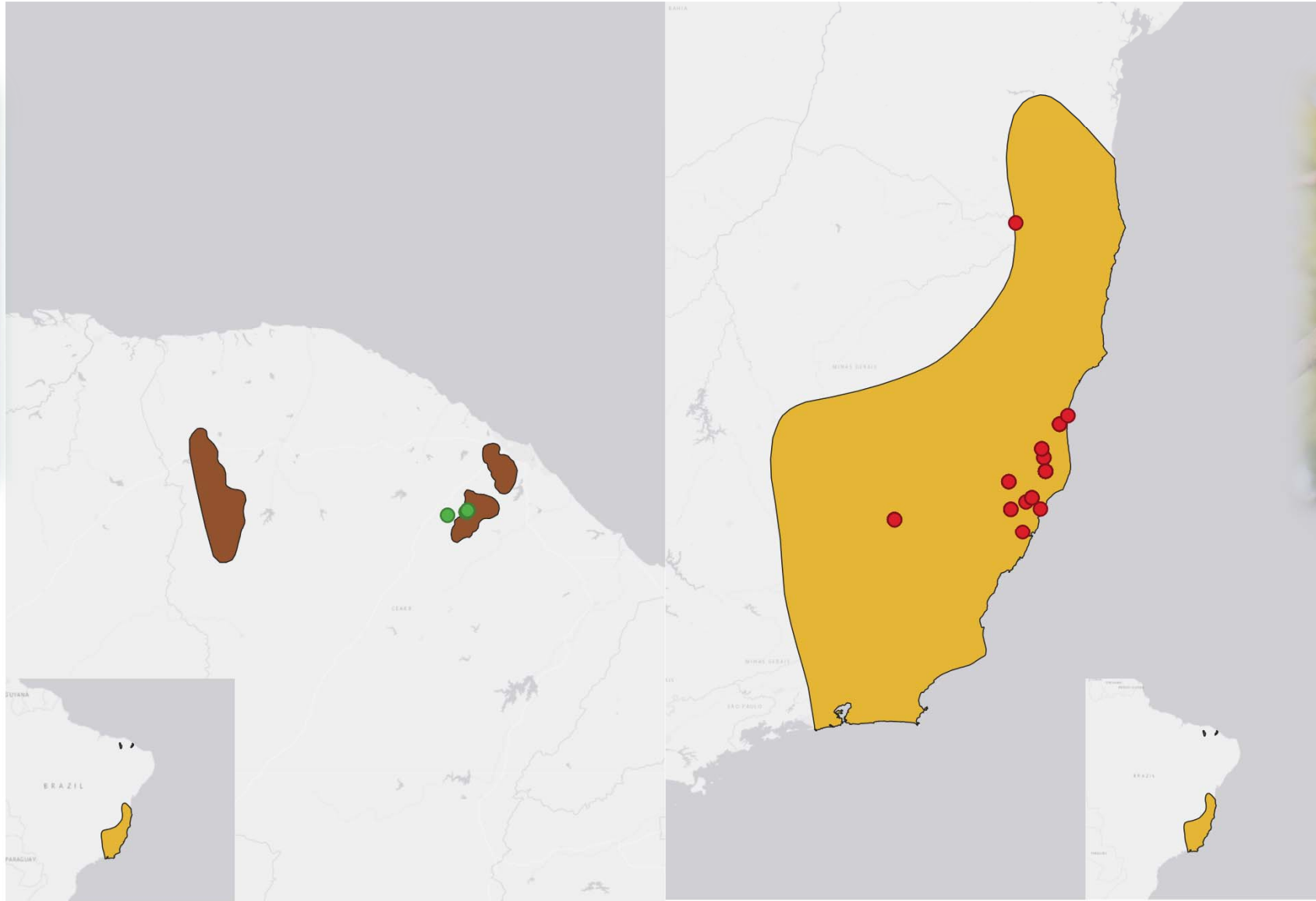
Photo Credit: Fabio Nunes







*Pyrrhura
griseipectus*



*Pyrrhura
leucotis*

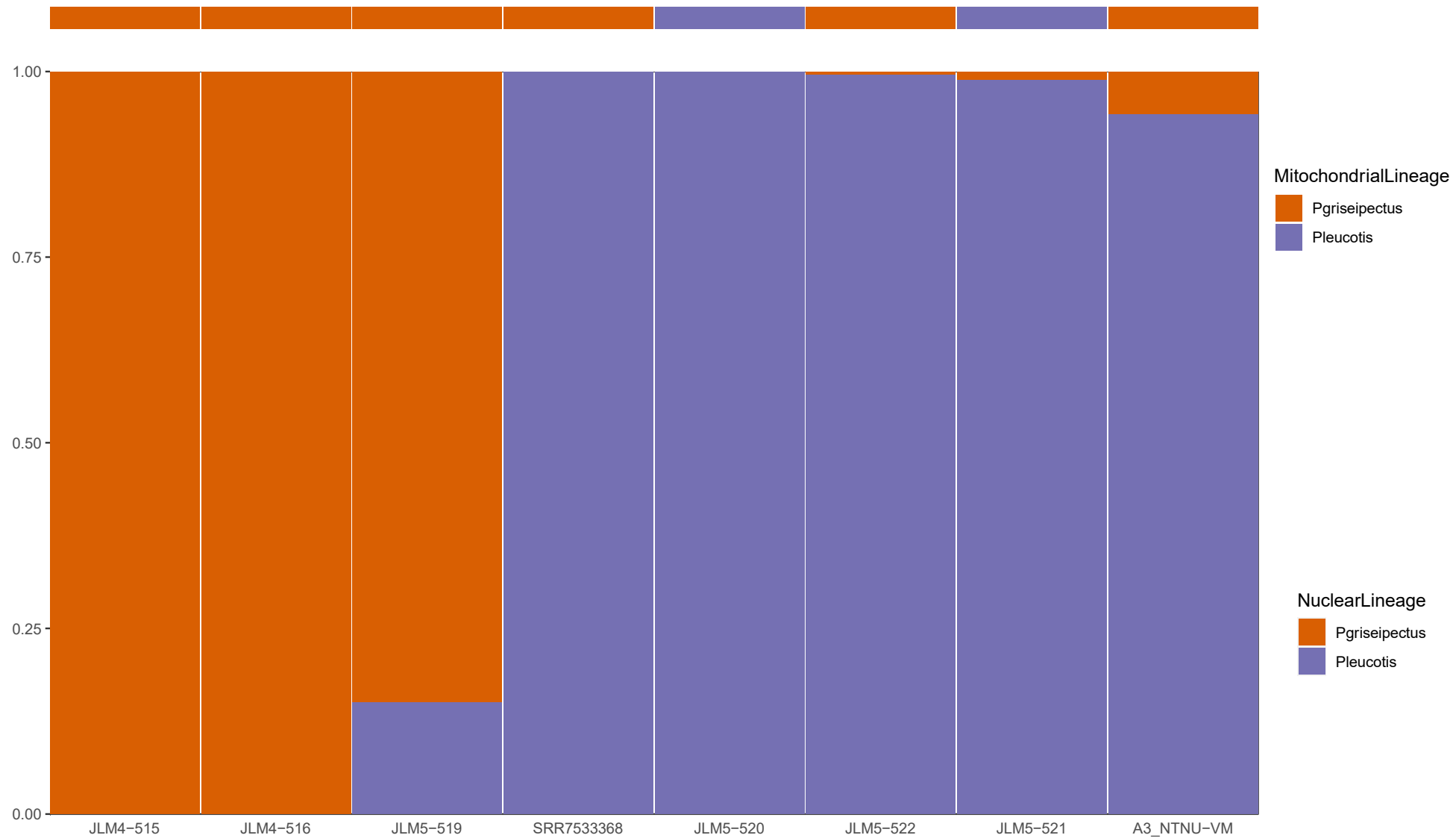
Pyrrhura leucotis



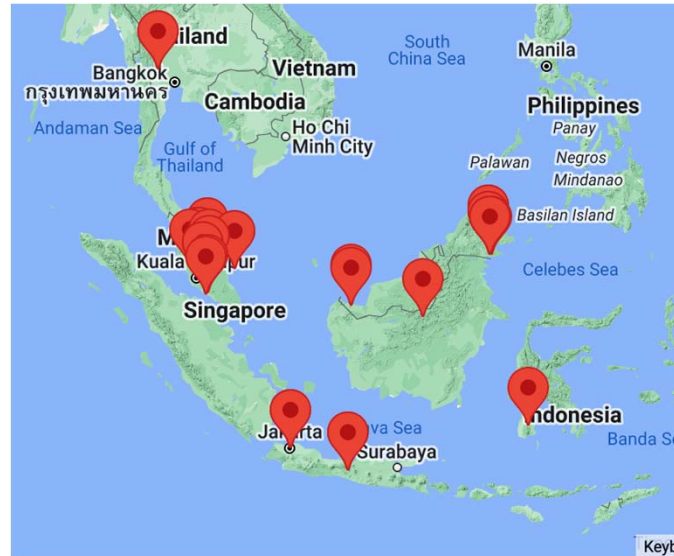
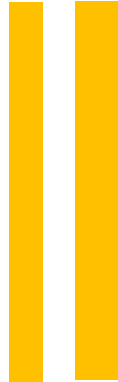
Genomic Ancestry of Captive Grey-Breasted (*Pyrrhura griseipectus*) & White-eared Conures (*Pyrrhura leucotis*)



Pyrrhura griseipectus



The Sky's
the limit!





Moving Forward!

- Sequence across populations of species with wild museum specimens
 - Creation of reference panels & genoscapes.
- Creation of an online repository of protocols and pipelines
 - Sample collection protocols
 - DNA extraction protocols
 - Sequencing protocols
 - Bioinformatic pipelines

Acknowledgements



- The University of Chicago
- Field Museum
 - Grainger Bioinformatics Center
 - Negaunee Integrative Research Center
- Iridian Genomes
- Questions, Comments or Suggestions:
 - Please email
 - thains@uchicago.edu or
 - thains@fieldmuseum.org

Thank You
&
Keep flying!



Photo Credit: Ara Manzanilo