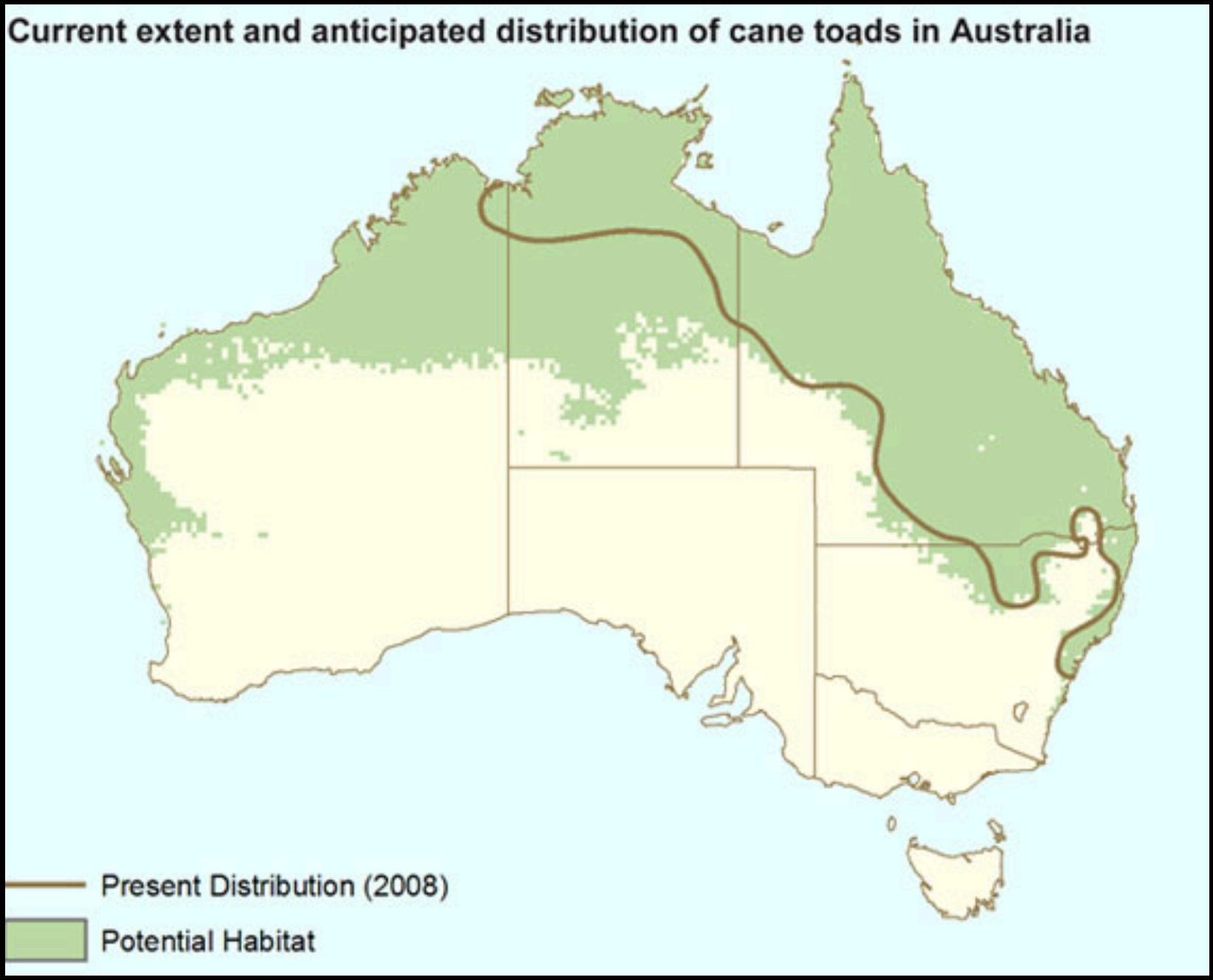
Science & Curiosity

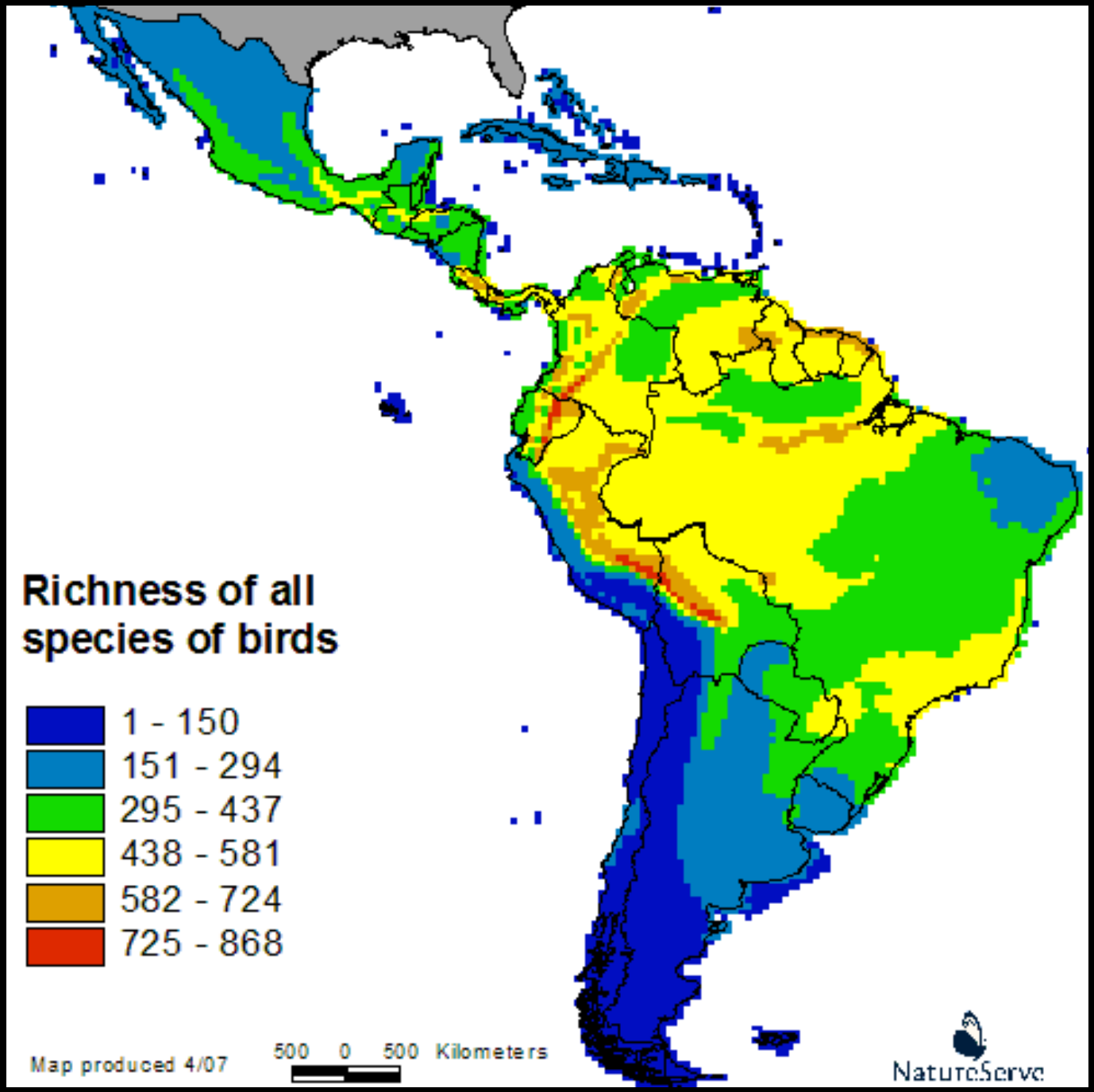
1) Where do species occur?
2) How did they get there?

Why Do We Study Species Occurrence*?

- to understand the abiotic and biotic factors determining occurrence
- to allow us to formulate questions about species
- Usually use species range maps

*Occurrence = range or distribution


Current extent and anticipated distribution of cane toads in Australia
Present Distribution (2008)
Potential Habitat


Richness of all species of birds
1 - 150
151 - 294
295 - 437
438 - 581
582 - 724
725 - 868
Map produced 4/07
500 0 500 Kilometers
NatureServe

How Do We Study Species Occurrence?

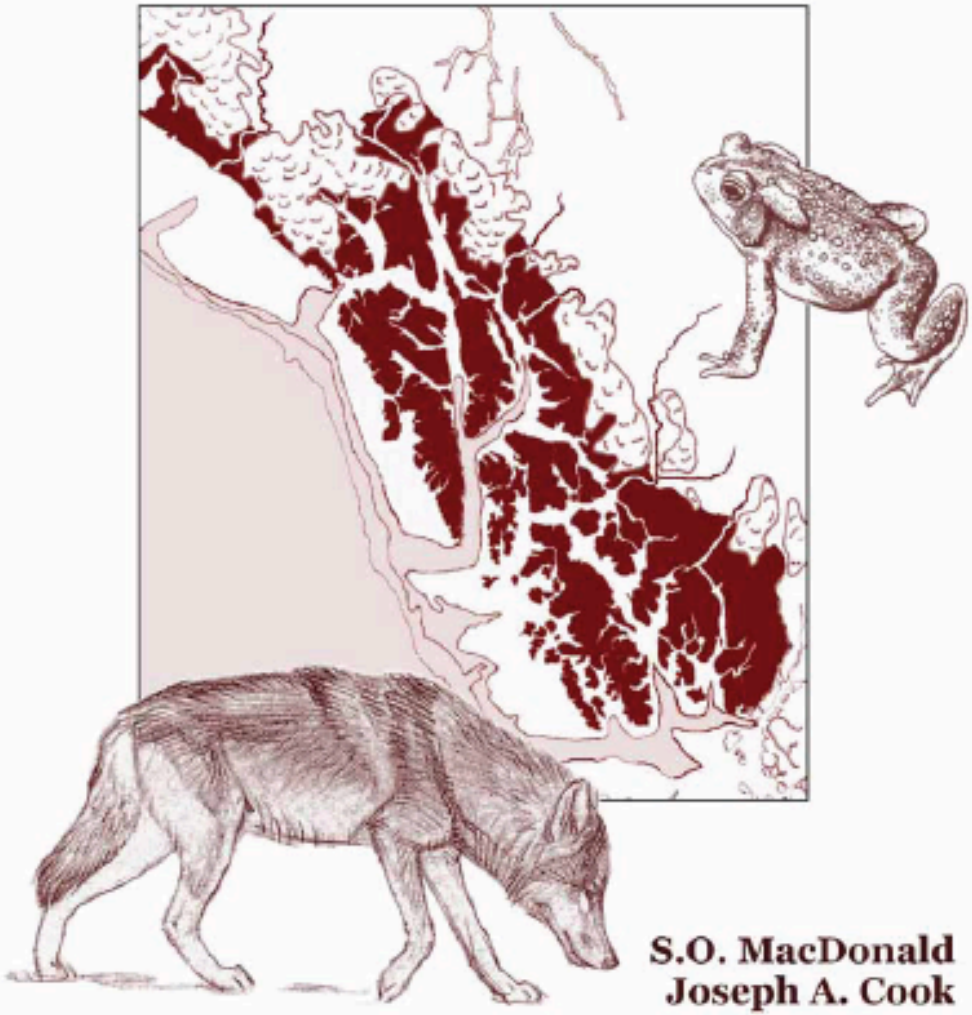
- Use Existing Information:
  - Published Work and Reports

Reptiles de Uruguay

S. Carreira, M. Meneghel y F. Achaval

Universidad de la República
Facultad de Ciencias - Montevideo
2005

Mammals and Amphibians of Southeast Alaska



S.O. MacDonald
Joseph A. Cook

Special Publication Number 8 — Museum of Southwestern Biology

How Do We Study Species Occurrence?

- Existing:
  - Published Work and Reports
  - Explore On-line Museum Data*

* our detective work

Arctos

Multi-Institution, Multi-Collection Museum Database

Search | Portals | My Stuff | About/Help

Access to 1,791,776 records

Search | Clear Form | Use Last Values | See results as: Specimen Records

Type: any | Require Tissues?

Identifiers

Customize | Show More Options

Collection: Alaska Lepidoptera, COA Birds, COA Eggs

Catalog Number:

Identification and Taxonomy

Show More Options

Identification (scientific name)

Identification

Include previous IDs? Current ID only

Match Type: contains

Locality

Show More Options

Any Geographic Element:

Select on Google Map

Date/Collector

Show More Options

Help | Collector or Preparator

Biological Individual

Show More Options

Part Name:

Define Add = for exact match

Usage

Show More Options

How Do We Study Species Occurrence?

- Existing:
  - Published Work and Reports
  - Explore On-line Museum Data
  - Explore Other Data (GenBank)

How Do We Study Species Occurrence Information

- Existing:
  - Published Work and Reports
  - Explore On-line Museum Data
  - Explore Other Data (GenBank)
- New:
  - Do Fieldwork and Collect New Data

Local Fieldwork

Field Expeditions

Where does information come from?

Museum Specimens

Alexander Archipelago Mammals

How Do We Study Species Occurrence Information

- Existing:
  - Published Work and Reports
  - Explore On-line Museum Data
  - Explore Other Data (GenBank)
- New:
  - Do Fieldwork and Collect New Data

Integrate across fields (Botany, Ornithology, Geology, Archaeology)

Why Southeast Alaska?

- Globally Important Coastal Rainforest

- Island Archipelago
  - Ecological Concepts?
  - Evolutionary Concepts?

Islands

Ecological Concepts

- Each island is simplified subset-
  - Fewer species, easier to study

N

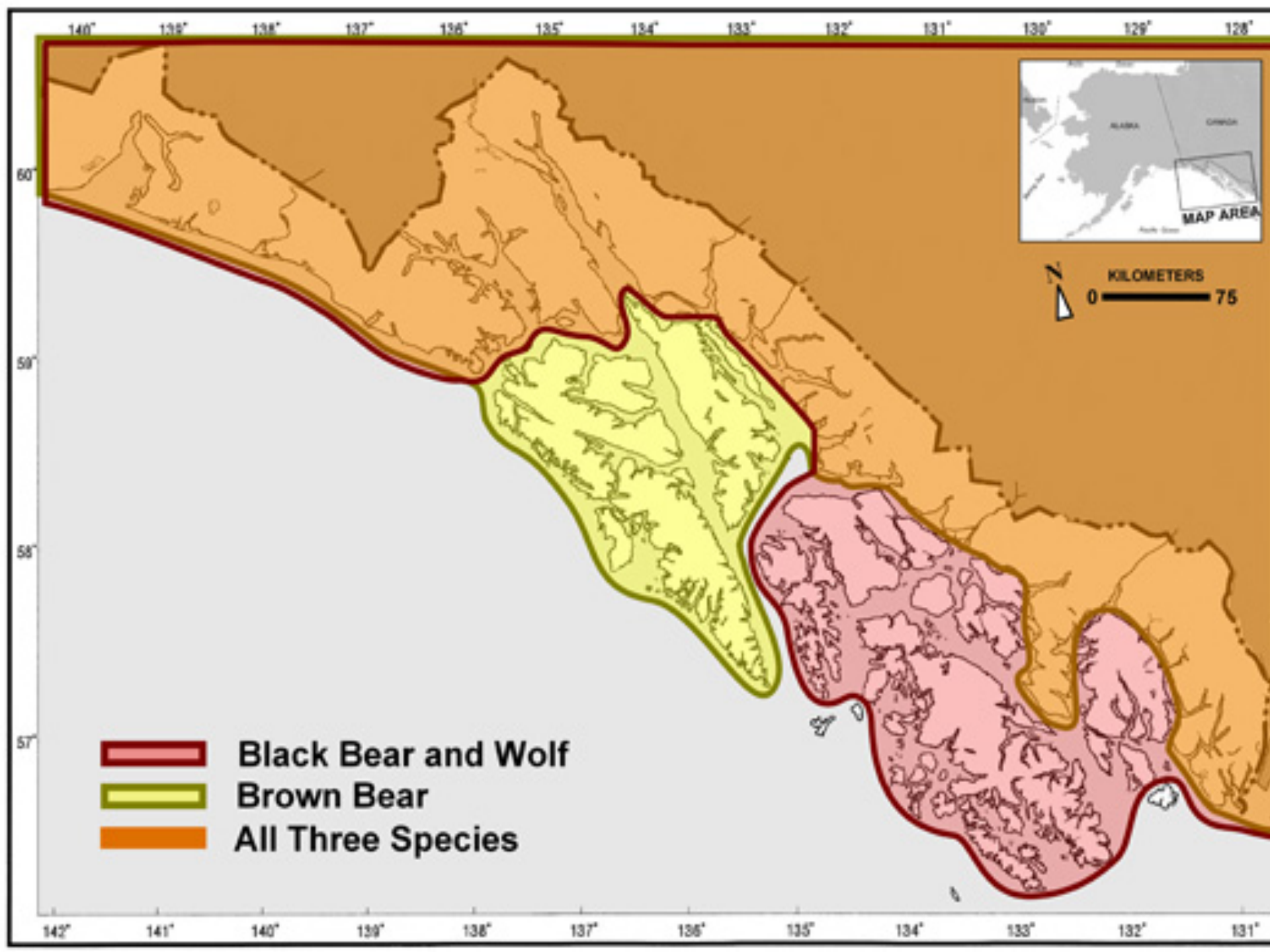
KILOMETERS

0 75

Cinereus Shrew (*Sorex cinereus*)

Dusky Shrew (*S. monticolus*)

Both Species


140°
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131°
ALASKA
CANADA
MAP AREA
N
KILOMETERS
0
75
Black Bear and Wolf
Brown Bear
All Three Species

MAP AREA

N

KILOMETERS

0 75

Root Vole (*Microtus oeconomus*)

Long-tailed Vole (*M. longicaudus*)

Meadow Vole (*M. pennsylvanicus*)

Islands

Ecological Concepts

- Each island is simplified subset-
  - easier to study

  BUT with numerous islands--- overall complexity increases

Islands

Ecological Concepts II

- Small islands have fewer organisms
- Large islands more like the mainland
- Islands near mainland (source) have more species than far islands

so Distance and Size should be important

Can we test these ideas on our islands in Southeast Alaska?


140°
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138°
137°
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129°
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56°
55°
YUKON TERRITORY
BRITISH COLUMBIA
CANADA
ST. ELIAS MTS.
COAST MOUNTAINS
Taku River
Stikine River
River
Iskut
Yakutat Foreland
Juneau
Admiralty I.
Sitka
GULF OF ALASKA
ALEXANDER ARCHIPELAGO
Baranof I.
Mitkof I.
Heceta I.
Prince of Wales I.
Clarence Strait
Ketchikan
Dall Island
Dixon Entrance
PACIFIC OCEAN
0 25 50 75 100 mi
0 50 100 150 km


140°
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YUKON TERRITORY
BRITISH COLUMBIA
CANADA
ST. ELIAS MTS.
COAST MOUNTAINS
Taku River
Stikine River
River
Iskut
Yakutat Foreland
Juneau
Admiralty I.
Sitka
GULF OF ALASKA
ALEXANDER ARCHIPELAGO
Baranof I.
Mitkof I.
Clarence Strait
Prince of Wales I.
Heceta I.
Ketchikan
Dall Island
Dixon Entrance
PACIFIC OCEAN
0 25 50 75 100 mi
0 50 100 150 km


Labouchere Bay
Red Bay Lake
Salmon Bay Lake
Whale Passage
Kosciusko Island
Sarkar Lake
Coffman Cove
PRINCE
Heceta I.
Thorne Bay
Shinaku Lake
OF
No Name Lake
Noyes Island
Klawock
Klawock River
Salmon Lake
Karta Lake
Craig
Hollis
One Duck Lake
WALES
Baker Island
Suemez I.
Mellen Lake
Summit Lake
Hydaburg
Marge Lake
Kegan Lake
Dall Island
Long I.
ISLAND

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Type: any | Require Tissues?

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Identification and Taxonomy

Show More Options

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Identification

Include previous IDs? Current ID only

Match Type: contains

Locality

Show More Options

Any Geographic Element:

Select on Google Map

Date/Collector

Show More Options

Help | Collector or Preparator

Biological Individual

Show More Options

Part Name:

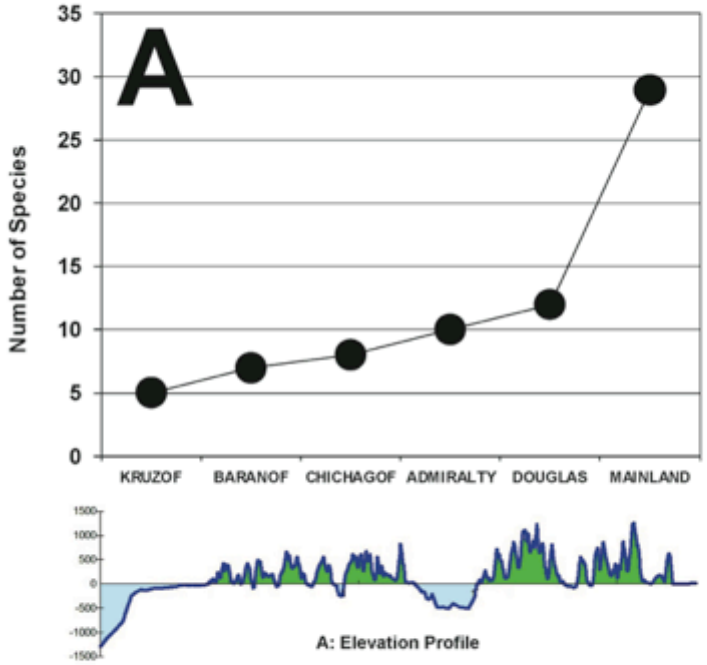
Define Add = for exact match

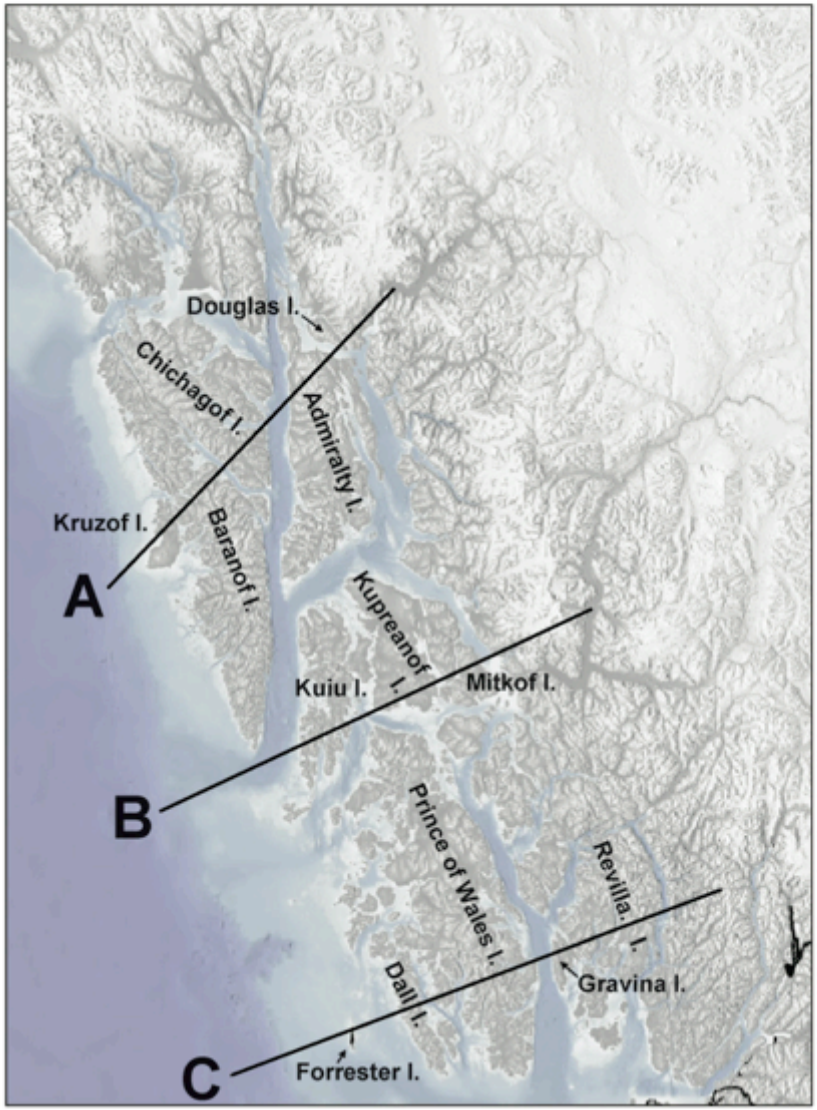
Usage

Show More Options

East-West Transects from Mainland to Outer Islands

Number of Species Declines Away from Mainland Source





Mammals are not evenly distributed across the Alexander Archipelago

- Do large islands, close to the mainland, have more species than small islands distant from the mainland?

- Science and Management needs to understand:
  - Variation from Island to Island
  - Connectivity Among Islands

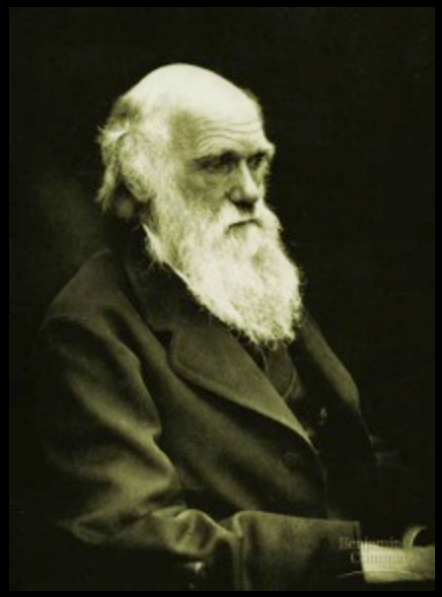
Introduction to Island Archipelago Module

- Un pequeno prueba de Conroy et al
- O prueba de “island rule”
- O uso de datos en GenBank basada en especimenes

- O su propio estudio que usan estos base de datos

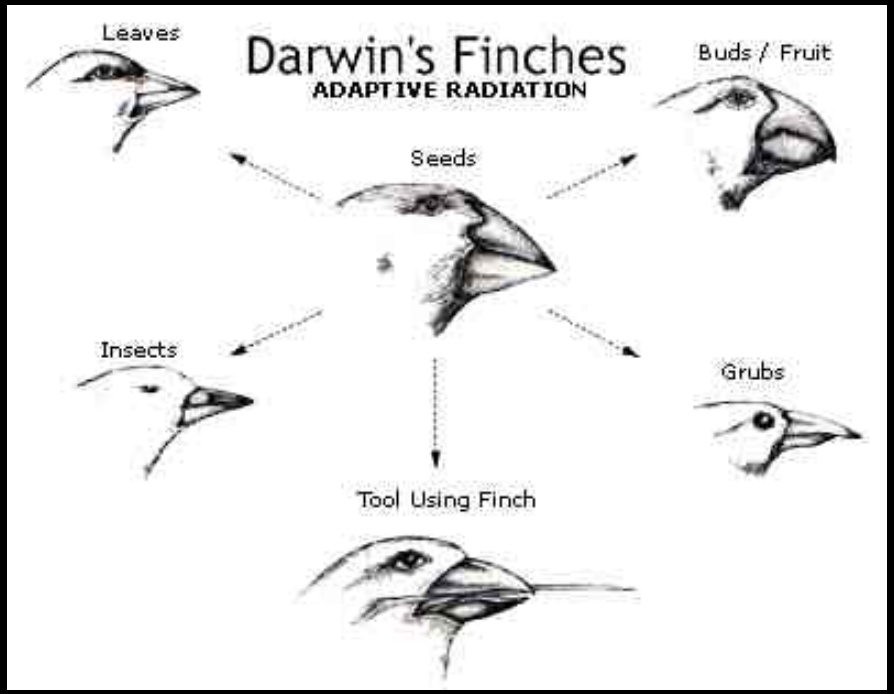
Islands are Important to Biology

- Island Archipelago
  - Ecological Concepts
  - Evolutionary Concepts



Island archipelagos are important models for understanding evolution.

•Divergence due to isolation and selection leads to island endemics



An endemic is a distinctive organism with a restricted range such as an island.

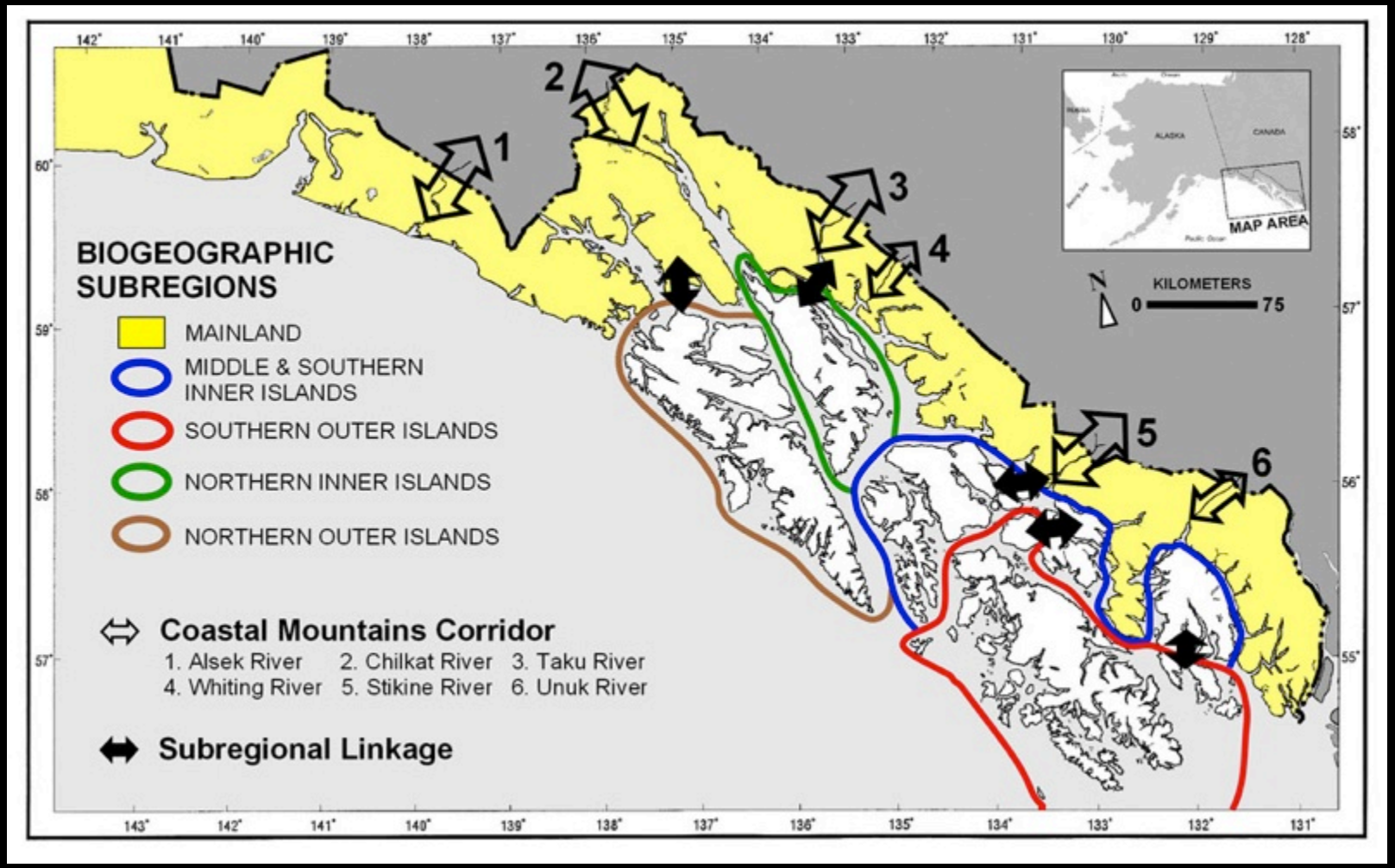
Islands and Evolution

- Islands have distinctive organisms, because **isolation over time (and possibly sel'n)** leads to divergence.
  - Survey across island mammals for unique signatures or clues of isolation
- Time & Isolation important to document
- Research and Information Needs
  - How connected are island populations

Over what time scale has diversification occurred on the Alexander Archipelago?

- Some islands share similar species.

  Contemporary linkages (connectivity) between these islands should be evaluated.

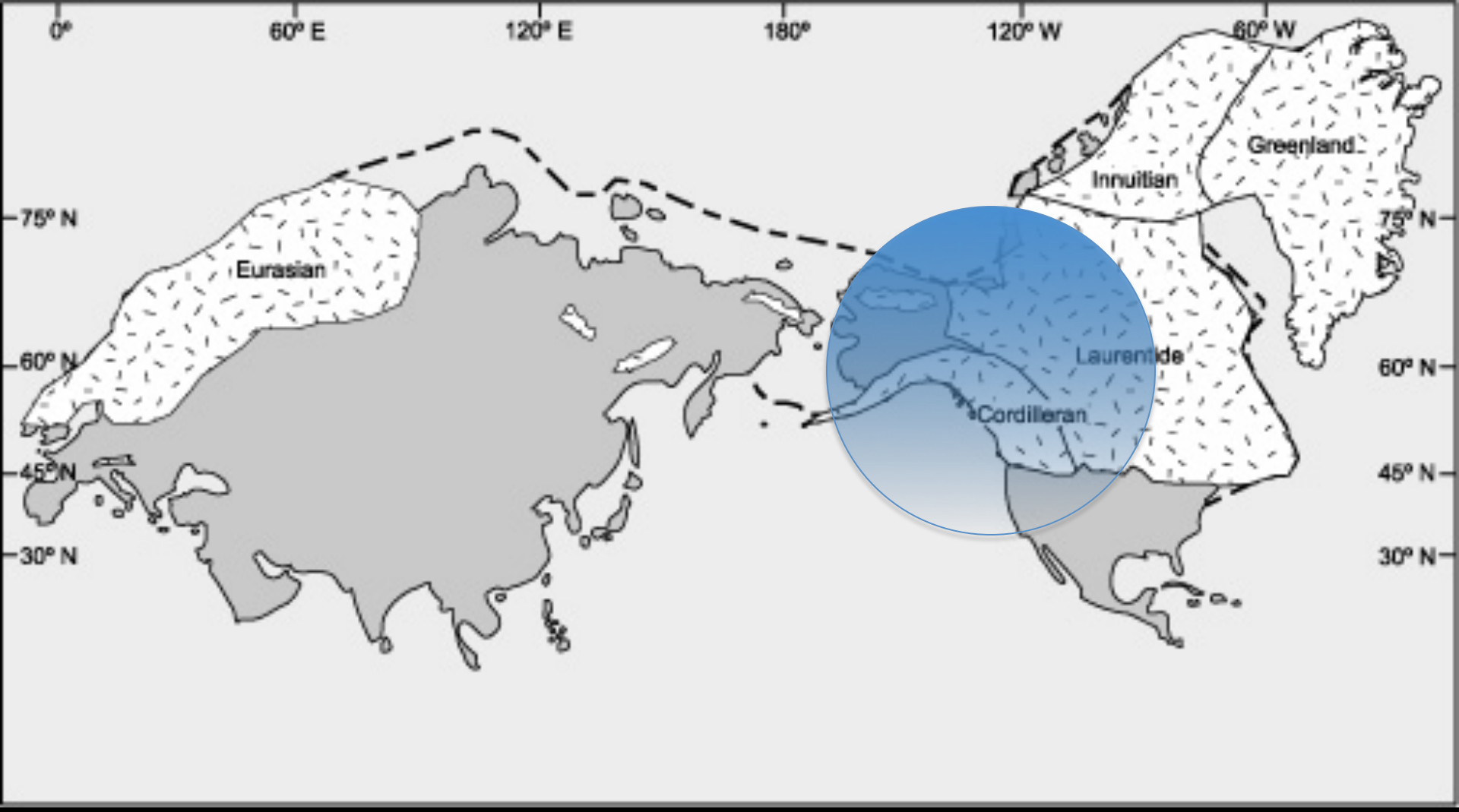


What about historic linkages?

- How has history of the region shaped biodiversity and community assembly?


Dynamic Geologic History

Extent of Last Full Glacial Advances in Northern Hemisphere



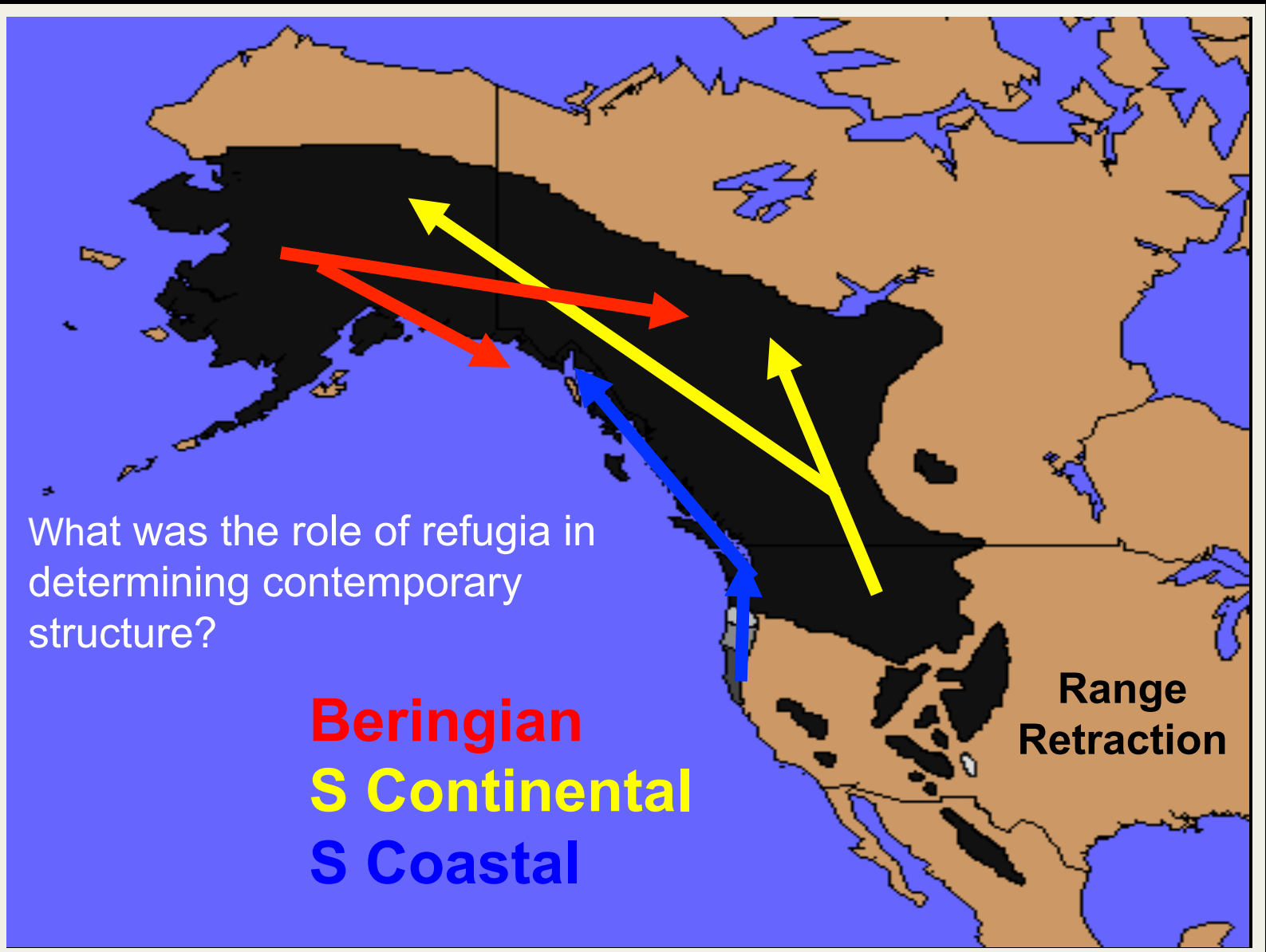
Focus on Impact of Glacial Advances and Sea Level Change on Mammals-

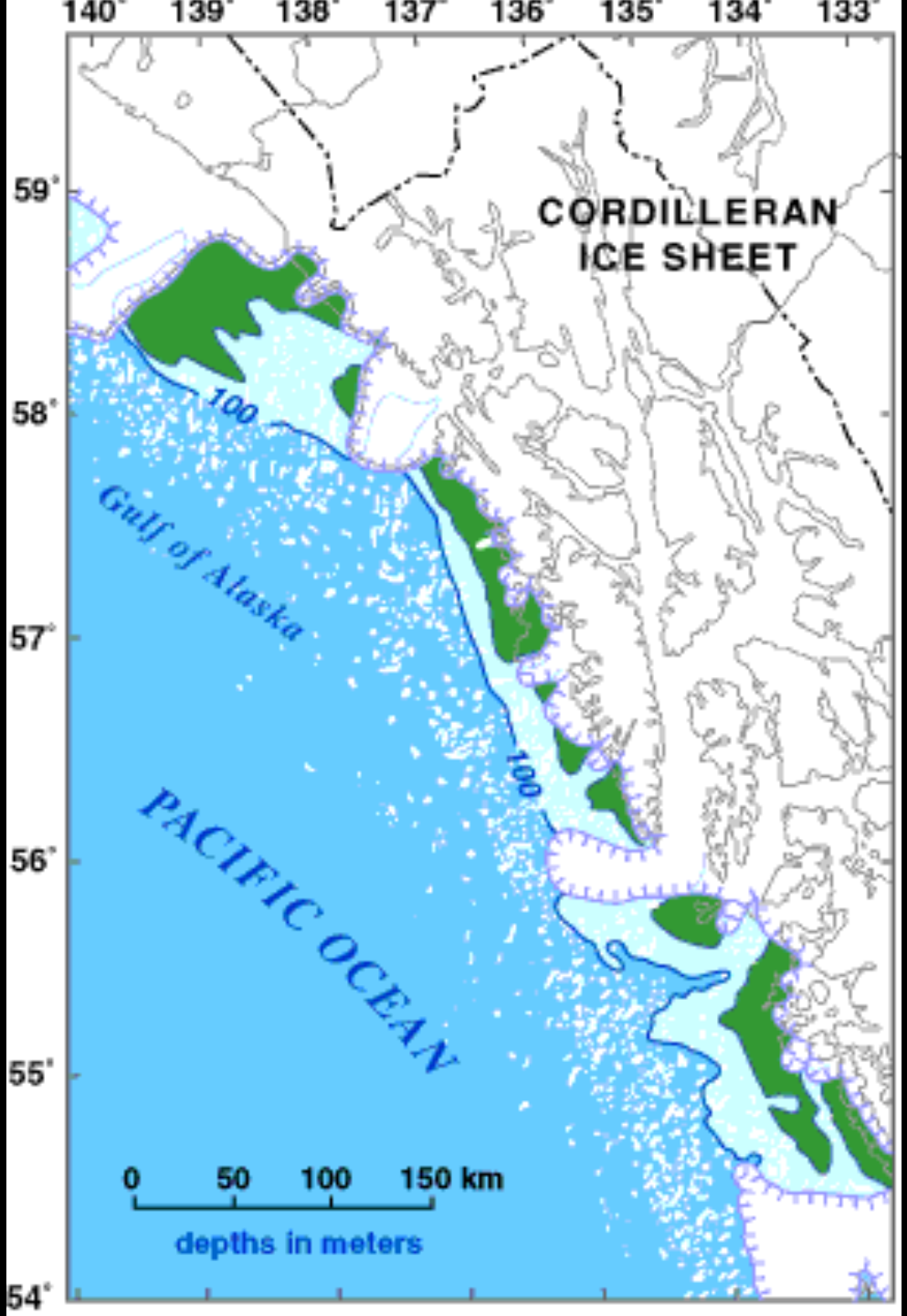
Glaciated regions should reflect colonization processes

Biotic refugia as sources for colonization of Southeast Alaska.

- Origin or source can be explored through DNA signatures

Glacial Refugia, Mountains and Possible Post-glacial Colonization Routes





Hypothesized extent of Cordilleran Ice Sheet at 15,000 ybp (Carrara et al. 2003, 2007). Outer shelf refugia may have persisted during full glacial advances.

Testing the Impact of Isolation Along the Northwest Pacific Coast

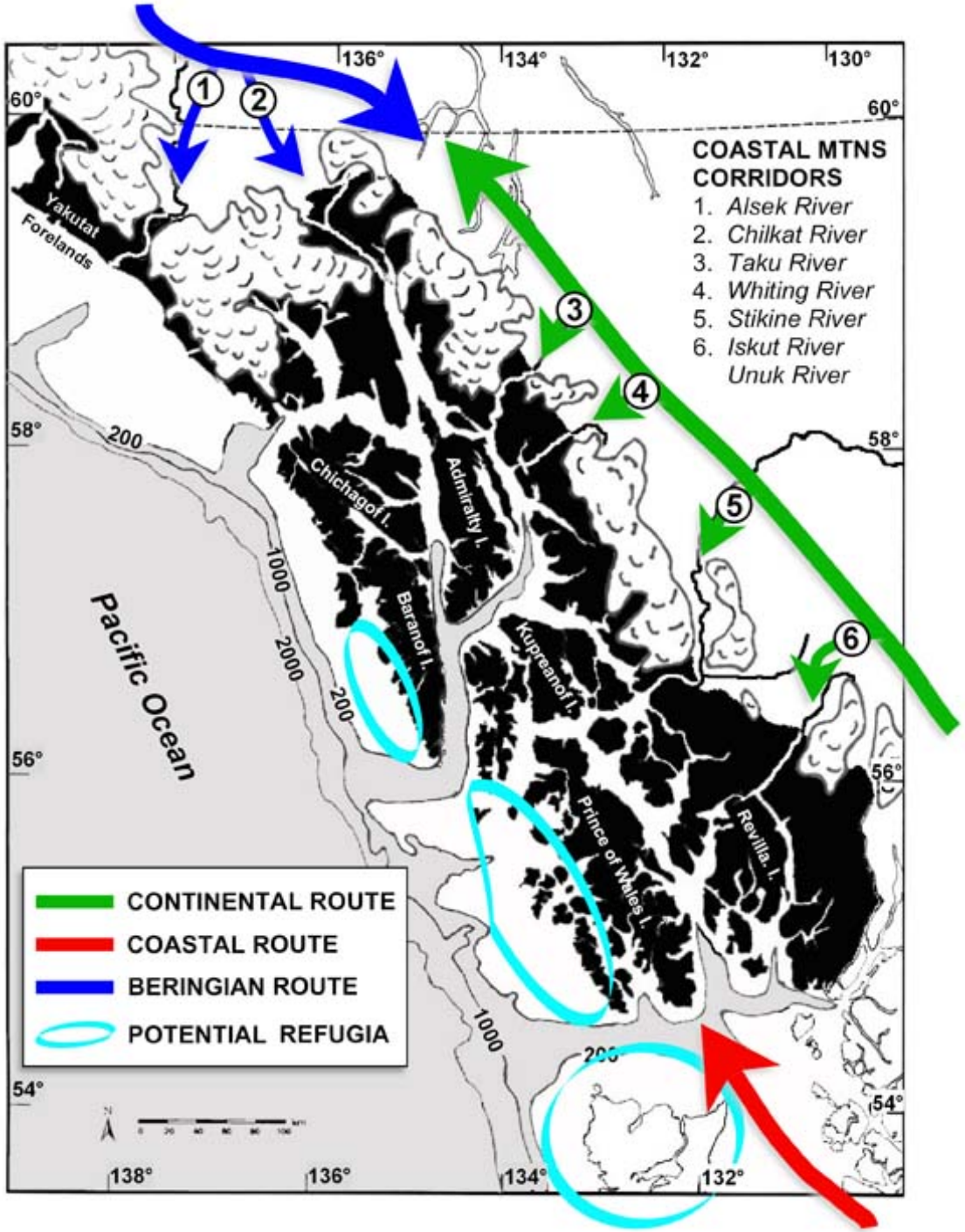
- LGM Isolation by Cordilleran Ice
- Now Isolated by Coast Mtn Range
- More Recently Fragmented into Islands

Connectivity among islands has shifted dramatically in last 10,000 years.

8,000 years ago

Today

Glaciers receded, ocean levels rose and islands rebounded. Provided new territory for species to colonize.


136°
134°
132°
130°
60°
COASTAL MTNS
CORRIDORS
1. Alsek River
2. Chilkat River
3. Taku River
4. Whiting River
5. Stikine River
6. Iskut River
Unuk River
Yakutat
Forelands
58°
200
Chichagof I.
Admiralty I.
1000
2000
Baranof I.
Kupreanof I.
Pacific Ocean
56°
Prince of Wales I.
Revilla. I.
CONTINENTAL ROUTE
COASTAL ROUTE
BERINGIAN ROUTE
POTENTIAL REFUGIA
54°
138°

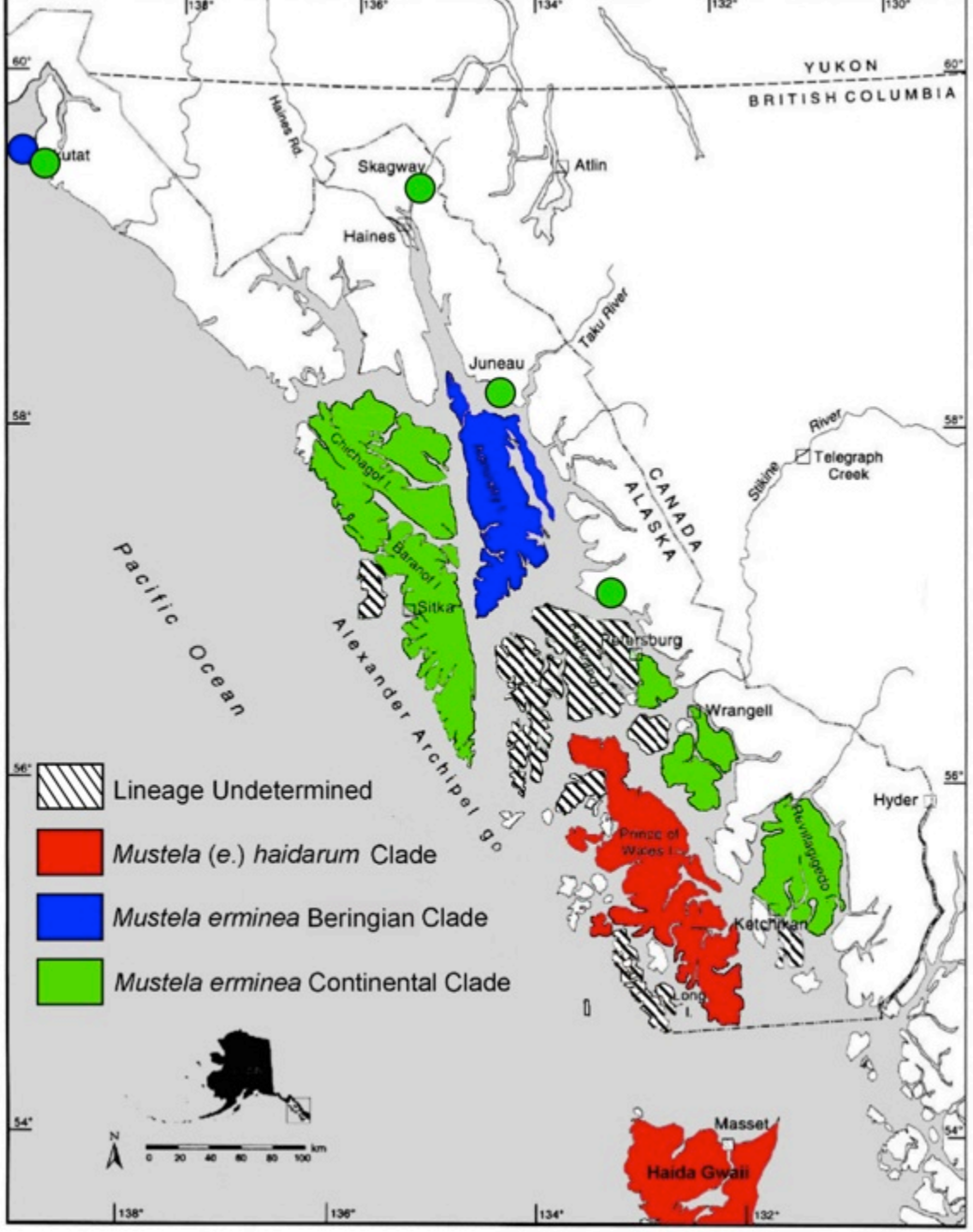
Canis lupus voucher UAM:Mamm 63147 cytochrome b (CYTB) gene, partial cds; tRNA-Thr and tRNA-Pro genes, complete sequence; and control region, partial sequence; mitochondrial

GenBank: JF311434.1

FASTA Graphics PopSet

Go to:

```
LOCUS       JF311434                611 bp    DNA     linear   MAM 13-MAY-2012
DEFINITION  Canis lupus voucher UAM:Mamm 63147 cytochrome b (CYTB) gene,
            partial cds; tRNA-Thr and tRNA-Pro genes, complete sequence; and
            control region, partial sequence; mitochondrial.
ACCESSION   JF311434
VERSION     JF311434.1  GI:386776327
KEYWORDS    .
SOURCE      mitochondrion Canis lupus (gray wolf)
  ORGANISM  Canis lupus
```


YUKON
BRITISH COLUMBIA
Yutat
Haines Rd.
Skagway
Haines
Atlin
Taku River
Juneau
Stikine River
Telegraph Creek
CANADA
ALASKA
Pacific Ocean
Alexander Archipelago
Chichagof I.
Baranof I.
Sitka
Petersburg
Wrangell
Hyder
Prince of Wales I.
Revillagigedo I.
Ketchikan
Long I.
Masset
Haida Gwaii
Lineage Undetermined
Mustela (e.) haidarum Clade
Mustela erminea Beringian Clade
Mustela erminea Continental Clade
N
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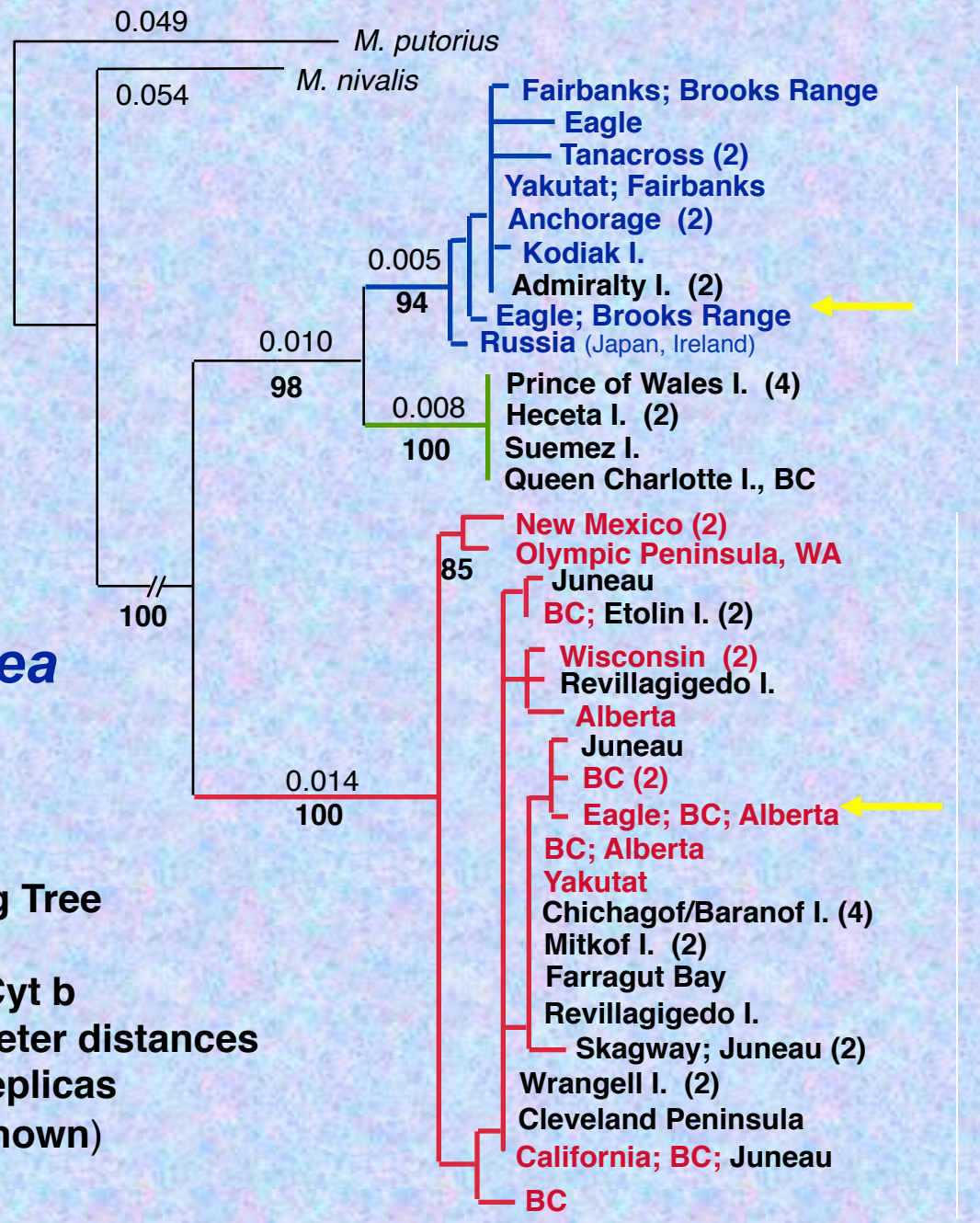
134°
132°
130°
60°
58°
56°
54°

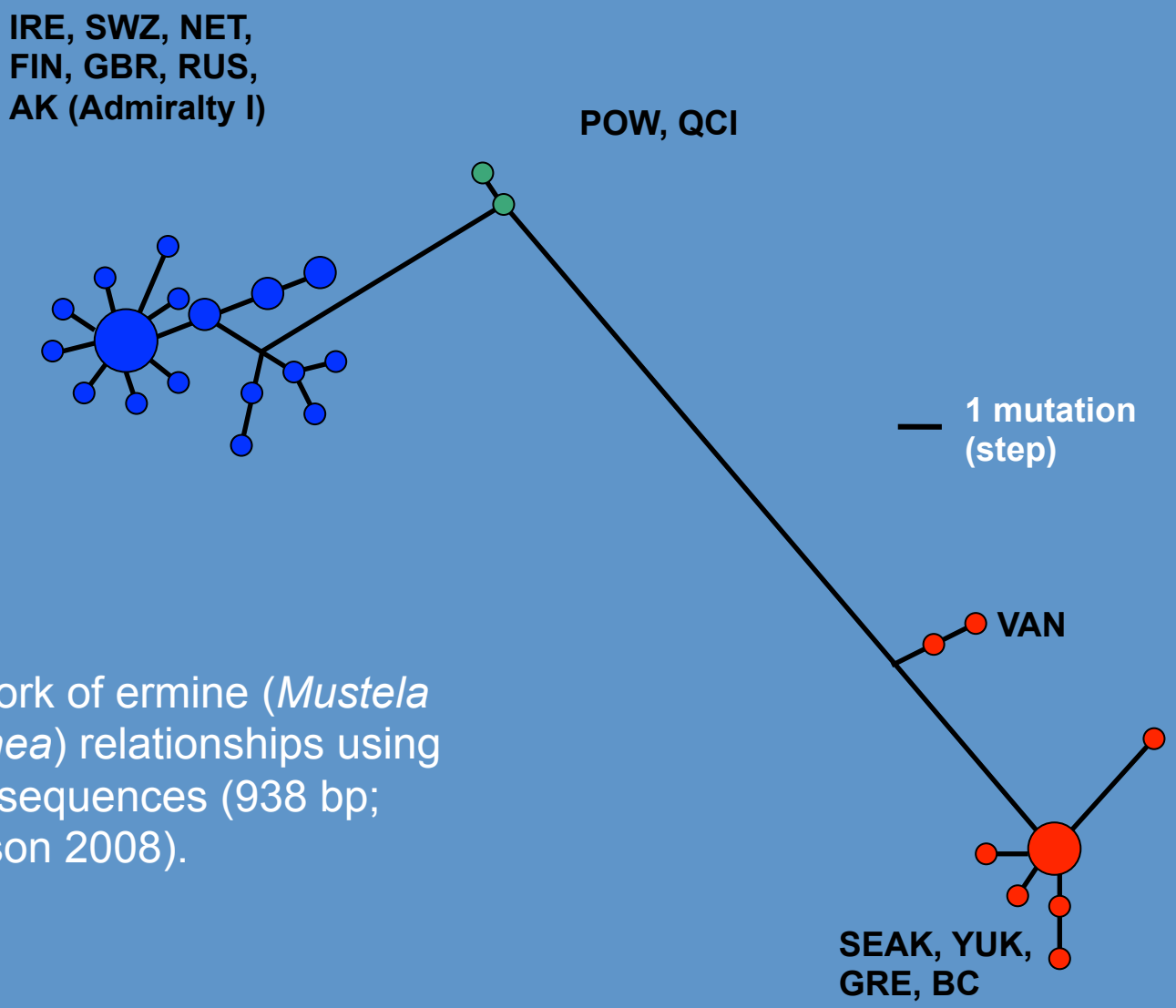
Mustela erminea
Ermine



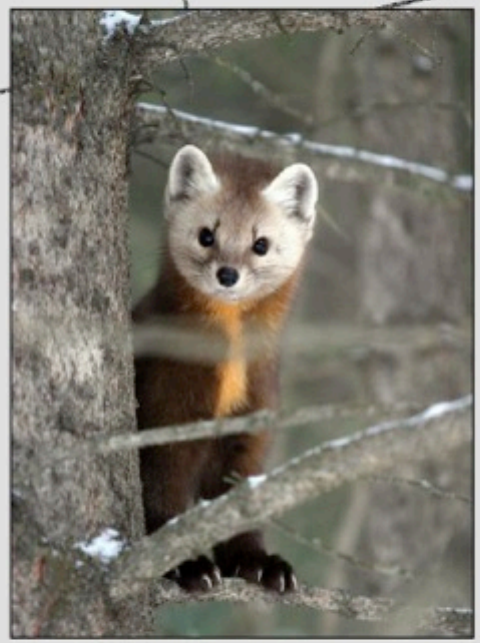
Neighbor-joining Tree
68 Ermine
1140 or 790 bp Cyt b
Kimura 2-parameter distances
500 Bootstrap replicas
(values > 70% shown)

Contact Eastern Beringia

Ermine



Network of ermine (*Mustela erminea*) relationships using DNA sequences (938 bp; Dawson 2008).



Marten, *Martes americana* **and** *M. caurina*

● = *americana* specimen record
■ = specimen record (introduced *americana* population)
● = *caurina* specimen record

Haida Gwaii

Origins (Refugia) of NW Coastal Mammals

Beringian Origin (7):

moose (*Alces alces)*
wolverine (*Gulo gulo)*
northern red-backed vole (*Myodes rutilus)*
root vole (*Microtus oeconomus)*
arctic ground squirrel (*Spermophilus parryii*)
collared pika (*Ochotona collaris)*
brown lemming (*Lemmus trimucronatus)*

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Continental (Eastern and Southern) Refugia (4)

northern flying squirrel (*Glaucomys sabrinus)*
southern red-backed vole (*Myodes gapperi)*
meadow vole (*Microtus pennsylvanicus)*
American marten (*Martes americana)*

Origins (Refugia) of NW Coastal Mammals

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meadow vole *Microtus pennsylvanicus*
American marten *Martes americana*

Multiple Lineages (likely multiple refugial origins)

dusky shrew (*Sorex monticolus)*
long-tailed vole (*Microtus longicaudus)*
black bear (*Ursus americanus)*
ermine (*Mustela erminea)*

Endemism in Southeast Alaska

Endemic is distinctive with a restricted range (island.)

About 25% mammals (species or subspecies) recognized as endemic, based on < 28 islands visited (of 1000+ named islands).

Molecular genetics --reassessed endemics, explore hidden diversity, and provide new insight.

Similar study needed for many insects, plants, fungi and other organisms.

Potential Support for Coastal Refugium:

northwestern deermouse (*Peromyscus keeni)*
wolf (*Canis lupus ligoni)*
Sitka black-tailed deer (*Odocoileus hemionus sitkensis)*
mountain goat (*Oreamnos americanus)*
Pacific marten (*Martes caurina)*
ermine (*Mustela erminea haidarum)*

Further tests of these preliminary hypotheses needed

Threats to Endemics on Island Systems--Extinction

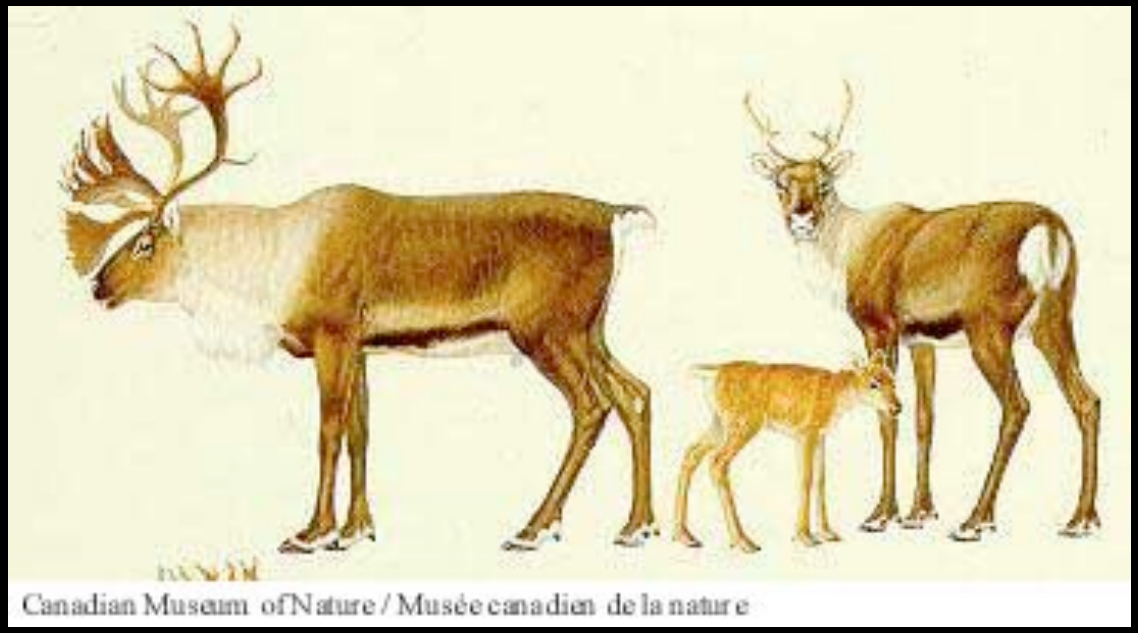
- Pathogens
- Introduction of Exotics
- Over exploitation
- Environmental change
  - Habitat conversion
  - Climate

Extinction or Extirpation

Extinction-

More than 65% of all documented vertebrate extinctions in the last 400 years are island endemics due to habitat destruction, overhunting, pathogens or introduced exotics.

island endemism due to isolation



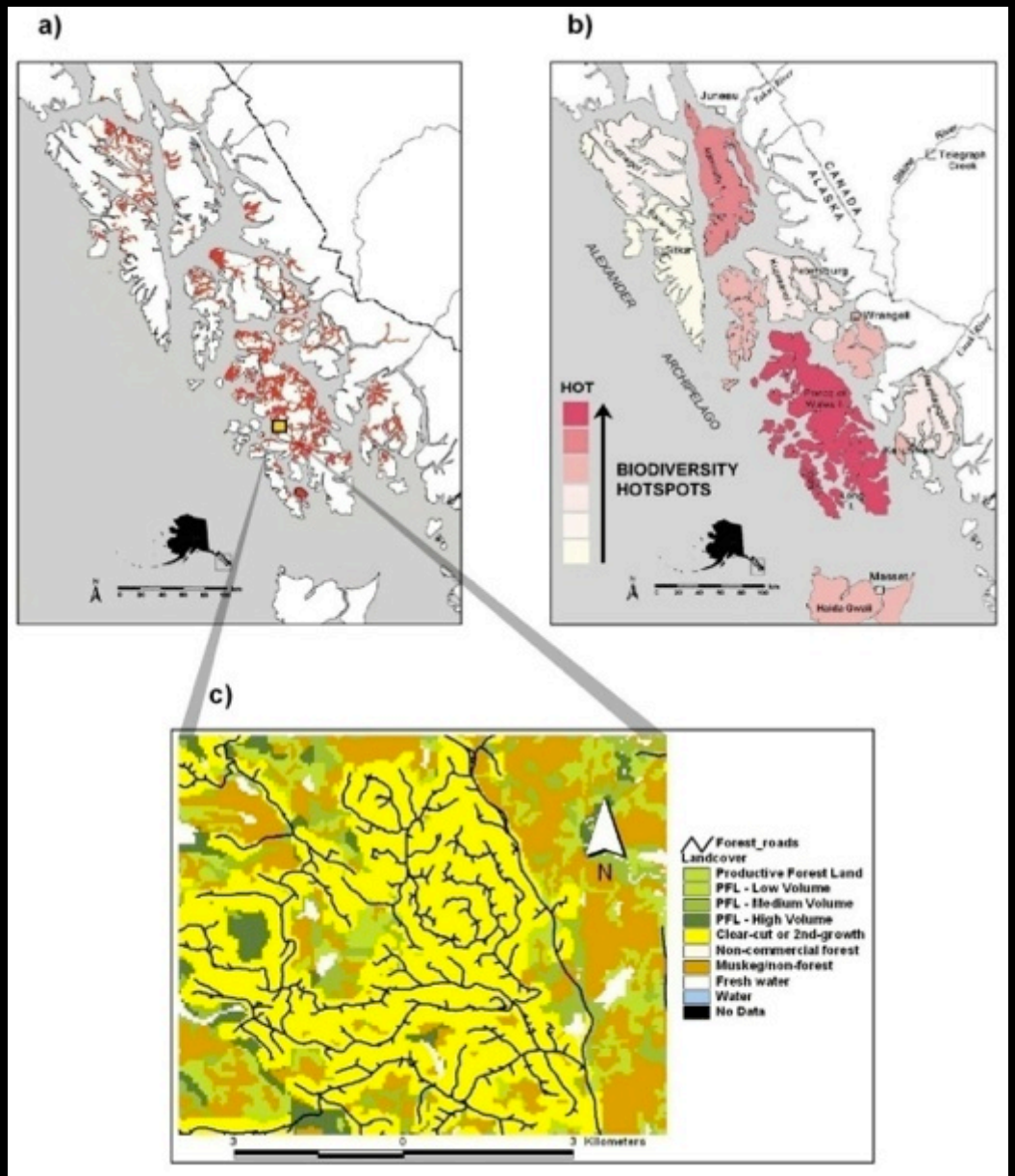
Dawson's caribou—Haida Gwaii

Habitat conversion

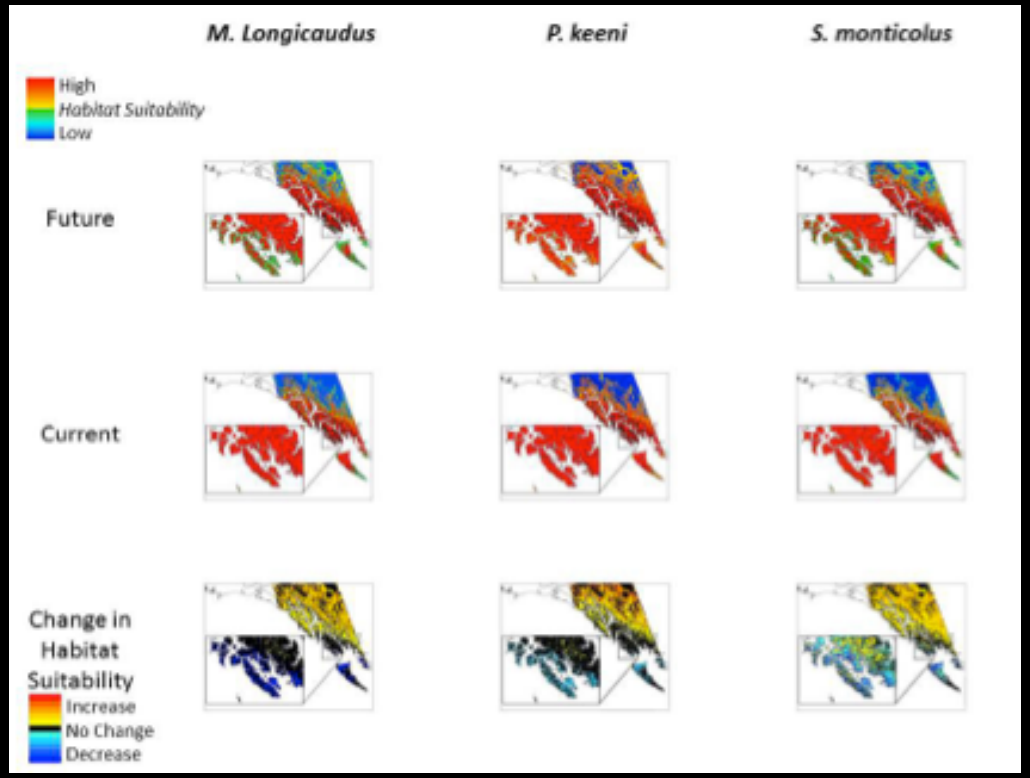
80 meter tall tree on Tongass is between 1700 and 2000 years old.

Habitat conversion

Deforestation and Endemism



Climate change



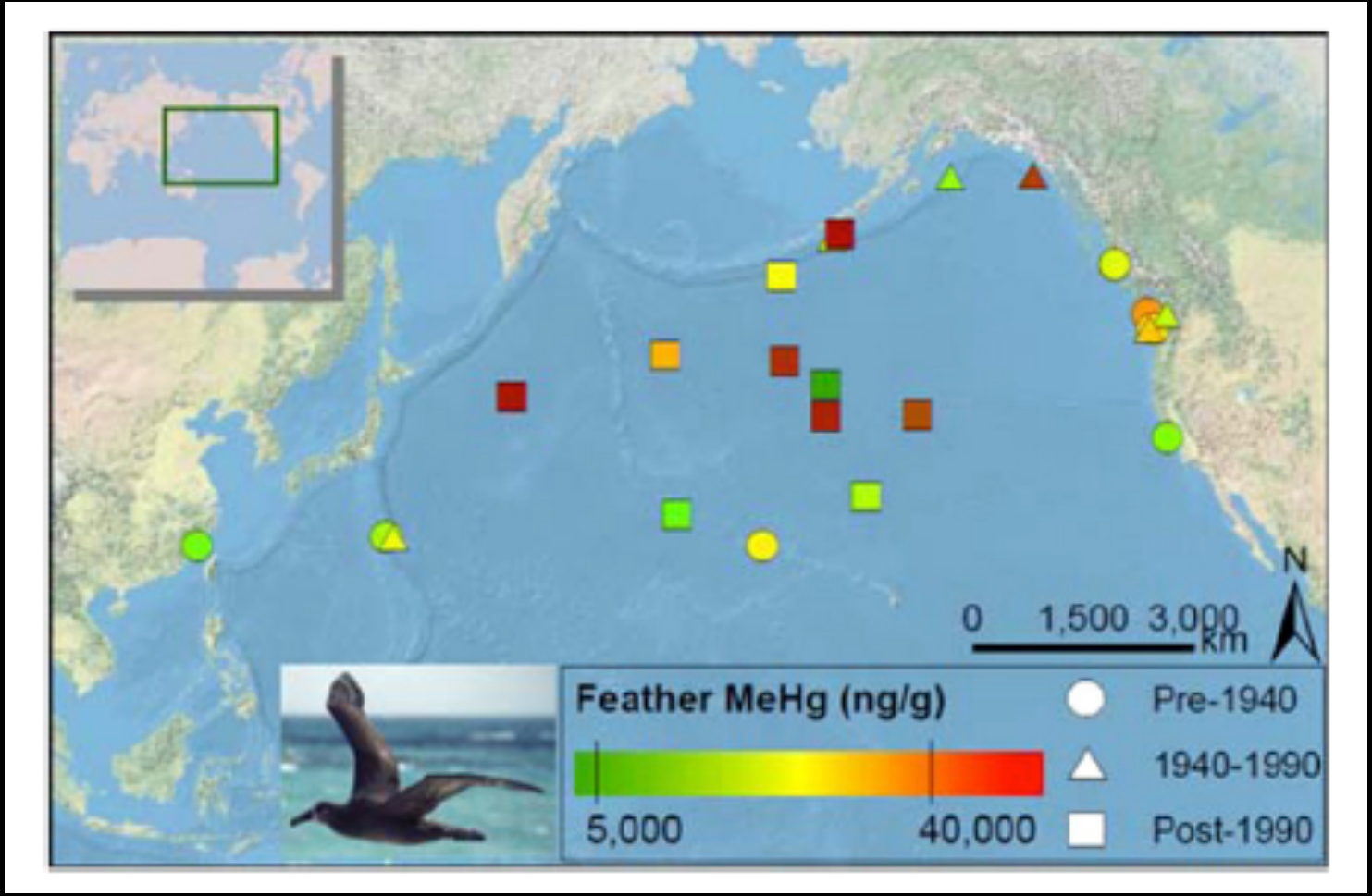
Ecological Niche Modeling from Specimens

Forecasting Future Distributions Under Climate Change

Parasites, emerging pathogens & diseases

Worldwide distribution of y confirmed Powassan virus activity.
Deardorff et al., 2013. Emerging and Infectious Diseases.

Pollutants

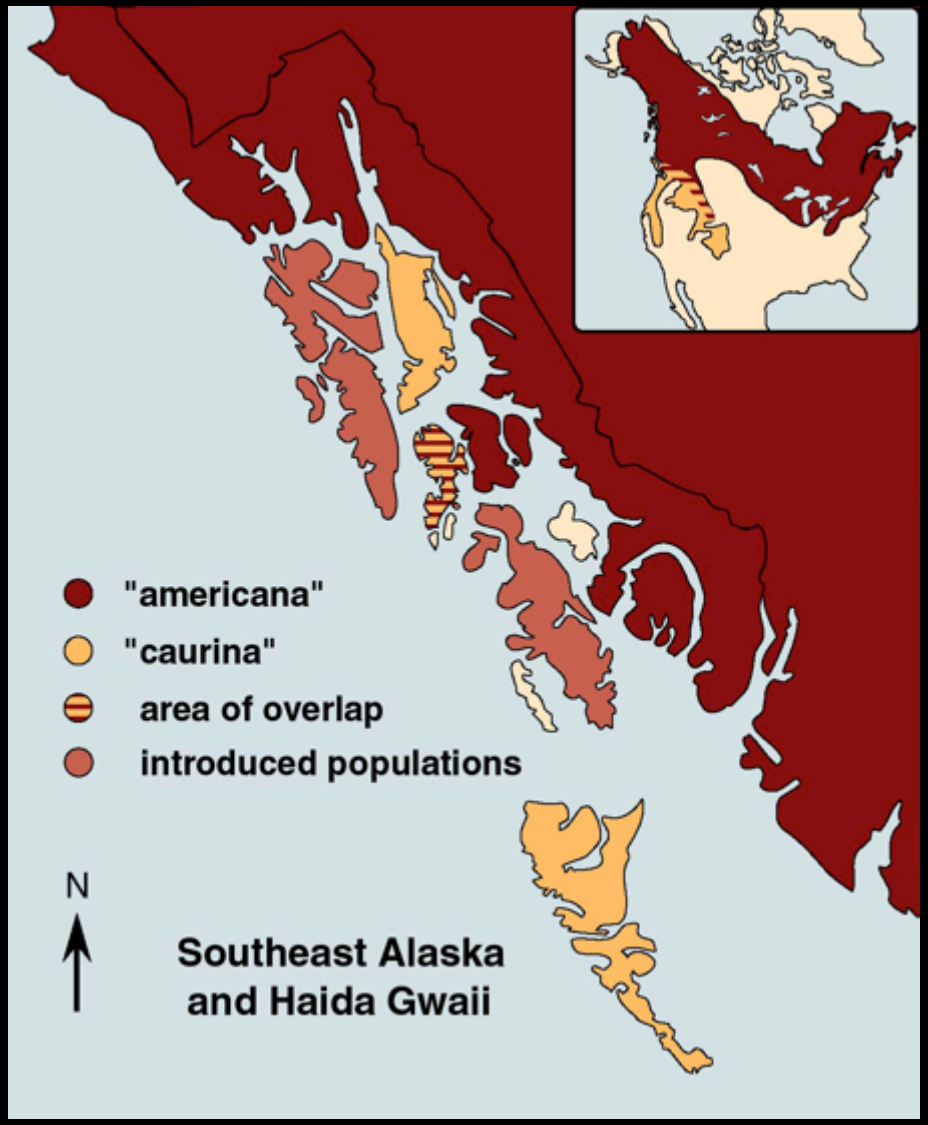


Collection localities and methylmercury concentrations measured in the breast feathers of black-footed albatross museum specimens.
Vo et al., 2011. PNAS

Introduction of exotics

Two species of marten

“Active Management”



Preguntas Sobre Proyecto?

Nestedness

- **Used to describe the distribution structure of lineages or species within a biogeographic region and especially for islands**
- **Attributed to both extinction and colonization processes (Patterson 1990)**
- **May be attributed to nested pattern of communities and species niches (Patterson and Brown 1991)**

Reanalysis of Conroy et al. 1999

- Defined lineage as "reciprocally monophyletic" based on molecular genetic marker (cytochrome b)
- Original data set from Conroy et al. 1999), but now analyzed at lineage level
- Nestedness calculator (15 degrees) to explore pattern
- Mann-Whitney test

Results: Island Occurrence table

Table 2 Maximally packed data matrix for mammal species on the Alexander Archipelago, AK. Species abbreviations are as follows: *O. h., Odocoileus hemionus; P. k. u, Peromyscus keeni* (unresolved); *M.l., Microtus longicaudus coronarius; S. m., Sorex monticolus* (coastal); *C. lu., Canis lupis ligoni; M. v., Mustela vison; U. a. s., Ursus americanus* (coastal); *S. c., Sorex cinereus; M. a., Martes americana; M. e. c., Mustela erminea* (continental); *T. h., Tamiasciurus hudsonicus; G. s.1., Glaucomys sabrinus* (1); *U. ar., Ursus arctos; E. d., Erethizon dorsatum; U. a. c., Ursus americanus* (continental); *A. a., Alces alces; M. e. q., Mustela erminea* (QCI); *O. z., Ondatra zibethicus; G. g., Gulo gulo* (SE AK); *S. b., Synaptomys borealis; C. g.1., Clethrionomys gapperi* (1); *M. o., Microtus oeconomus; G. s. 2., Glaucomys sabrinus* (2); *M. c., Martes caurina; M. p., Microtus pennsylvanicus; C. r., Clethrionomys rutilus; C. g.2., Clethrionomys gapperi* (Wrangell); *P. k. g, Peromyscus keeni gravina; M. e. b., Mustela erminea* (Beringian); *C. la., Canis latrans; Z. h., Zapus hudsonius.* The last three rows are z scores from Mann-Whitney U tests. Boldface values are significant at P<0.05.

Island Name	No. of Species	Isolation (km)	Area (km^2)	*O. h.*	*P. k. u.*	*M. l.*	*S. m.*	*C. lu.*	*M. v.*	*U. a. s.*	*S. c.*	*M. a.*	*M. e. c.*	*T. h.*	*G. s. 1*	*U. ar.*	*E. d.*	*U. a. c.*	*A. a.*	*M. e. q.*	*O. z.*	*G. g*	*S. b.*	*C. g. 1.*	*M. o.*	*G. s. 2.*	*M. c.*	*M. p.*	*C. r.*	*C. g. 2.*	*P. k. g.*	*M. e. b.*	*C. la.*	*Z. h.*
1. Mitkof	19	1.00	547.1	X	X	X	X	X	X	X	X	X	X	X		X	X		X		X	X				X		X				X	
2. Revillagigedo	19	2.00	3024.2	X	X	X		X	X	X	X	X	X	X			X	X	X		X	X	X	X		X							X
3. Wrangell	17	1.00	569.0	X	X	X	X	X	X	X	X	X	X	X			X		X			X	X			X				X			
4. Etolin	16	2.00	889.3	X	X	X	X	X	X	X	X	X	X	X			X	X	X							X				X			
5. Kupreanof	16	2.00	2822.0	X	X	X	X	X	X	X	X	X	X	X			X		X		X	X	X										
6. Kuiu	14	3.00	1933.1	X	X	X	X	X	X	X	X	X		X					X		X	X				X							
7. Prince of Wales	11	6.25	5777.5	X	X	X	X	X	X	X					X			X	X	X													
8. Admiralty	10	5.00	4309.7	X	X	X	X		X							X					X					X	X			X			
9. Gravina	10	3.00	232.9	X				X			X	X		X				X					X		X						X			
10. Dall	9	7.25	658.2	X	X	X	X	X	X	X					X					X													
11. Zarembo	9	5.00	472.3	X	X	X	X	X	X	X				X						X													
12. Kosciusko	9	7.25	482.2	X	X	X	X	X		X		X			X			X															
13. Chicagof	8	5.00	5448.9	X	X	X			X		X		X			X									X									
14. Suemez	8	7.25	153.1	X	X	X	X	X		X					X					X													
15. Tuxekan	7	6.50	85.2	X	X	X	X	X		X					X																			
16. Heceta	7	8.75	189.0	X	X		X	X		X					X					X													
17. Baranof	7	6.00	4162.6	X	X				X		X		X			X									X									
18. Douglas	7	1.00	202.6	X							X			X			X	X						X				X						
19. Kruzof	7	7.00	446.5	X	X				X		X	X	X			X																		
20. Anguilla	5	9.00	12.1	X	X	X	X		X																									
21. Coronation	5	10.50	91.1	X	X	X	X		X																									
22. Warren	5	10.50	50.6	X	X	X	X	X																										
23. Baker	4	12.75	135.0	X	X		X	X																										
24. Duke	4	5.00	155.3	X	X		X	X																										
25. Forrester	4	33.75	10.1	X	X	X	X																											
Occurrence				---	-0.403	**-2.072**	-0.684	-0.469	**-2.988**	**-1.972**	**-3.170**	**-2.908**	**-2.728**	**-3.592**	-1.474	-0.958	**-3.332**	-1.570	**-3.748**	-0.616	**-3.044**	**-3.318**	**-2.389**	-1.362	-0.211	**-3.098**	-1.311	-1.765	-0.279	-1.866	-0.279	-0.838	-1.606	-1.61
Distance				---	-0.252	**-2.432**	-0.239	-1.580	-1.923	**-2.377**	**-2.722**	**-3.583**	**-2.721**	**-2.503**	-0.192	-0.717	**-2.621**	-1.726	**-3.283**	-0.751	**-2.150**	**-2.969**	**-2.197**	-0.302	-0.420	**-2.830**	-0.453	-1.006	-0.697	-1.912	-0.348	-0.139	-1.533	-1.12
Area				---	-0.100	**-2.300**	-0.204	-0.990	**-2.441**	**-2.393**	-1.095	-1.076	-0.757	**-2.038**	-0.573	-0.136	-1.654	-1.336	**-2.481**	-1.834	**-2.378**	-1.766	-1.334	-0.902	-0.251	-1.334	-1.803	-1.402	-0.139	-0.801	-0.000	-1.664	-0.277	-1.11

Results

Table 1 Results from linear regressions between variables. Boldface values are significant at $P<0.05$.

Variables	R^2	Adj R^2	Slope	SE Model
Log isolation *v.* log richness	**0.601**	0.583	-0.438	0.136
Log area *v.* log richness	**0.438**	0.414	0.181	0.162
Log isolation *v.* log area	**0.226**	0.193	-0.983	0.693

Results

O. h.	*P. k. u.*	*M. l.*	*S. m.*	*C. lu.*	*M. v.*	*U. a. s.*	*S. c.*	*M. a.*	*M. e. c.*	*T. h.*	*G. s. 1*	*U. ar.*	*E. d.*	*U. a. c.*	*A. a.*	*M. e. q.*	*O. z.*	*G. g*	*S. b.*	*C. g. l.*	*M. o.*	*G. s. 2.*	*M. c.*	*M*
---	-0.403	**-2.072**	-0.684	-0.469	**-2.988**	**-1.972**	**-3.170**	**-2.908**	**-2.728**	**-3.592**	-1.474	-0.958	**-3.332**	-1.570	**-3.748**	-0.616	**-3.044**	**-3.318**	**-2.389**	-1.362	-0.211	**-3.098**	-1.311	-1.
---	-0.252	**-2.432**	-0.239	-1.580	-1.923	**-2.377**	**-2.722**	**-3.583**	**-2.721**	**-2.503**	-0.192	-0.717	**-2.621**	-1.726	**-3.283**	-0.751	**-2.150**	**-2.969**	**-2.197**	-0.302	-0.420	**-2.830**	-0.453	-1.
---	-0.100	**-2.300**	-0.204	-0.990	**-2.441**	**-2.393**	-1.095	-1.076	-0.757	**-2.038**	-0.573	-0.136	-1.654	-1.336	**-2.481**	-1.834	**-2.378**	-1.766	-1.334	-0.902	-0.251	-1.334	-1.803	-1.

- ✓**Endemics are not nested for either area or isolation**
- ✓**Known colonizers are nested by isolation**
- ✓**Only one species is nested by area alone (*M. vison*)**

Conclusions

- **Genetic data allow us to tease apart independent histories.**
- **Species-level analyses may not adequately reflect diversity across the Alexander Archipelago.**

- **Question: How can we use lineages (and evolutionary divergence) within southeast Alaska to identify areas of highest conservation concern?**