Island Biogeography and Nutrient Subsidies

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earth to ocean

SFU

Outline

- About me
- Island biogeography review
- Nutrient subsidies
  - What are they?
  - Examples
- My thesis work

About me

Calgary

About me

NORTHWEST TERRITORIES

Canada

MANITOBA

ALBERTA

SASKATCHEWAN

Calgary

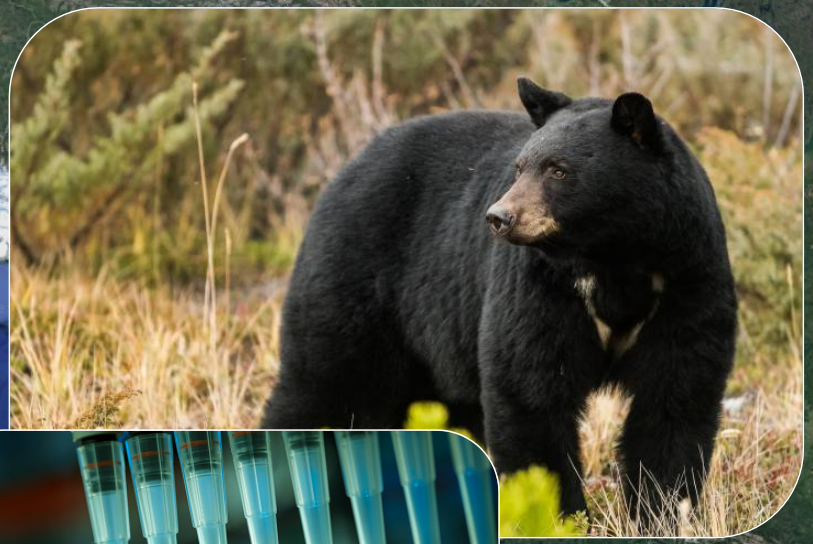
Victoria

MONTANA

WASHINGTON

WYOMING

About me



Calgary

Nelson

Victoria

Gulf of Alaska

NORTHWEST TERRITORIES

Canada MANITOBA

SASKATCHEWAN

MONTANA

WASHINGTON

WYOMING

About me

Central Coast, BC

Victoria

Why study islands?

- Small, simple
- Visibly discrete boundaries
  - "a unit the mind can pick out and understand"
- Natural replication
- Unique characteristics

What does this mean for species?

Early Theories

Carolus Linneaus (1776)
"Center of Origin"

Early Theories

- Buffon's Law (1776):

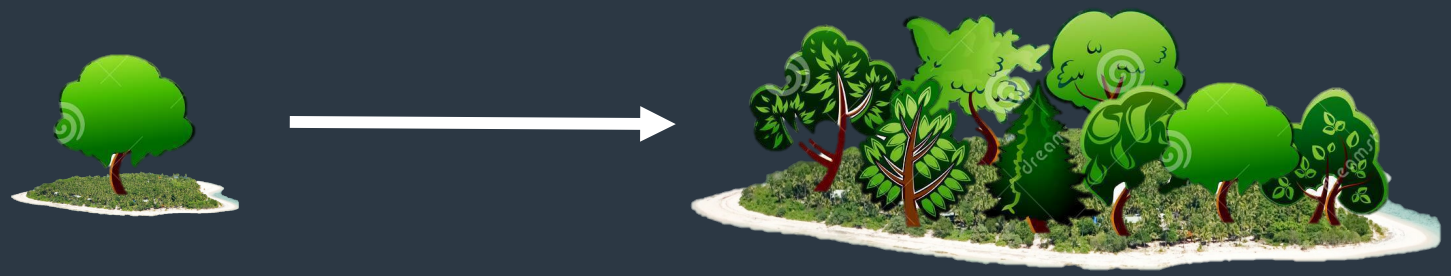
"Environmentally similar but geographically isolated regions are comprised of distinct biotas"

What do you call a species that is unique to a specific geographical location?

ENDEMIC SPECIES

Early Theories

- Johann Reinhold Forster (1778):
  - Isolated biotas generally less diverse than mainland
  - Diversity of plants increases with island area, availability of resources, variety of habitats, and heat energy from the sun



Old theory: Saturation

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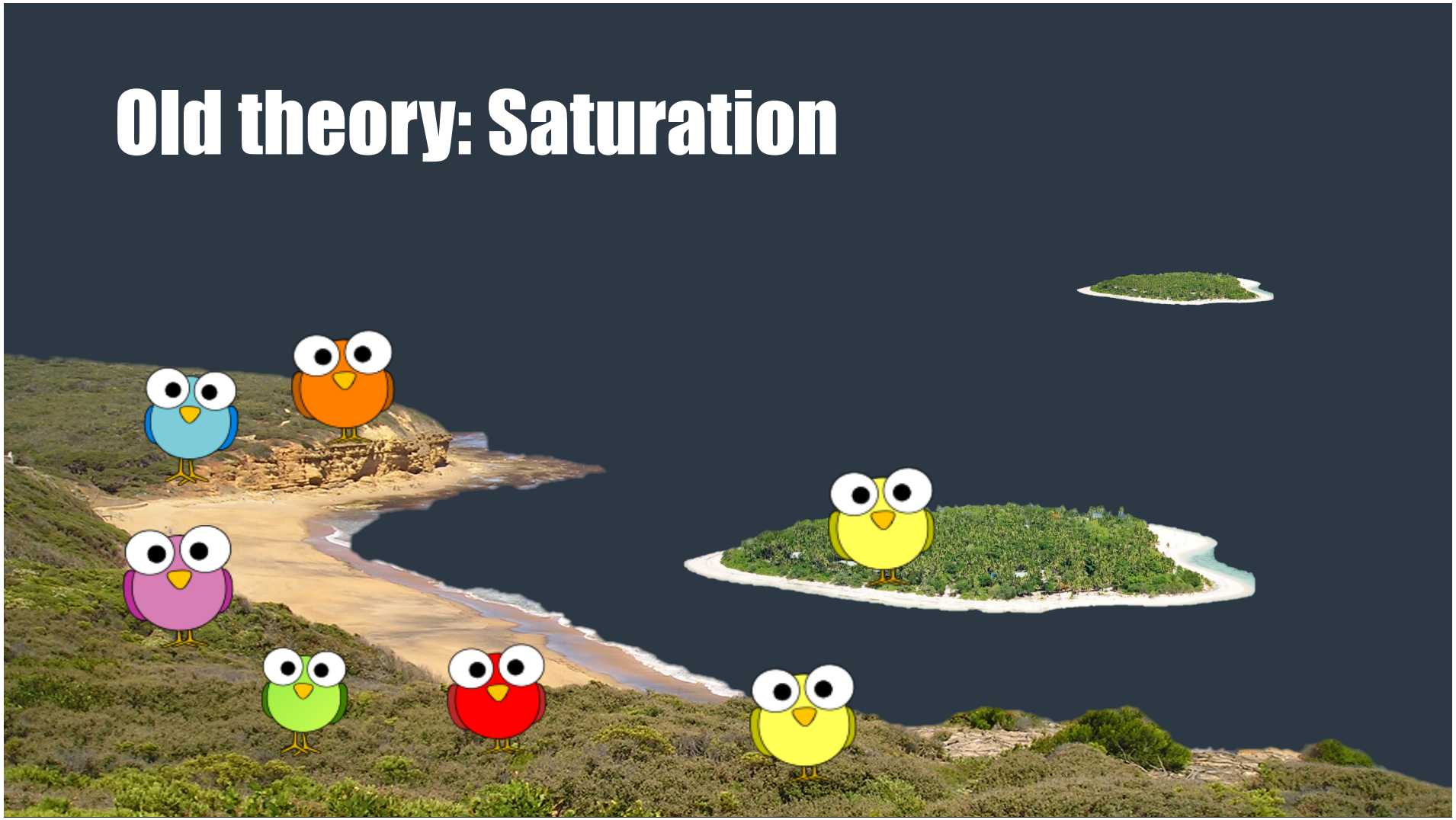

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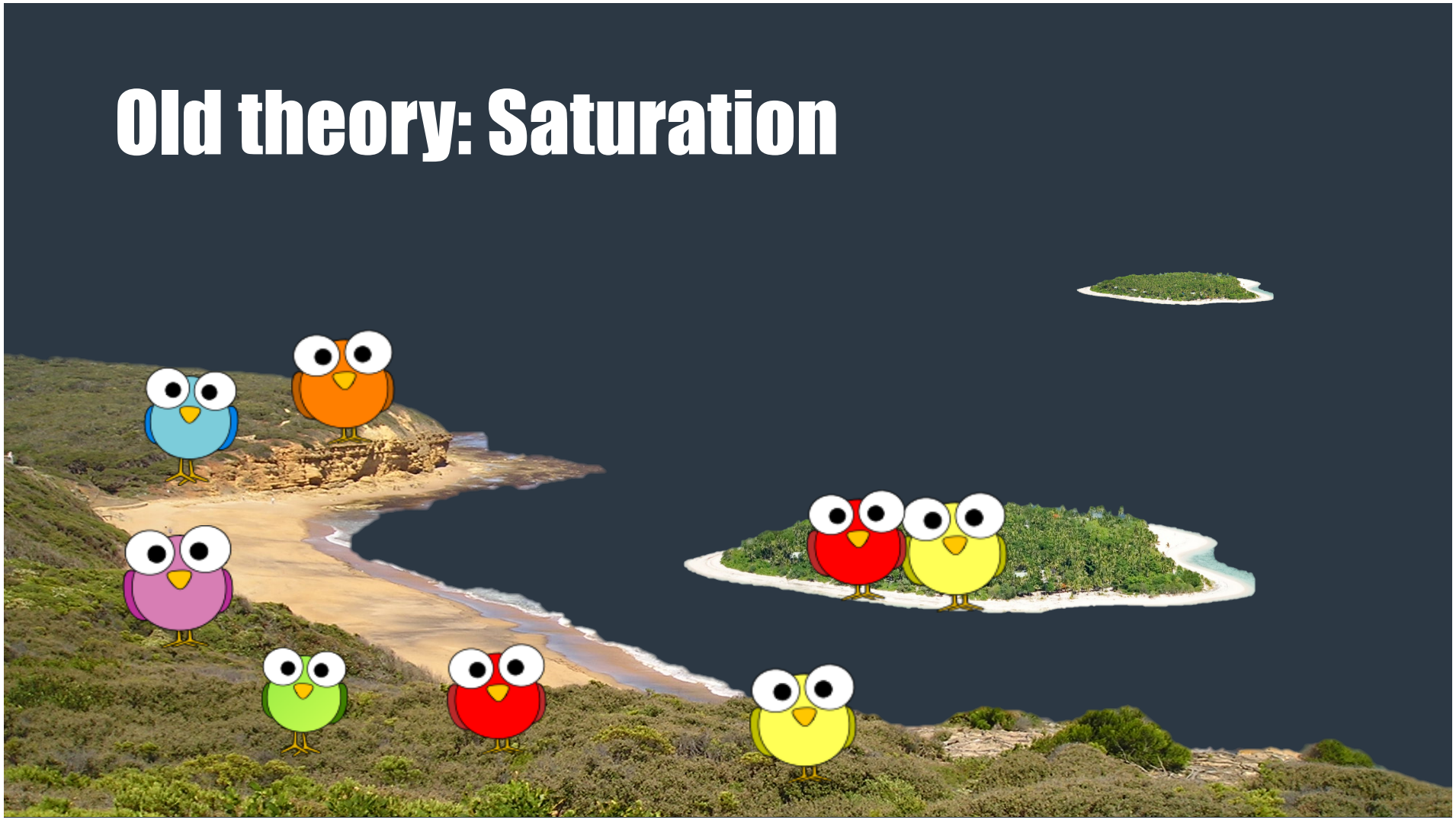

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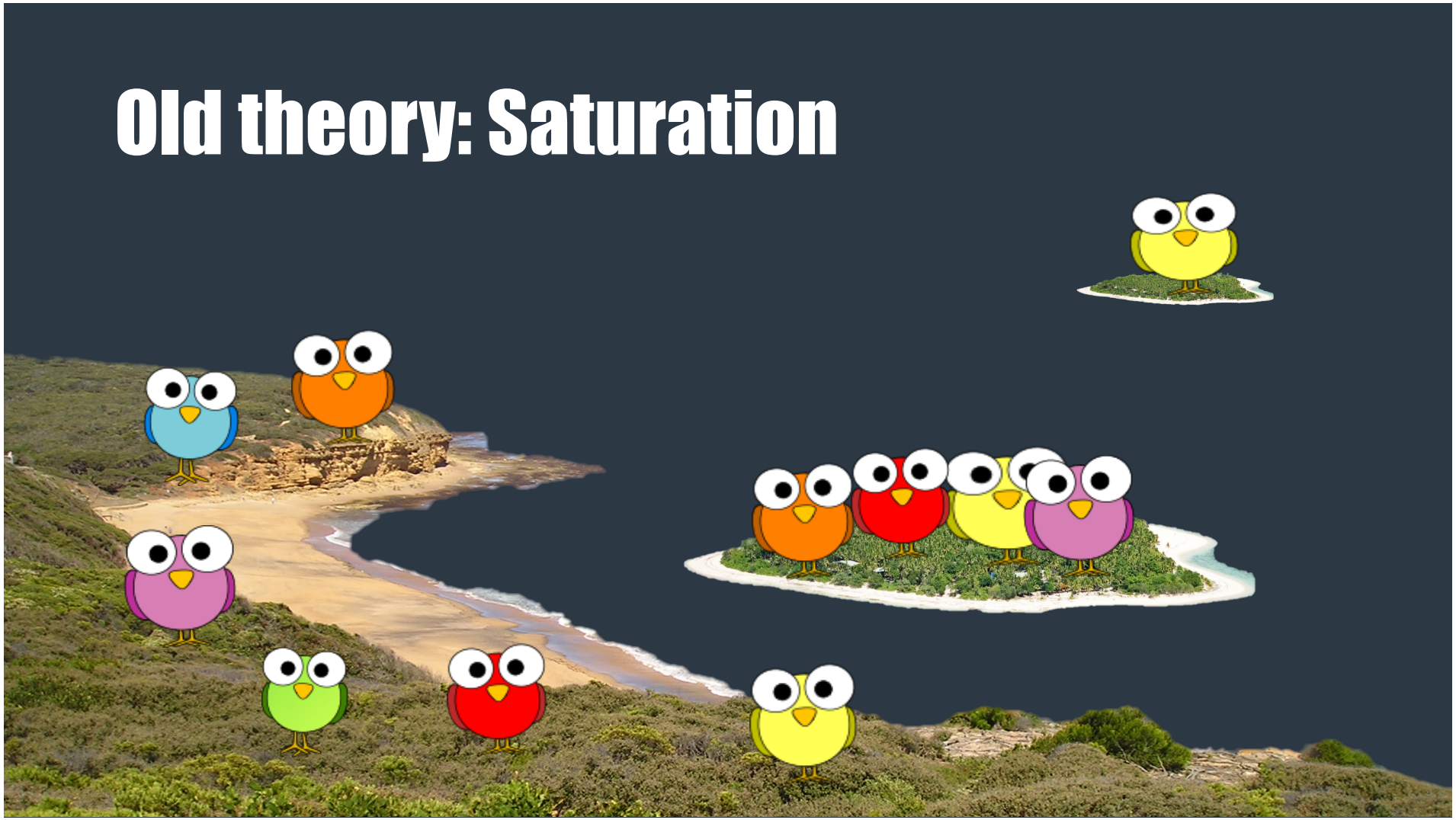
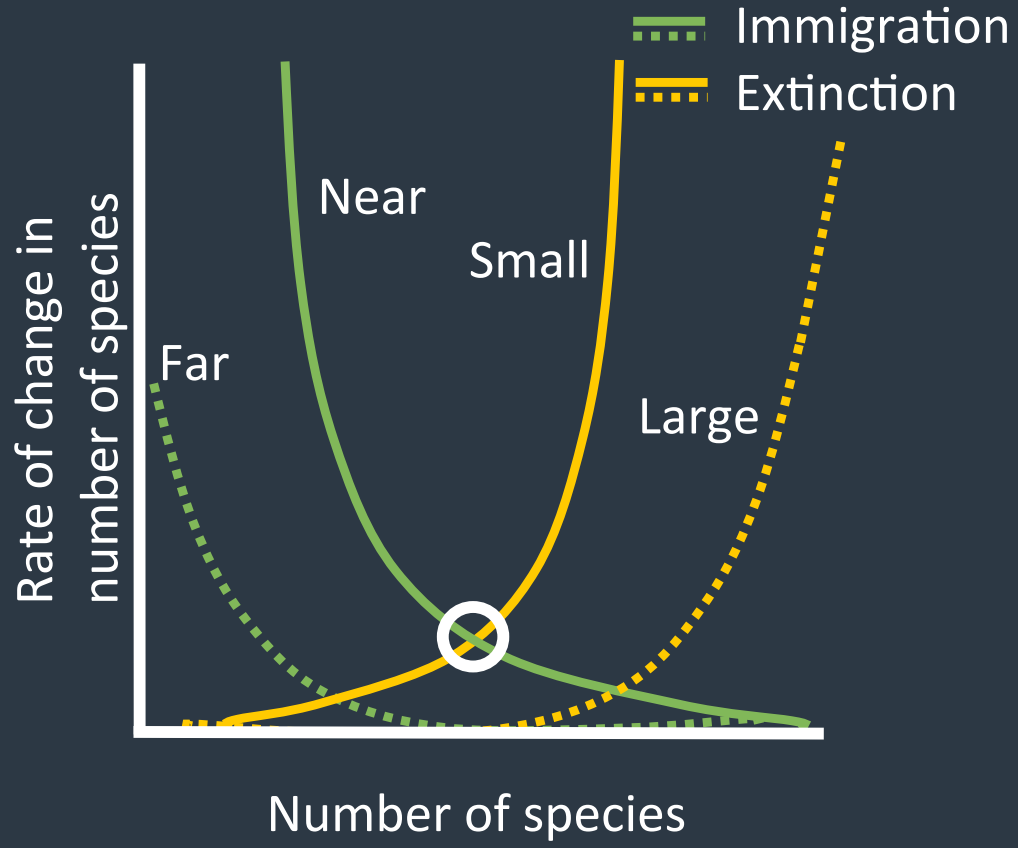


Theory of Island Biogeography

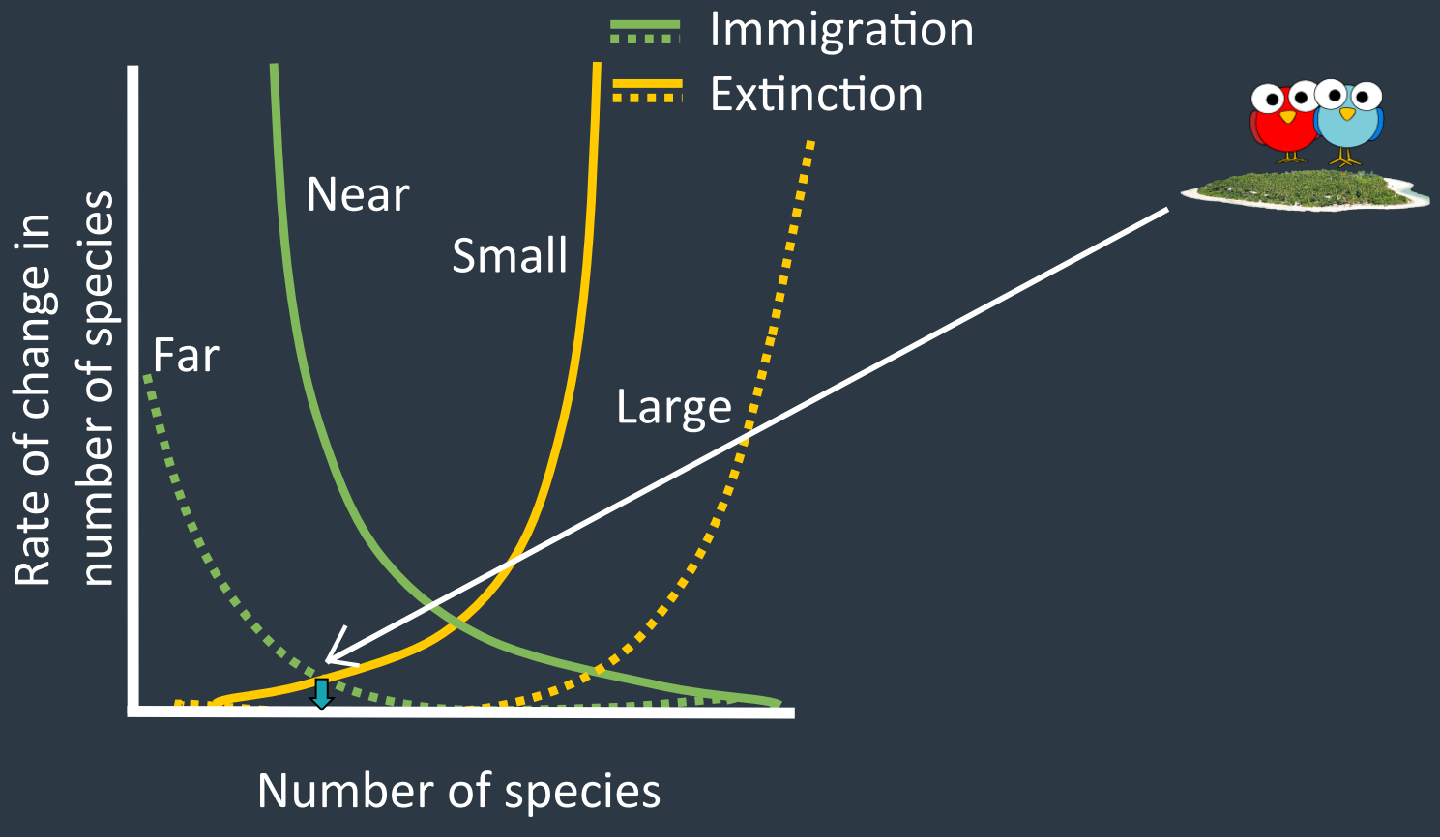


Immigration rate is determined by distance to mainland.

Extinction rate is determined by island size.

Intersection tells you the species richness of the island.

Theory of Island Biogeography



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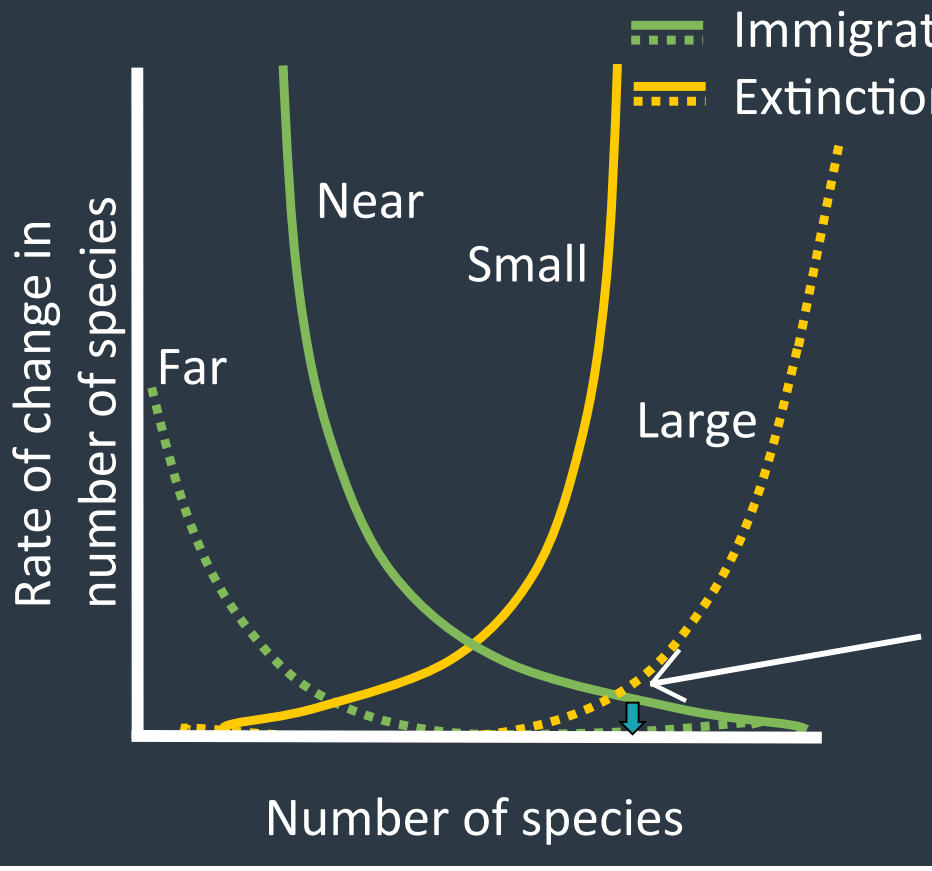

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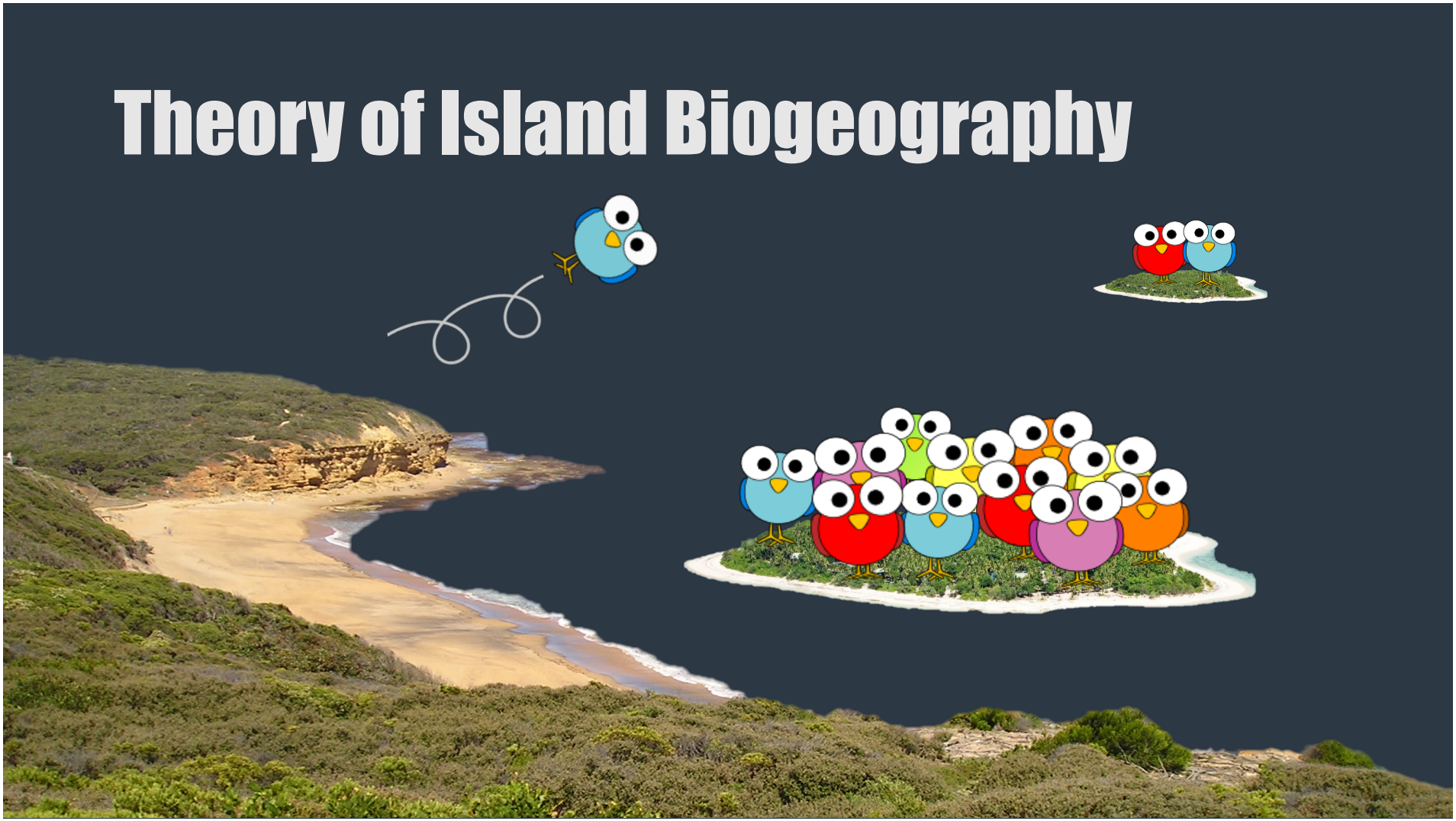
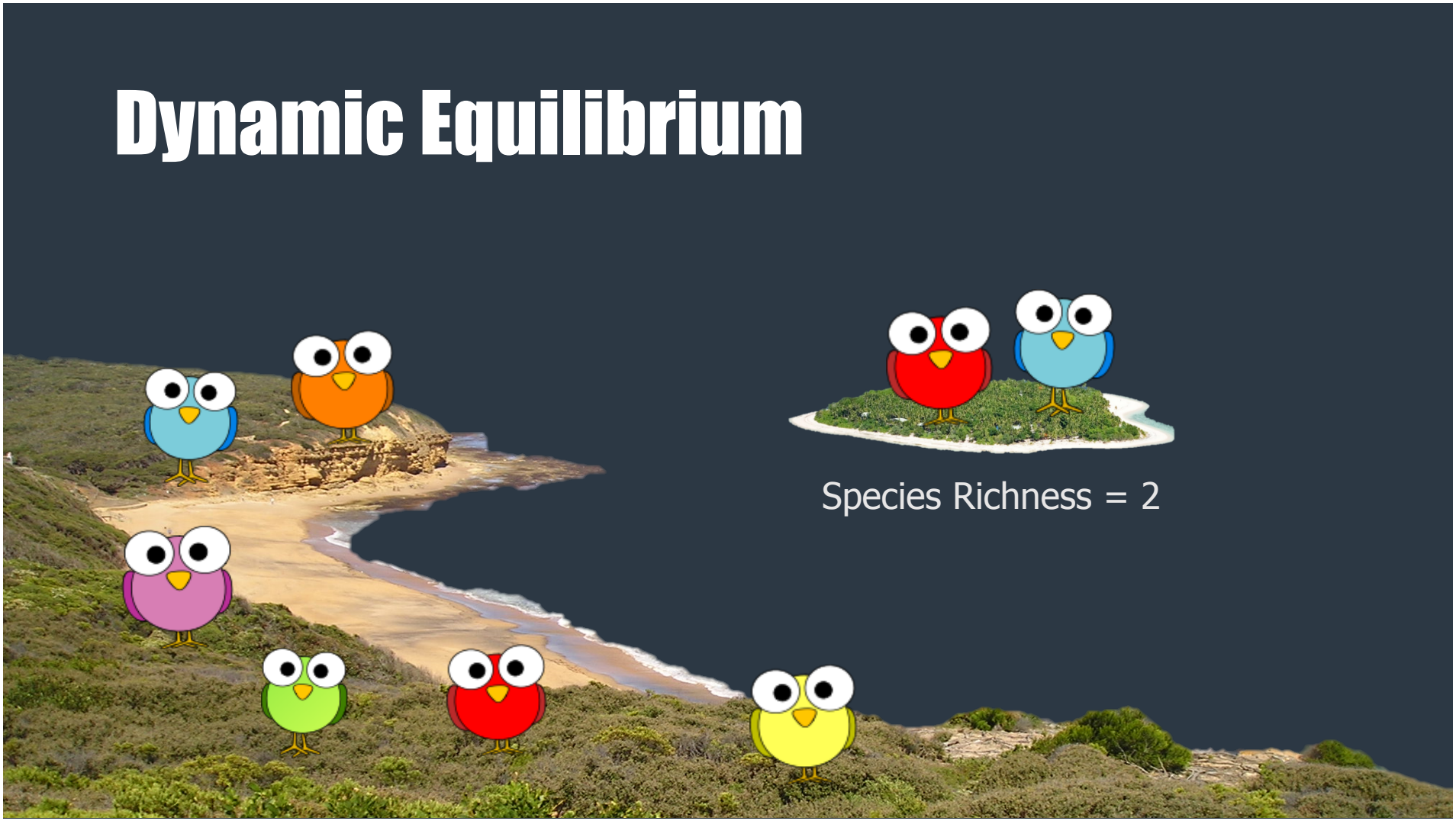


Dynamic Equilibrium



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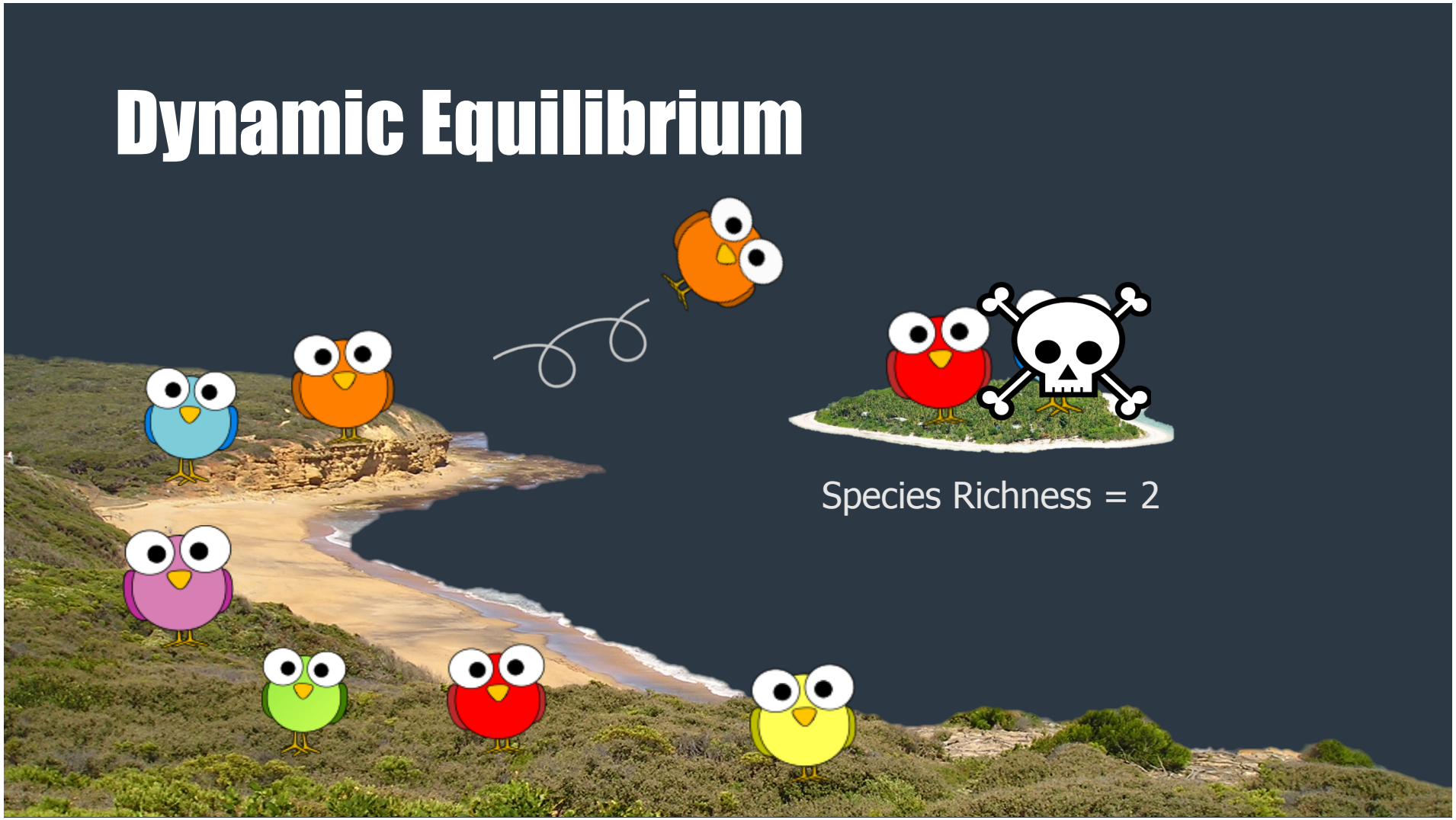

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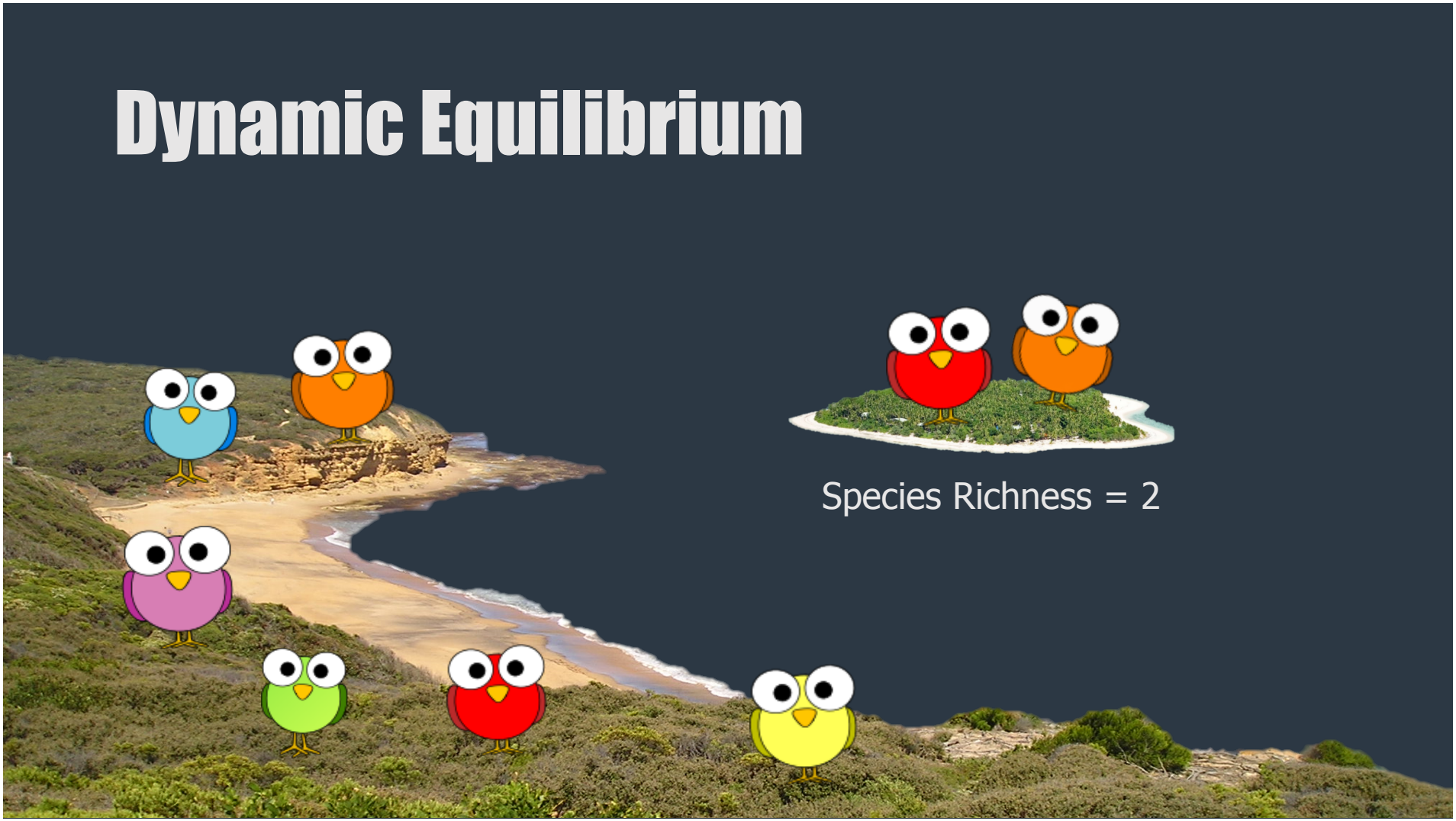

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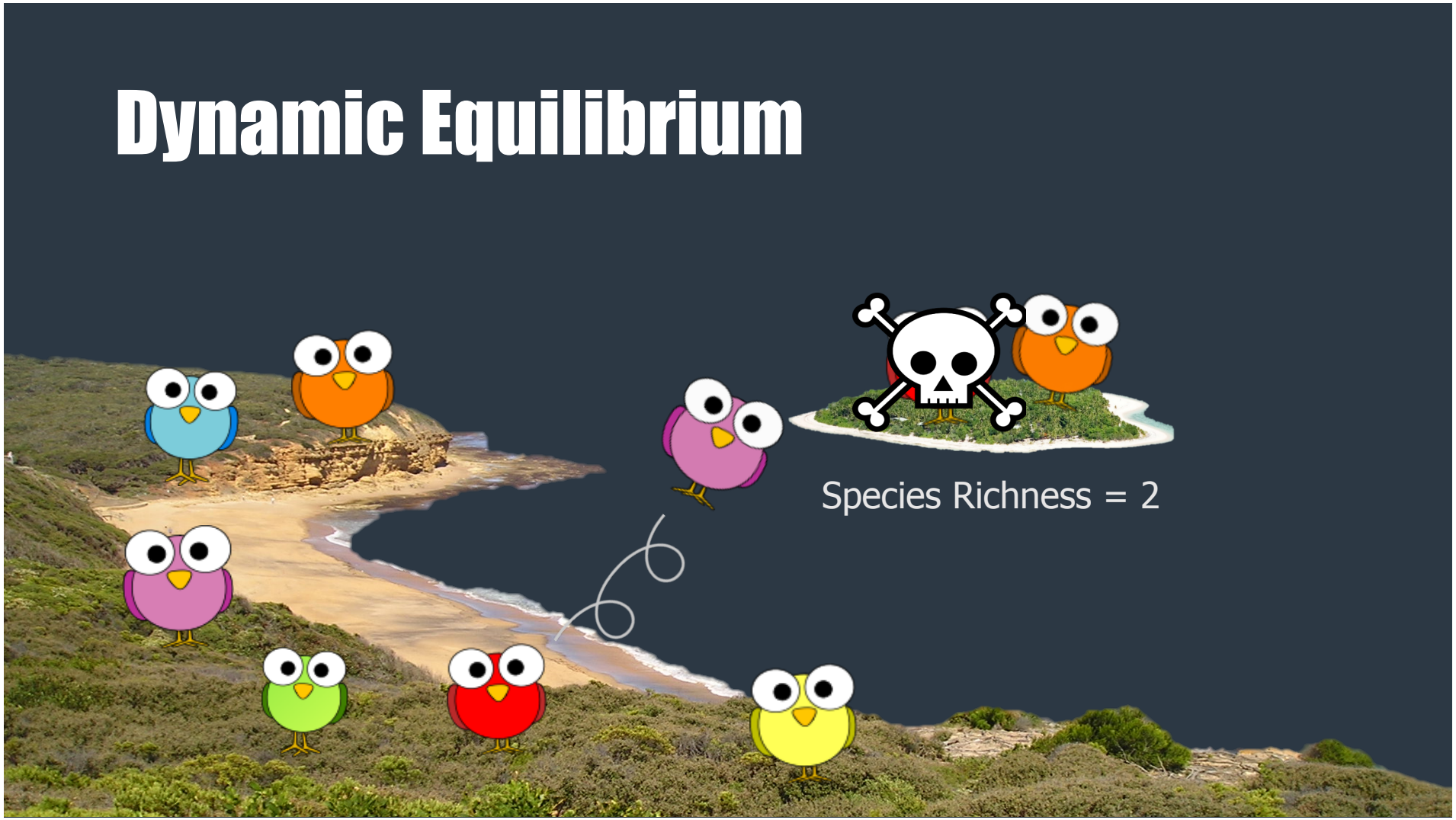

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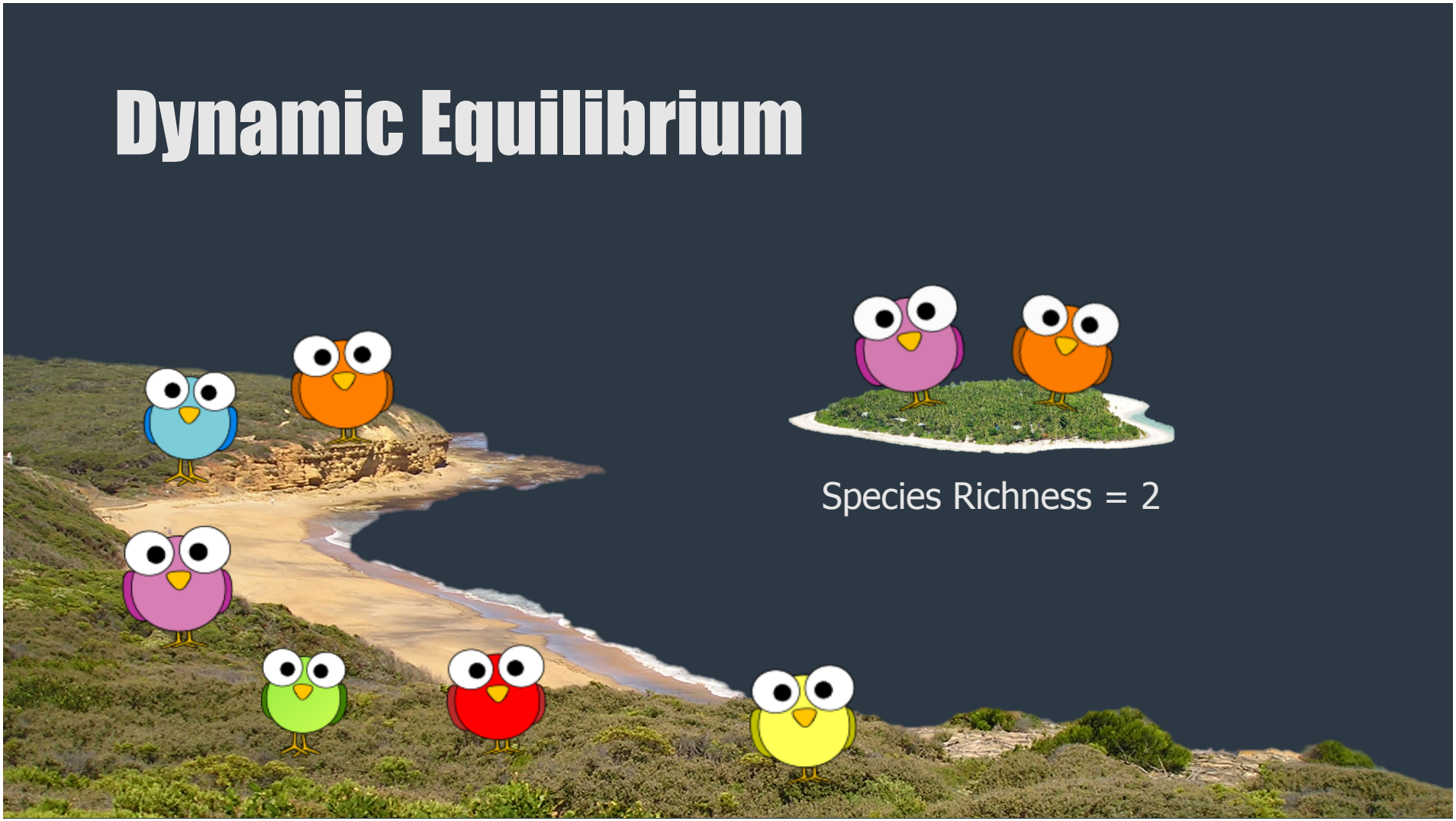

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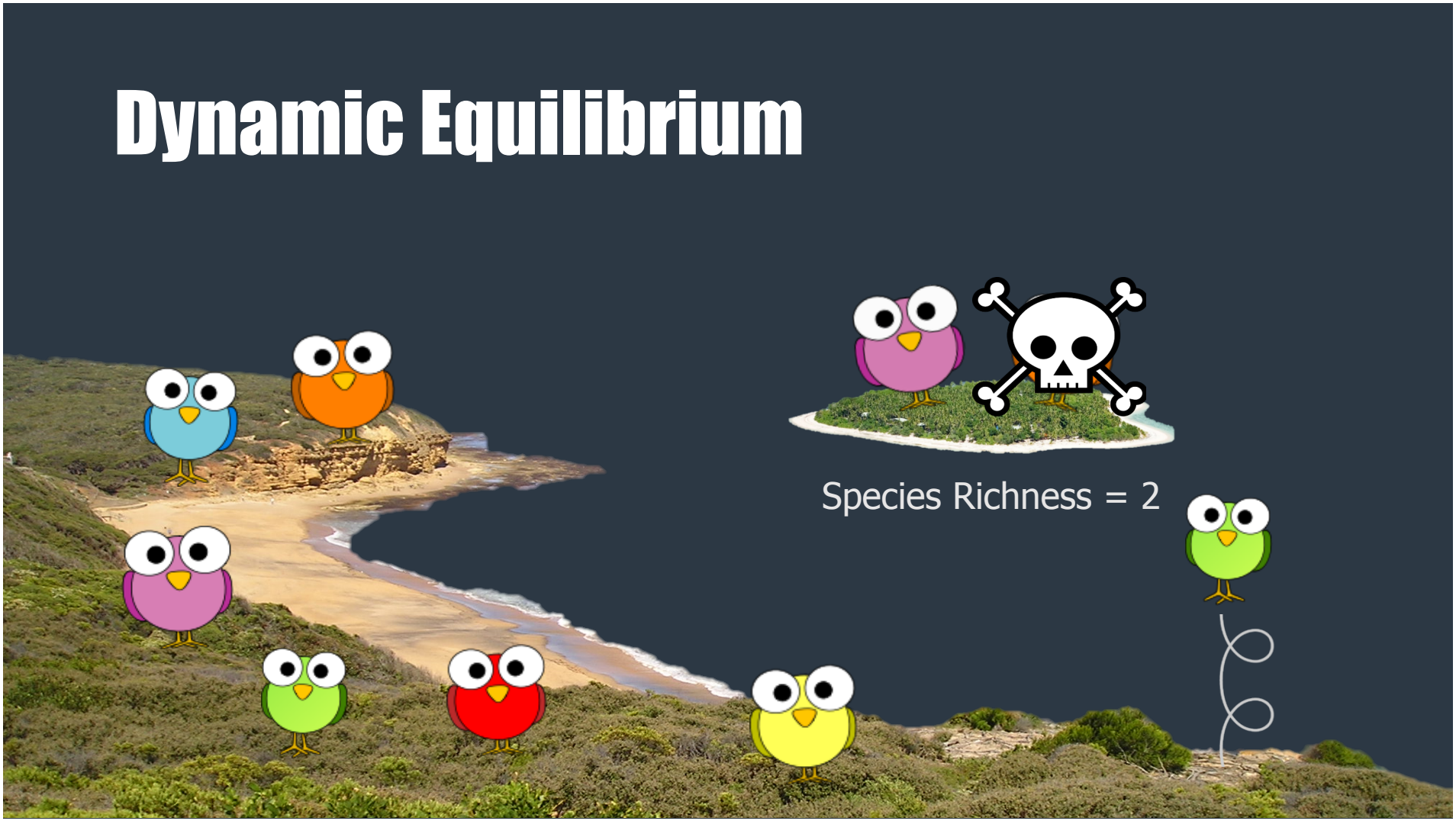

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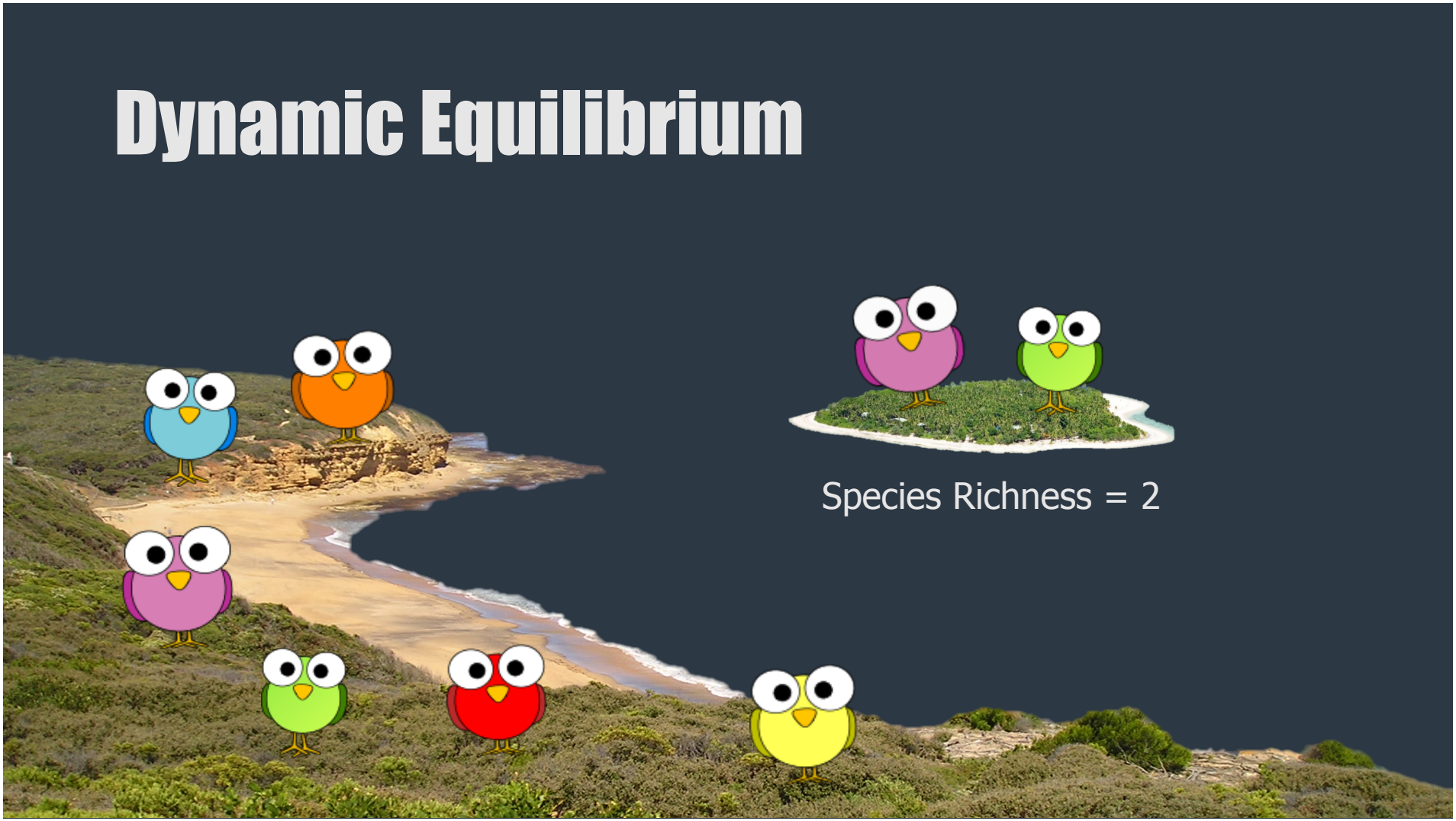


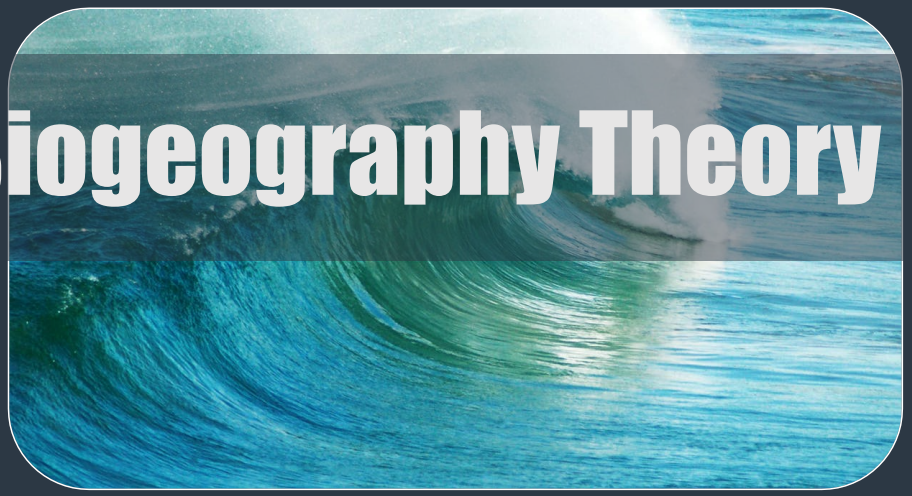
Dynamic Equilibrium

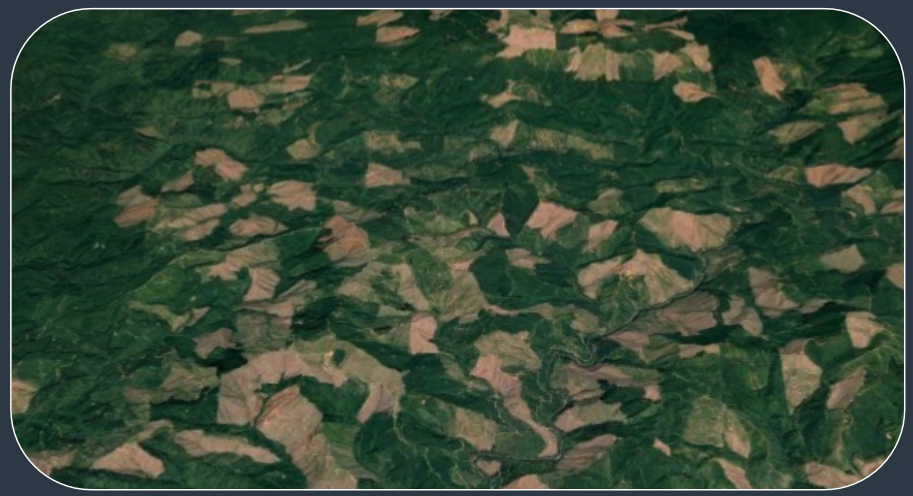
- Equilibrium reached between rate of immigration of new species, and rate of extinction of established species.
  →Determines species richness of island

- There is constant turnover in species present

- Before MacArthur and Wilson, it was thought that species composition was “static”

Additions to Island Biogeography Theory

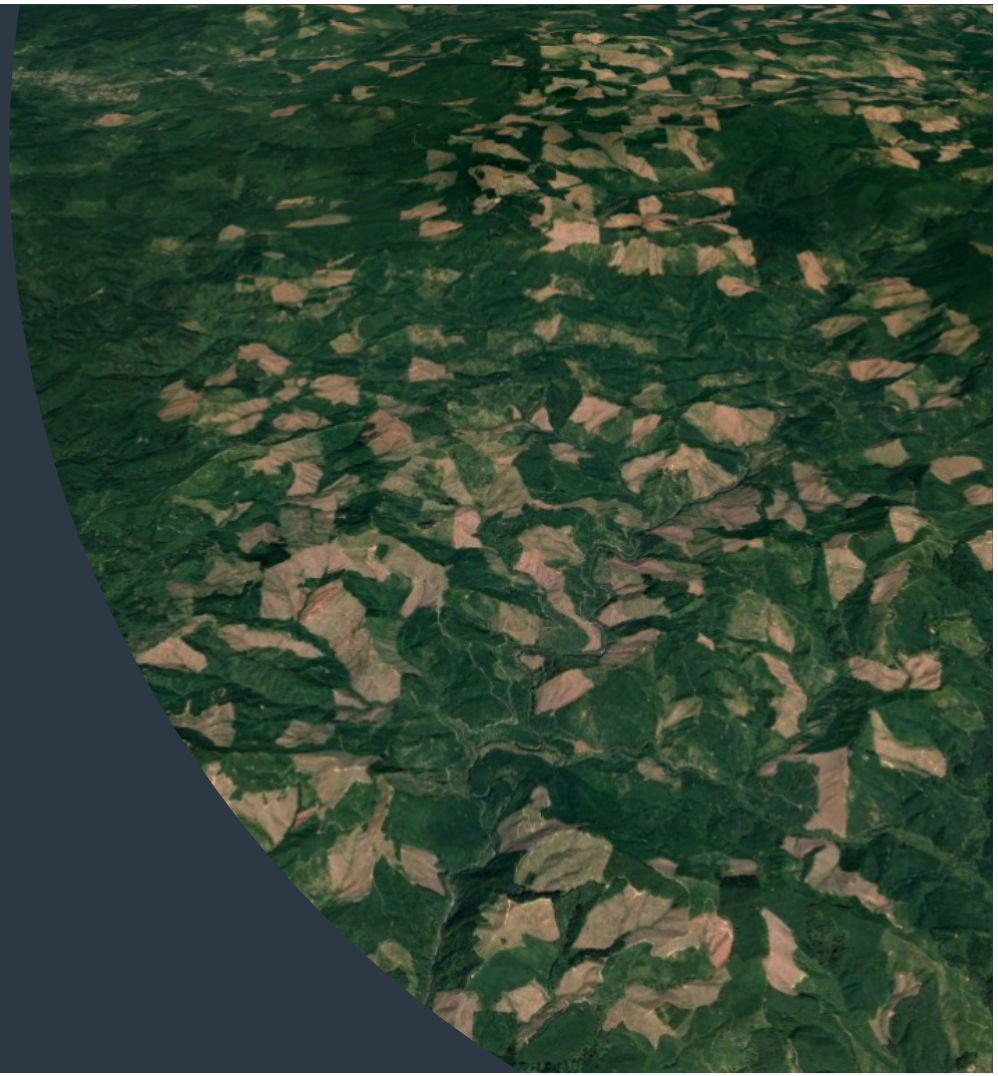


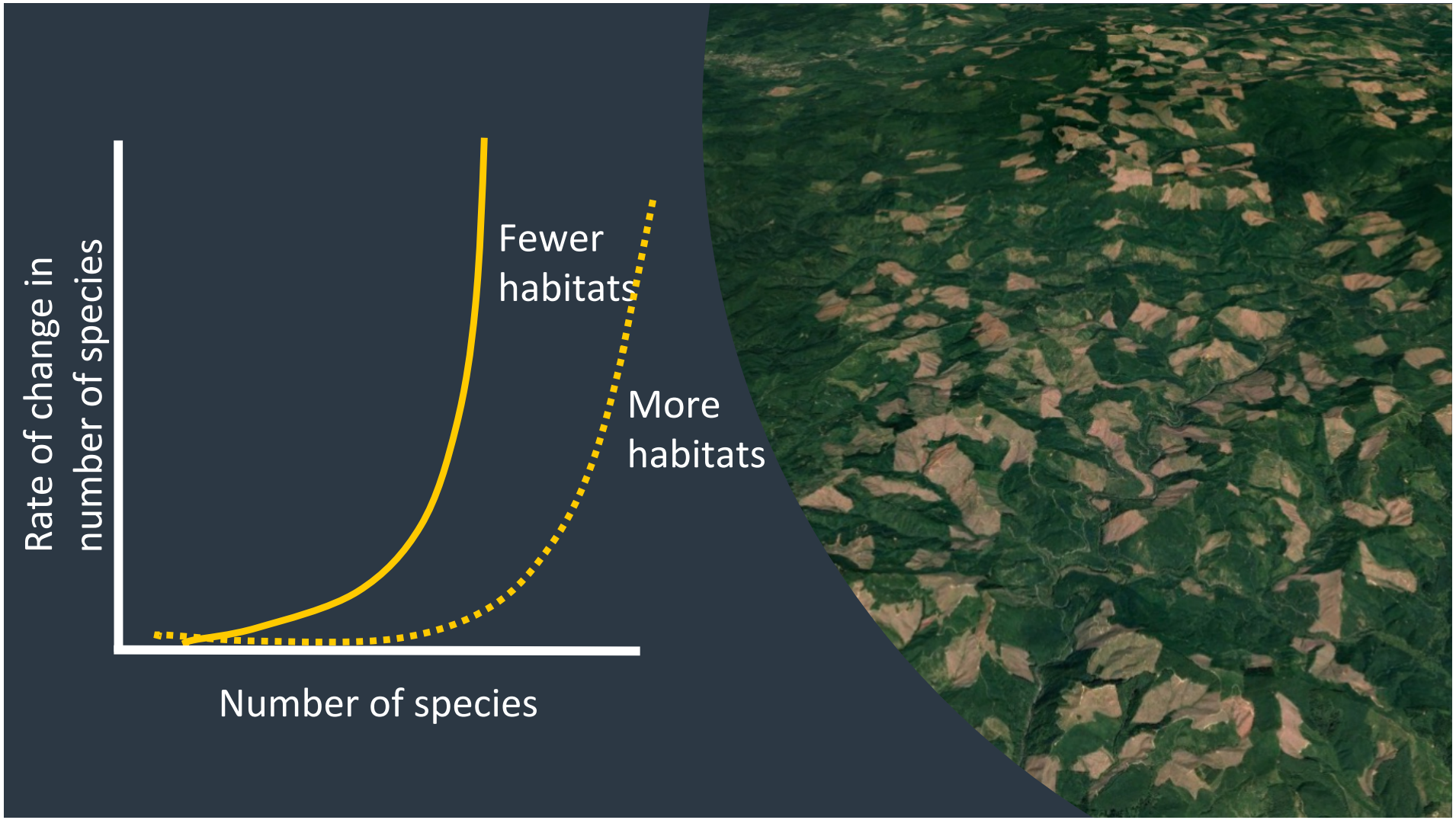


Habitat heterogeneity

The theory:

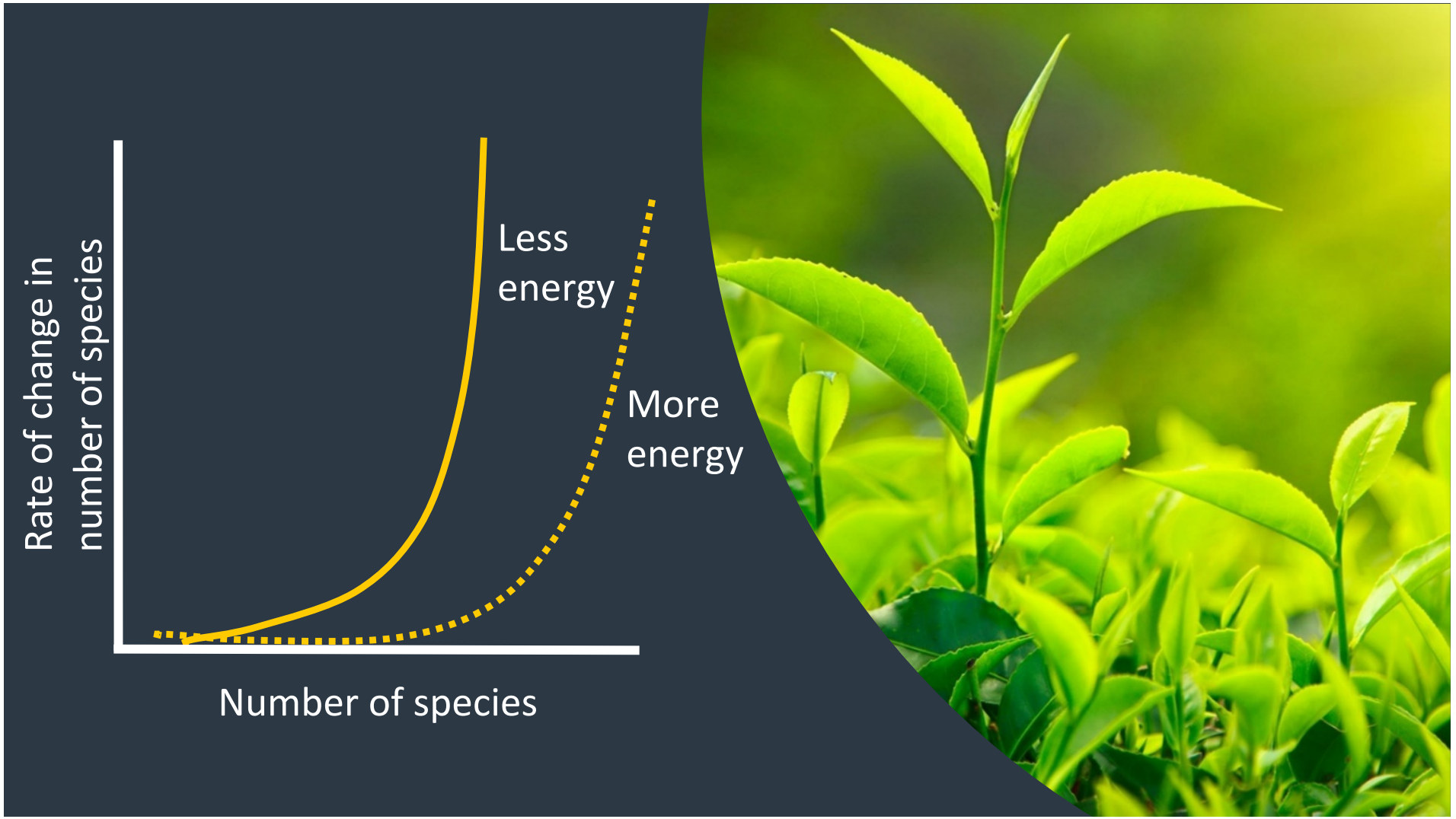
- Larger islands have more species on them because they have more different habitat types on them → more niche spaces to occupy
- Tested to see if area or habitat diversity had a greater effect on islands where area did not correlate with habitat diversity
- Found that it depends on how habitat-specialized taxa are




Rate of change in number of species
Fewer habitats
More habitats
Number of species

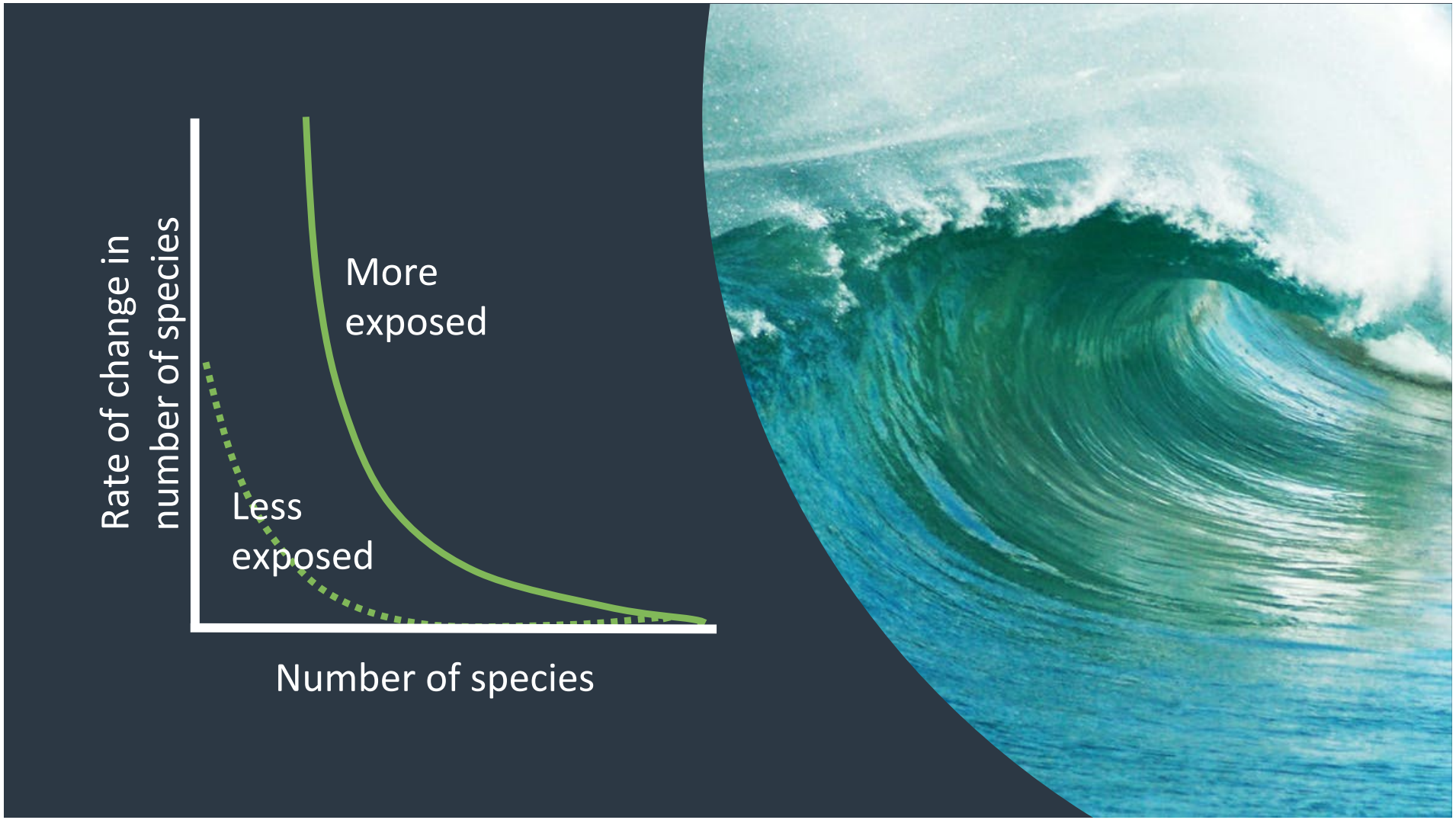
Primary Productivity

- Productivity is:
  - the rate of generation of biomass in an ecosystem.
  - A measure of amount of energy available
- Species-energy theory
  - Wright 1983
    - Instead of area, use availability of relevant resource
    - For plants → incident solar radiation
    - For birds → net primary productivity


Rate of change in number of species
Less energy
More energy
Number of species

Wind & waves

- Affect “isolation” of an island
  - If prevailing winds and currents direct organisms towards at an island, it is effectively less isolated


Rate of change in number of species
More exposed
Less exposed
Number of species

Climate

85 – 90% of global variation in insular species richness explained by:

- area
- average annual temperature
- distance to nearest continent

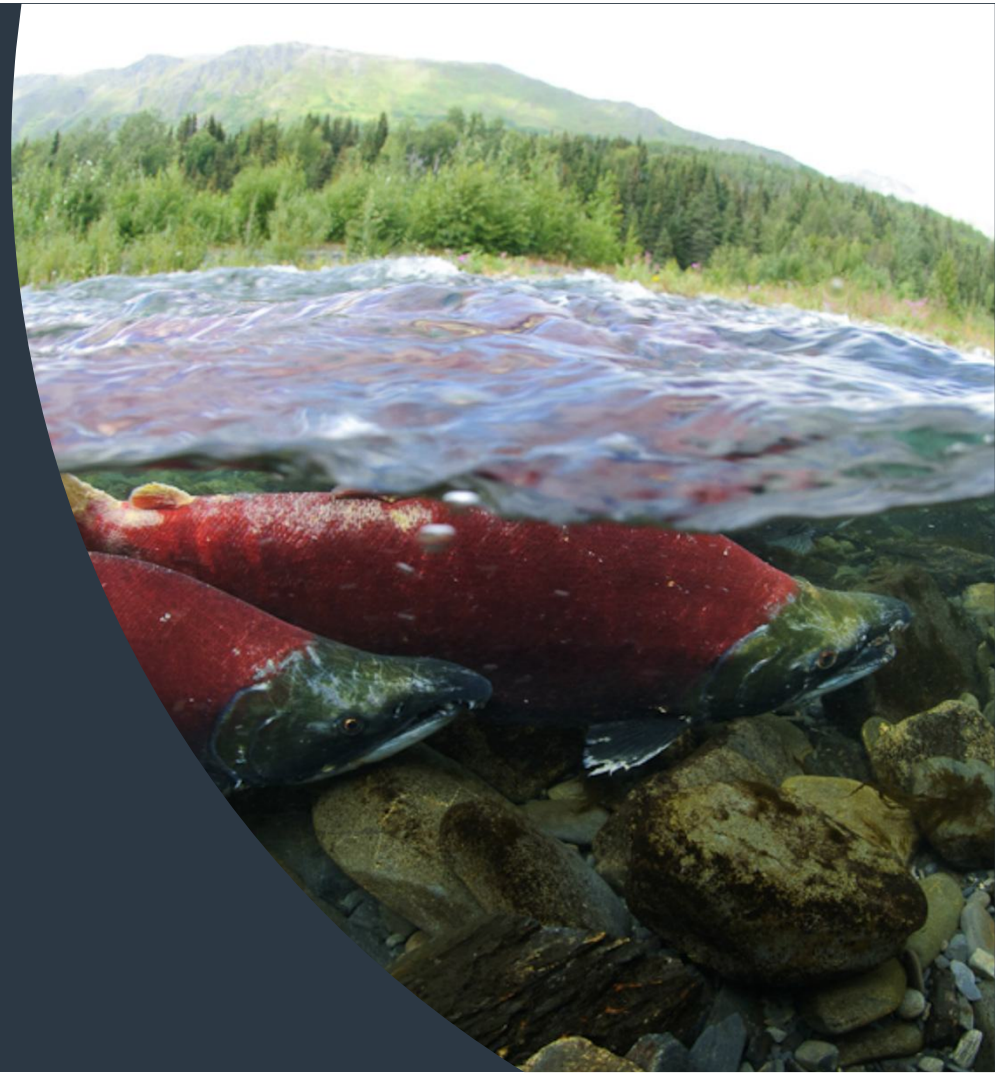
Slope of species-area curve depends on:

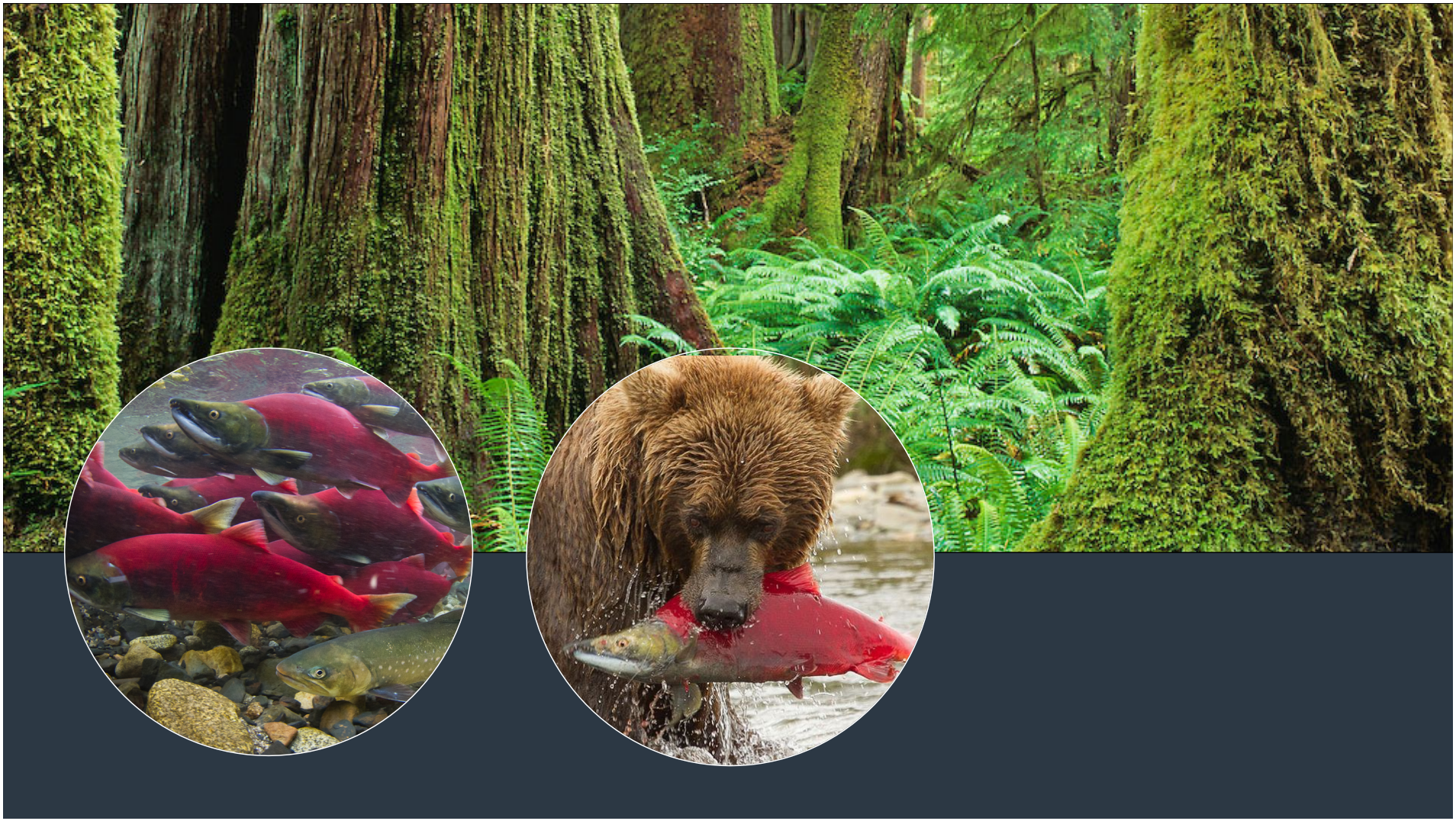
- average annual temperature
- total annual precipitation

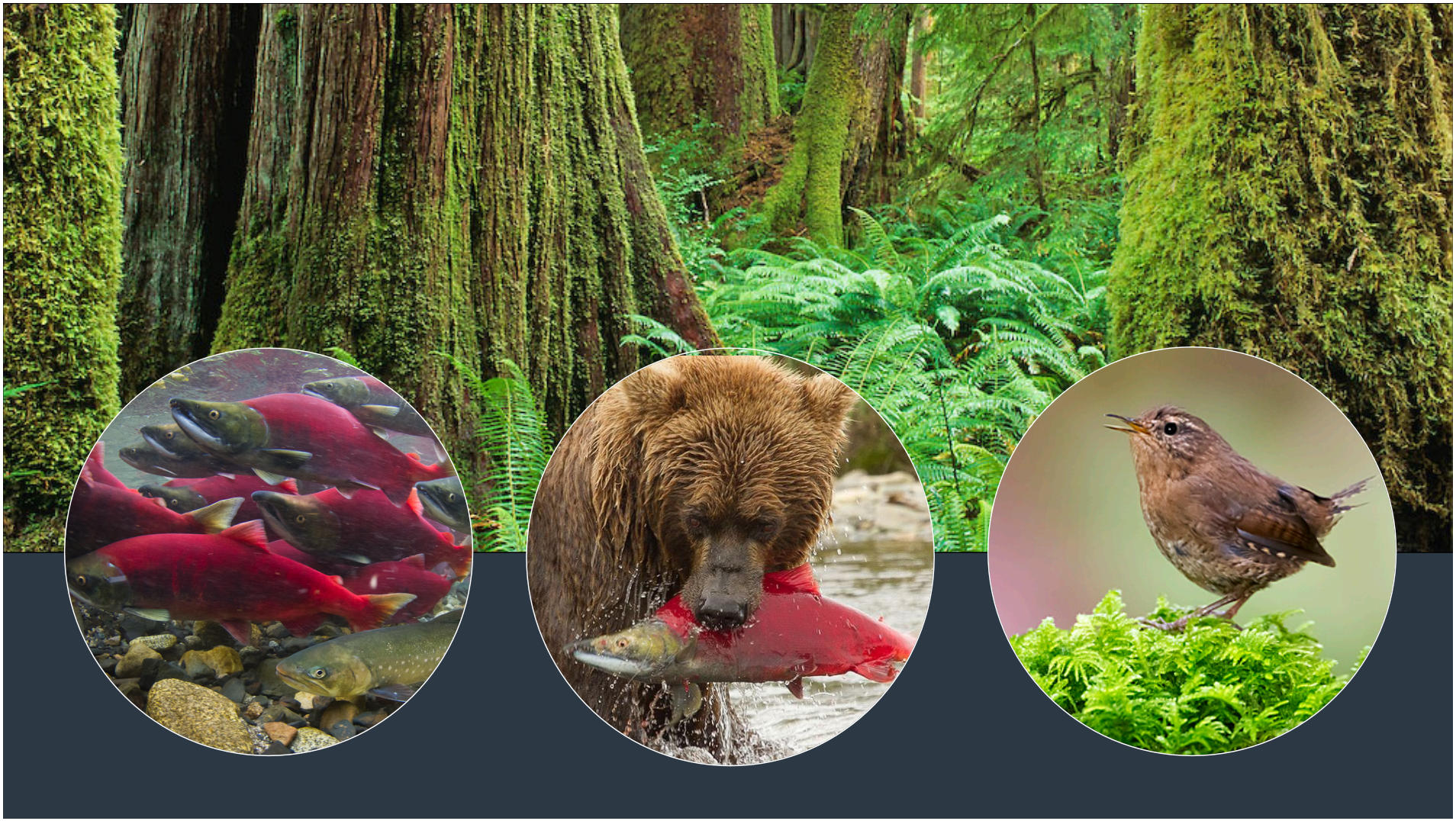
Kalmar & Currie (2006)

Spatial subsidies

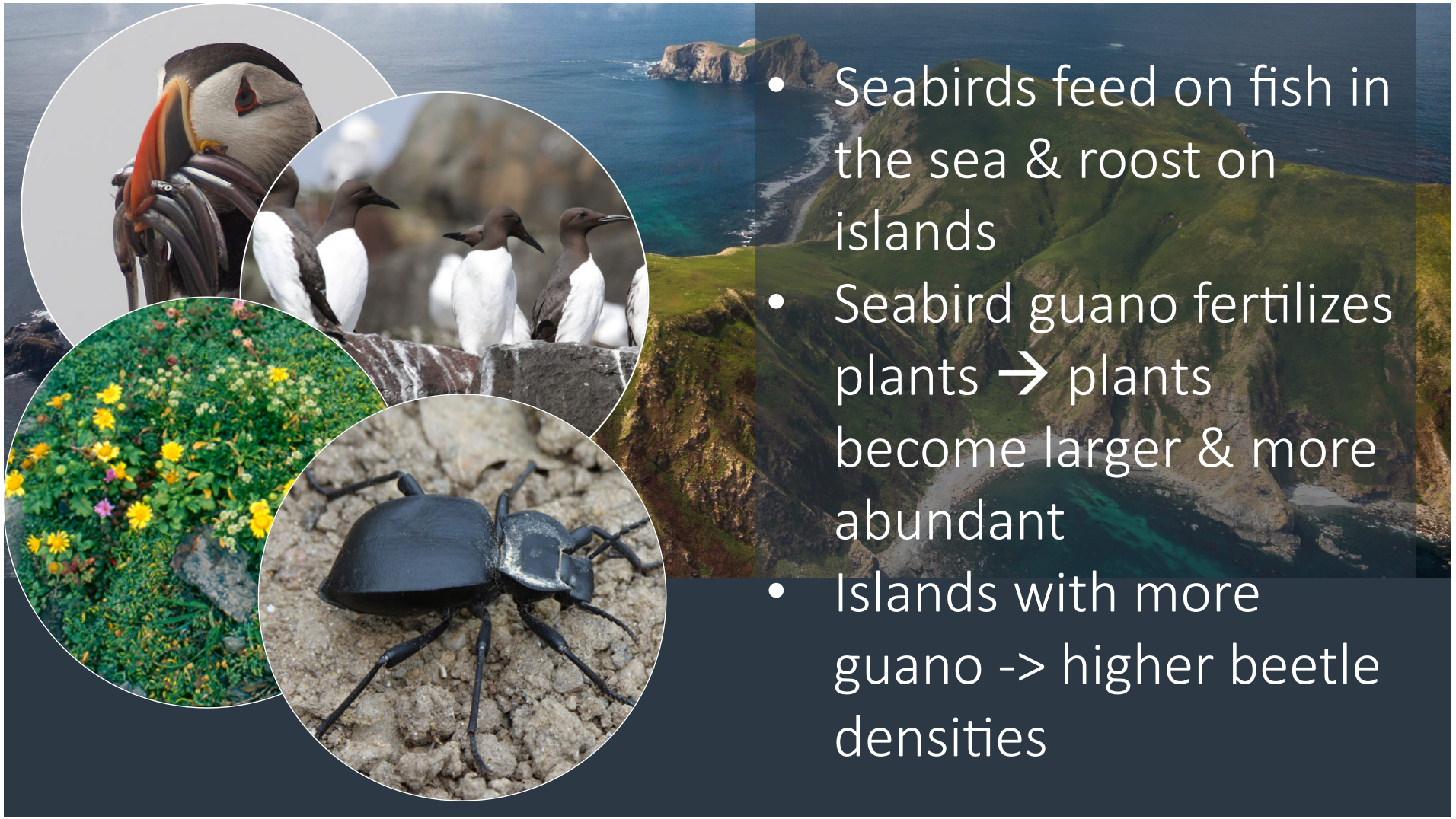
- Resources that pass from one ecosystem to another, increasing **productivity** of the recipient ecosystem
- Can be active or passive
- Organisms, materials, energy



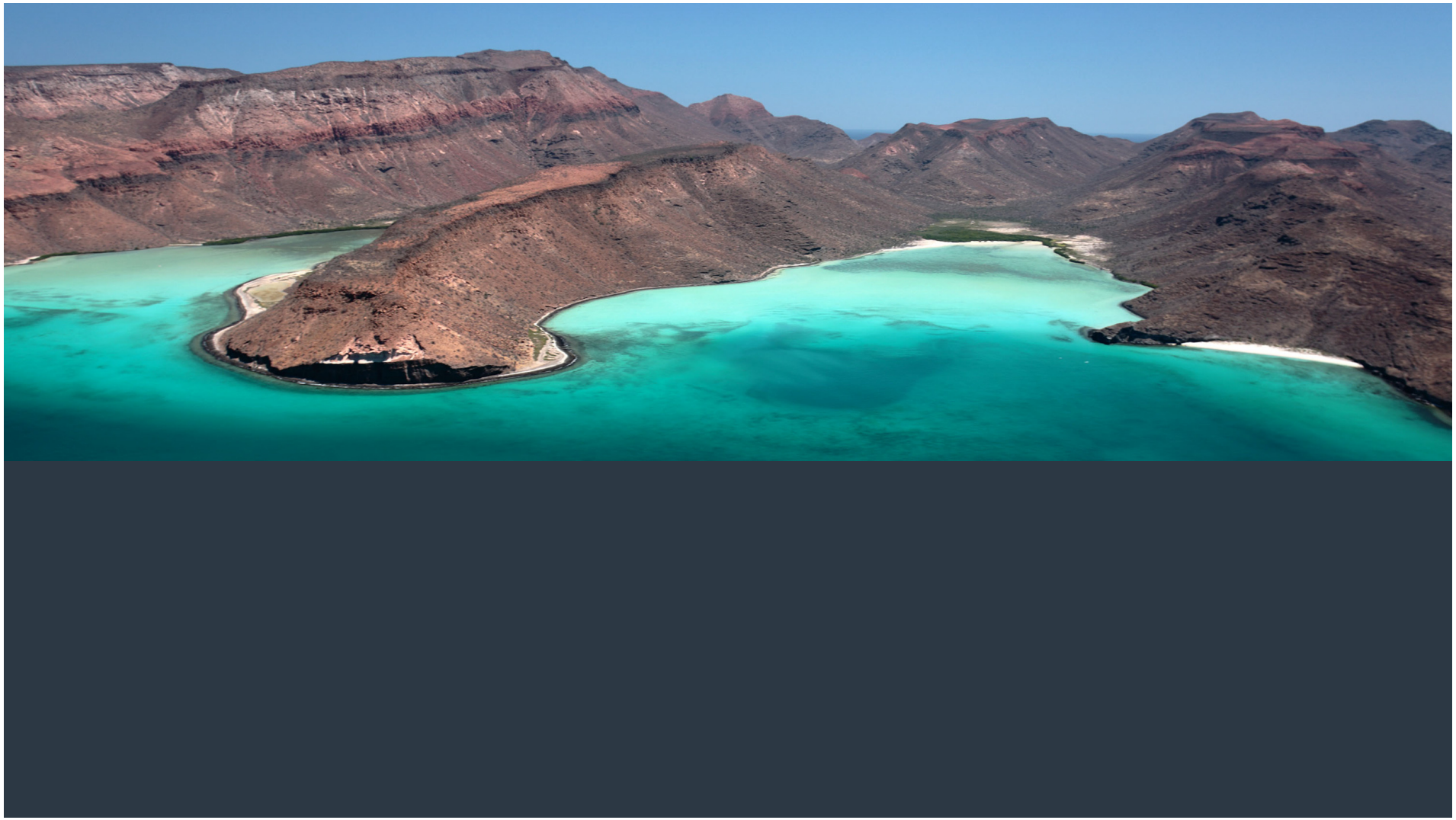


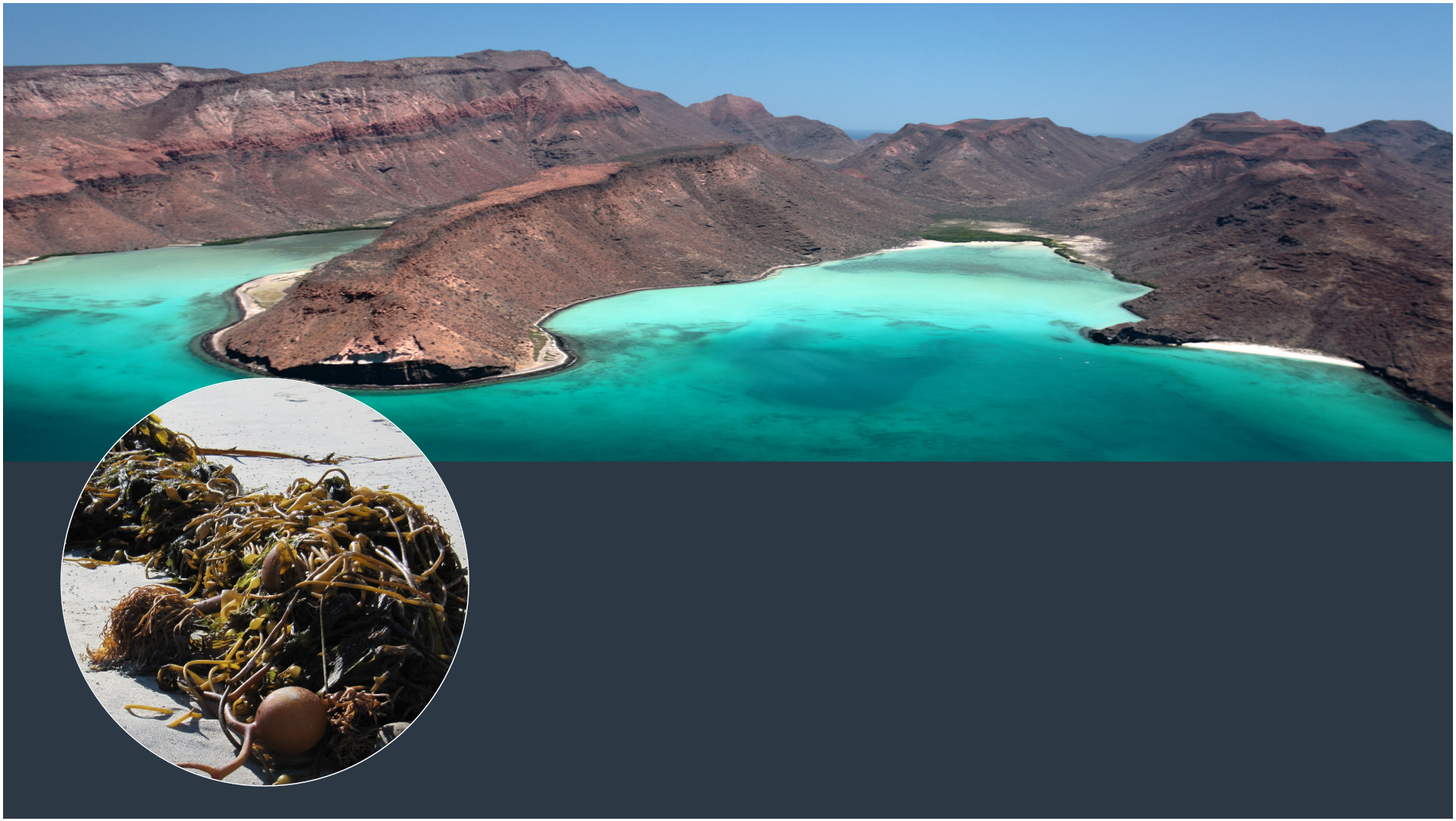


- Salmon feed in the ocean then return to natal streams to spawn & die
- Predators drag carcasses into riparian areas
- Leads to higher spider densities & diversity of songbirds, plants, and invertebrates

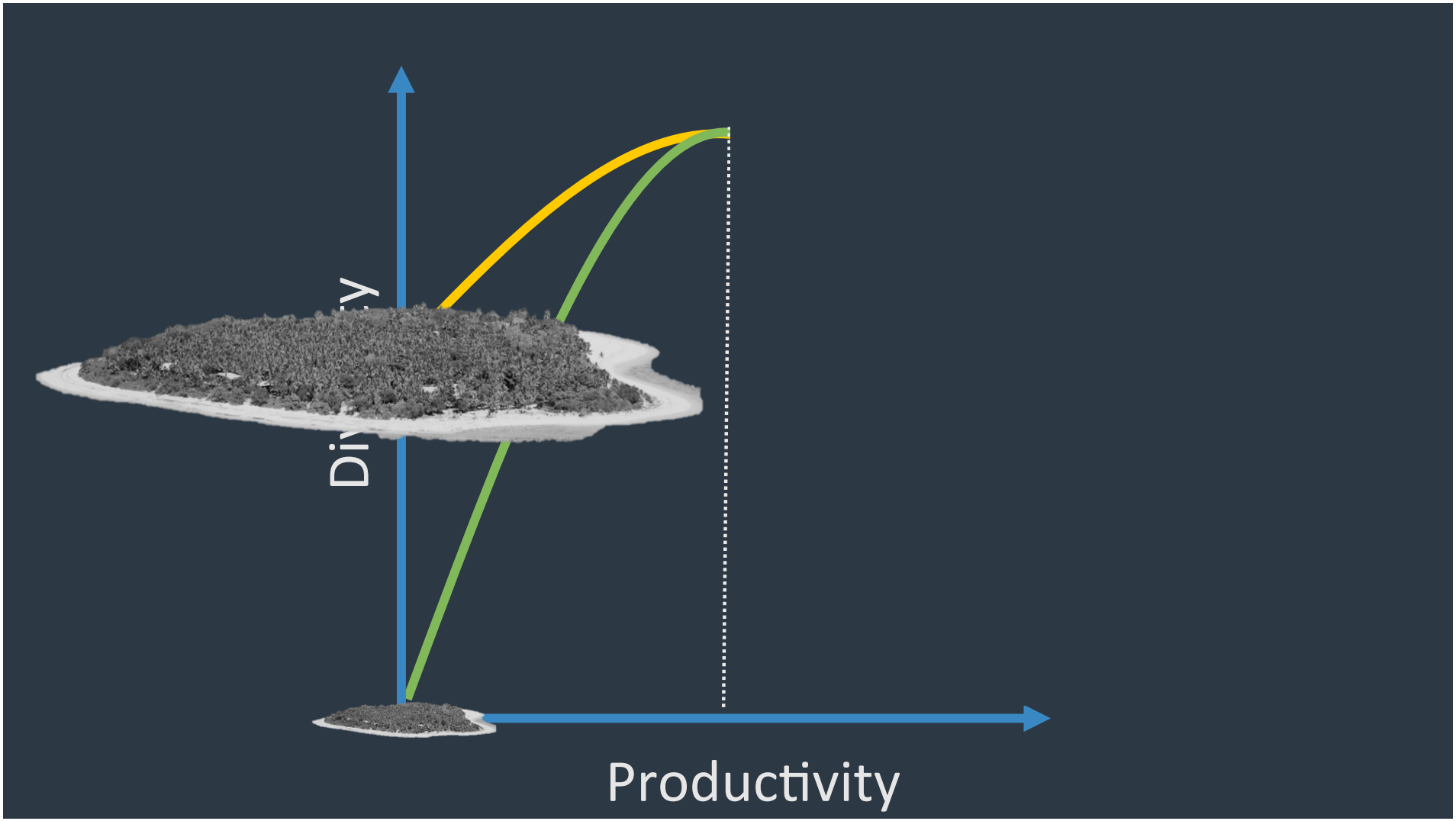


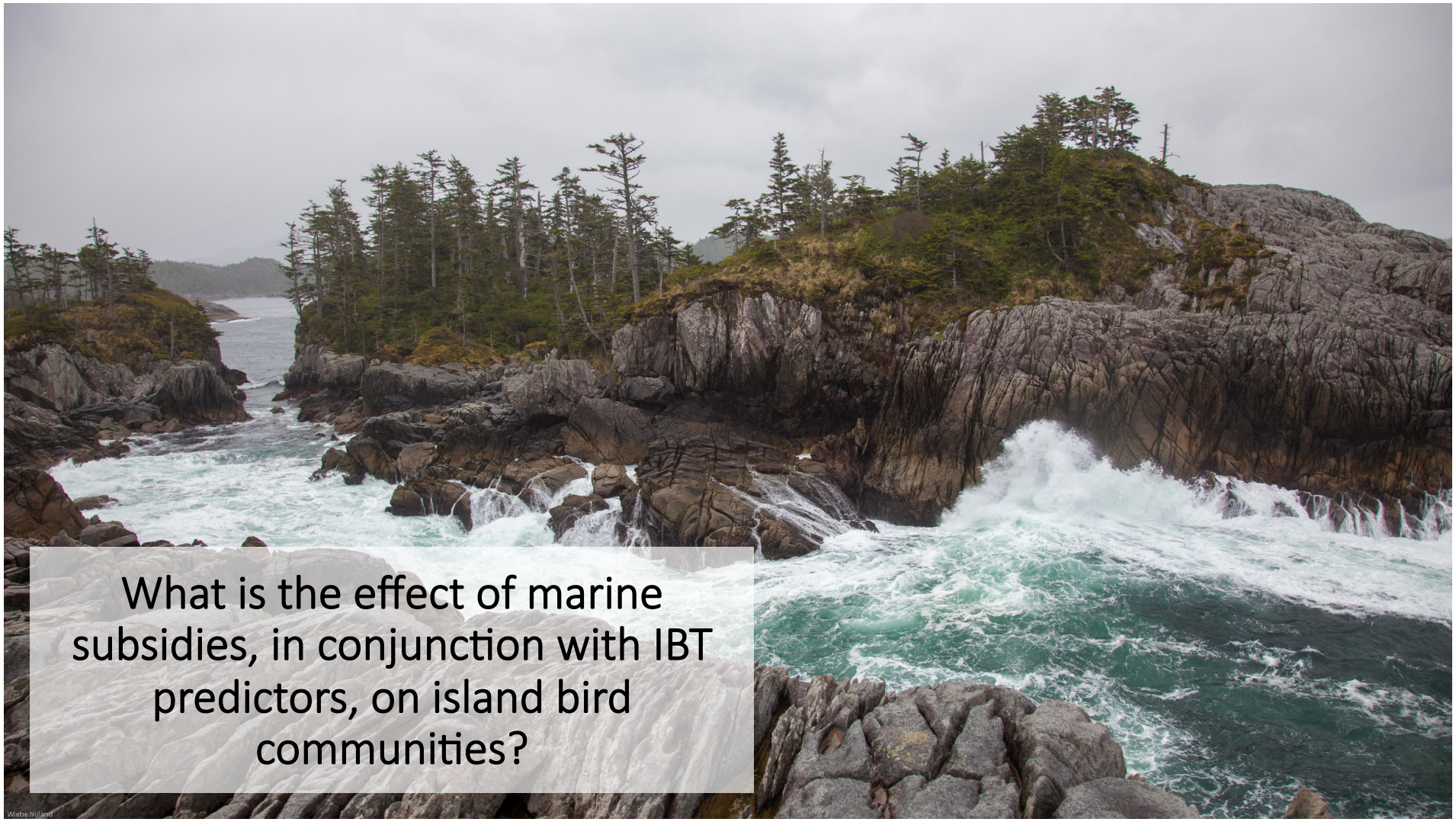
- Seabirds feed on fish in the sea & roost on islands
- Seabird guano fertilizes plants → plants become larger & more abundant
- Islands with more guano -> higher beetle densities

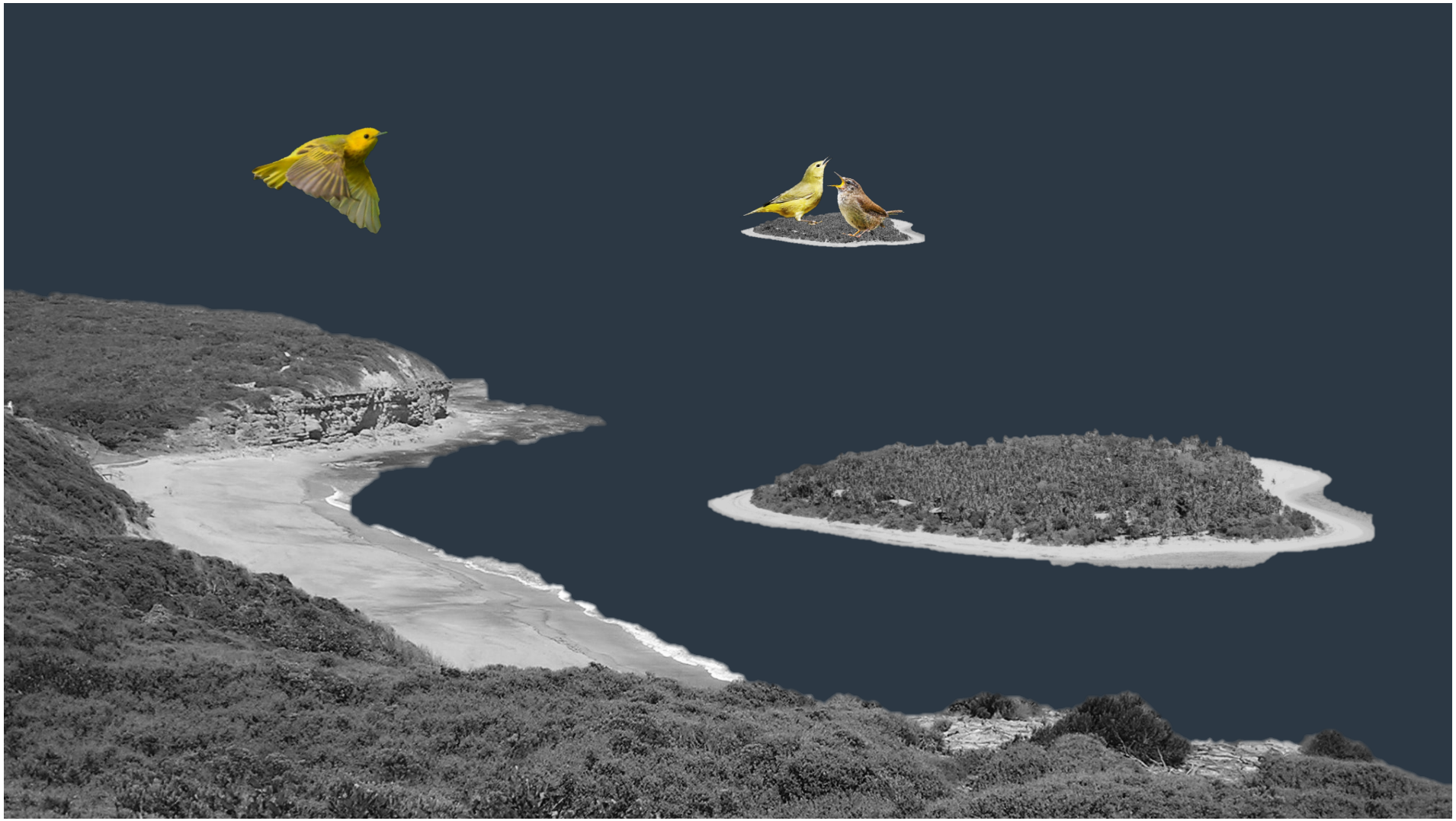




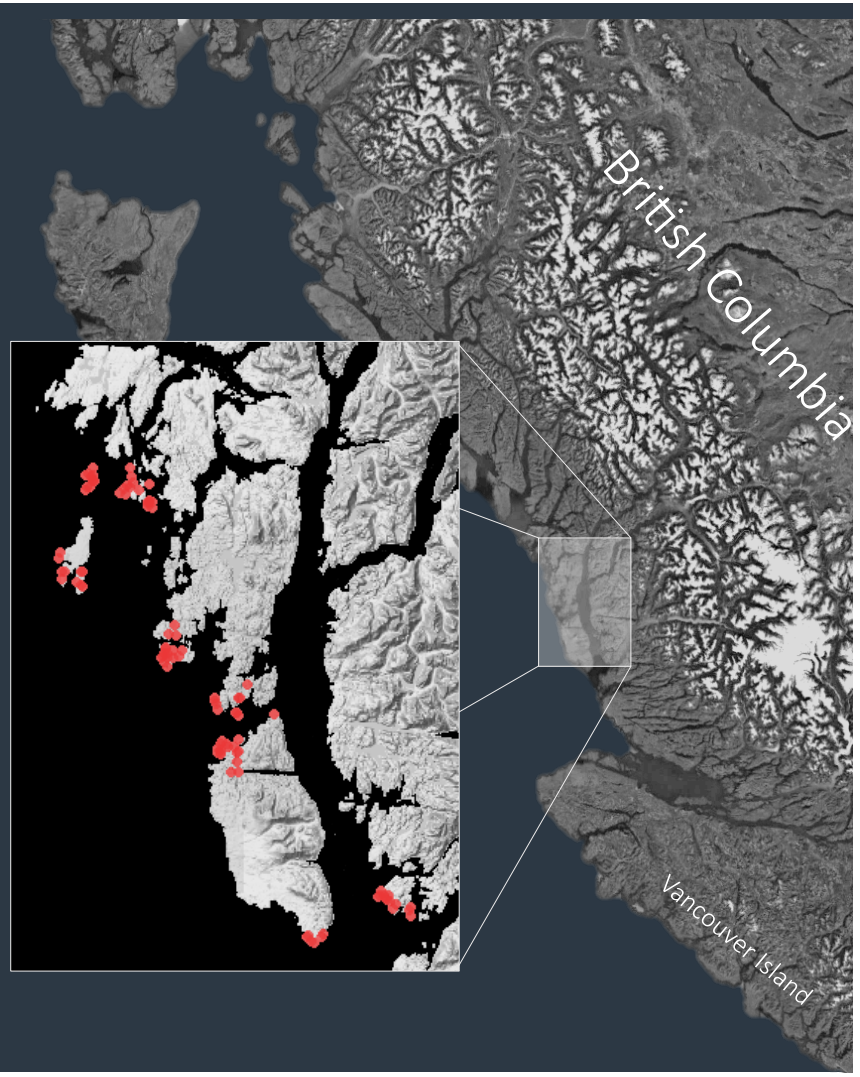
- Seaweeds wash up on island shores (wrack)
- Islands with more wrack → higher spider densities
- Higher spider densities → higher lizard densities


Productivity

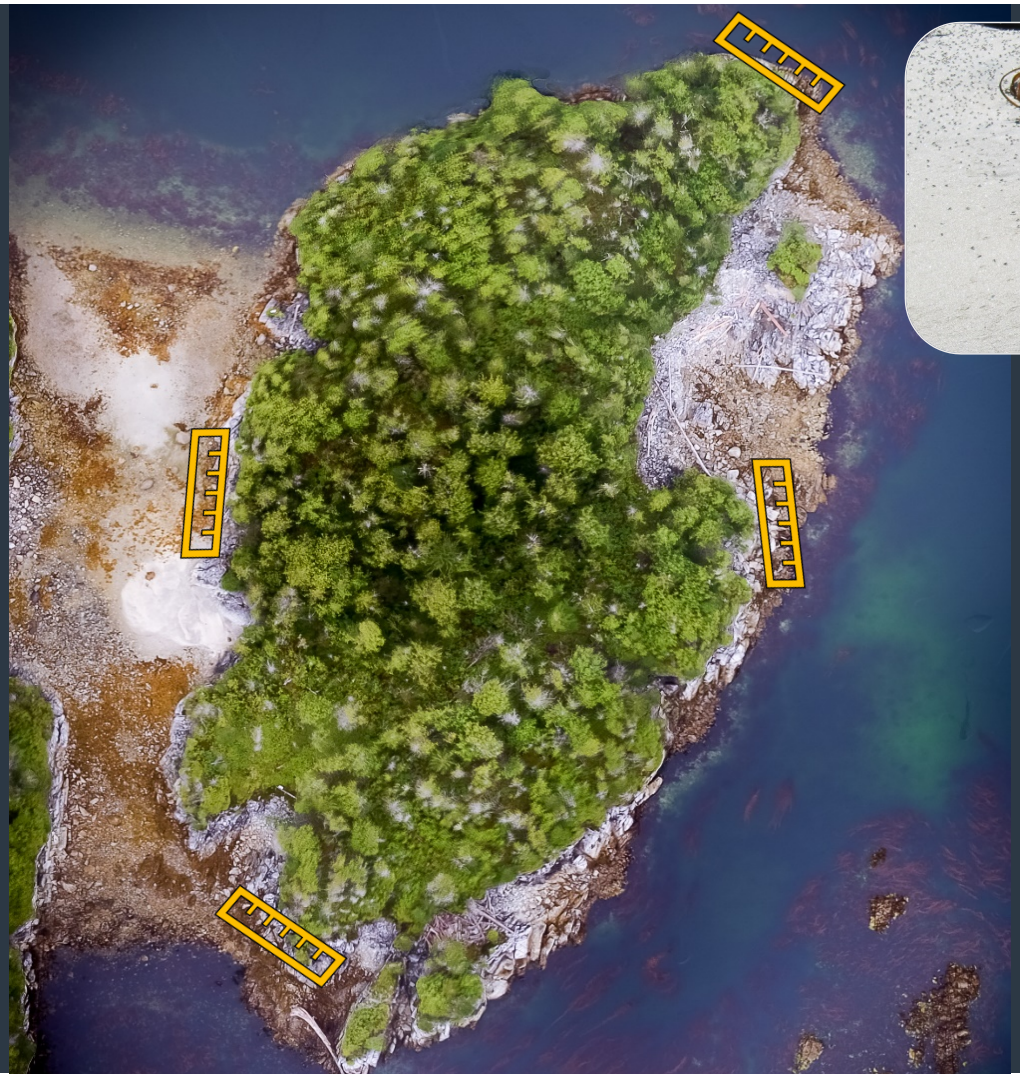

What is the effect of marine subsidies, in conjunction with IBT predictors, on island bird communities?
Wiebe Nijland

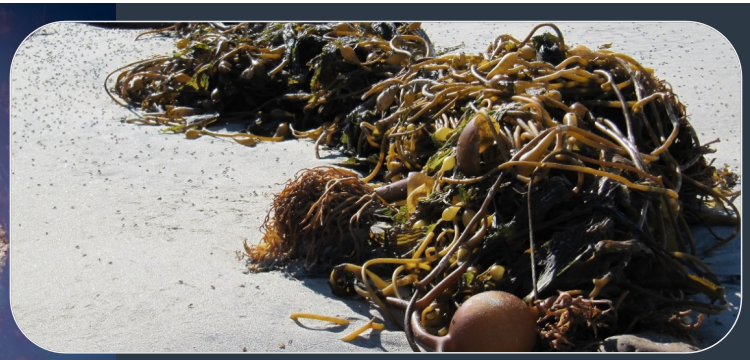


Subsidy sources:

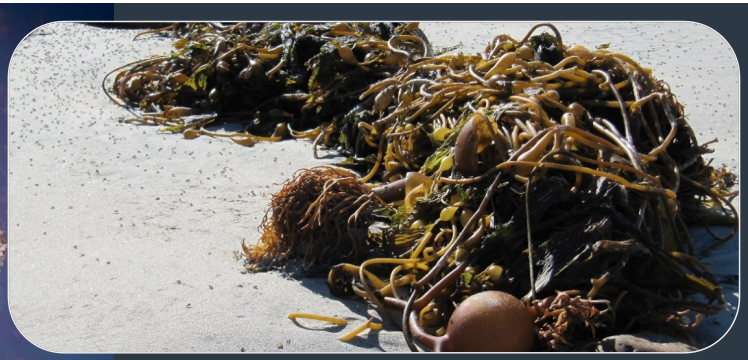


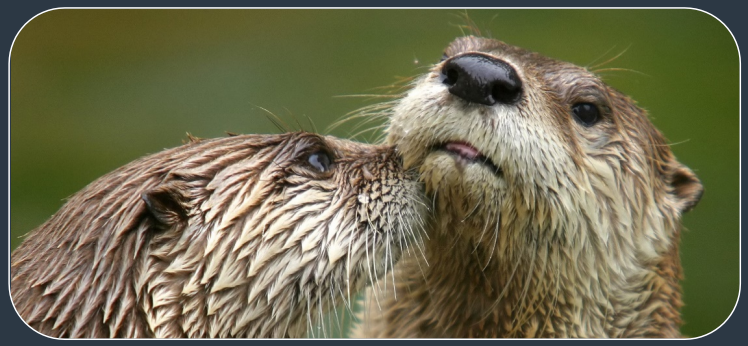
We used available geospatial data to get island areas and “isolation”. Since birds can easily fly between islands, we used the distance to nearest island large enough to act as a mainland. used drones to get accurate measures of area, habitat heterogeneity and shoreline substrate.





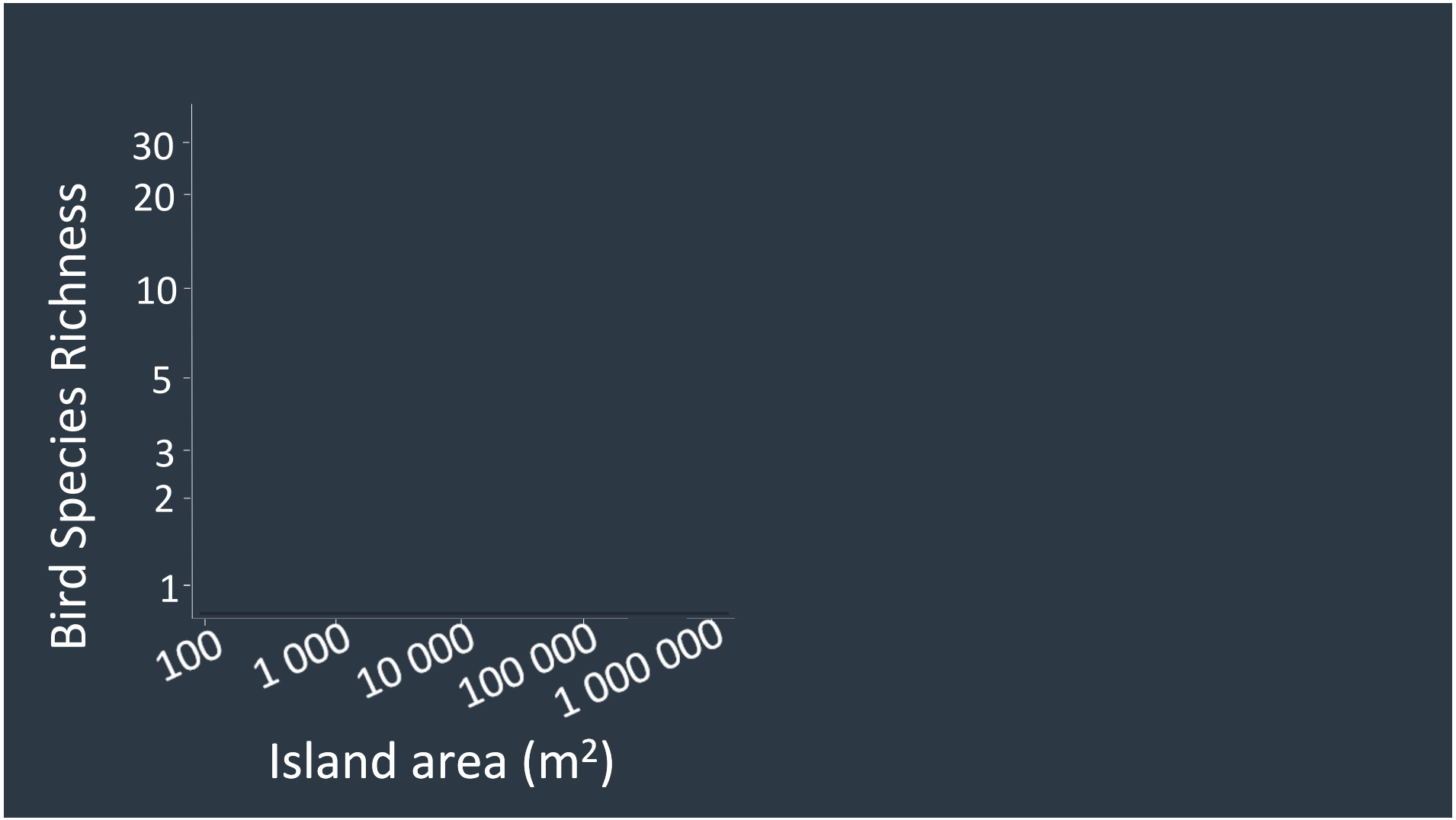
We weighed the amount of wrack that washed up on island shorelines at 4 points on every island.





We measured amount of nitrogen that was marine-derived in island soils (represents river otter activity)


We conducted point count surveys to quantify bird communities.


Bird Species Richness
30
20
10
5
3
2
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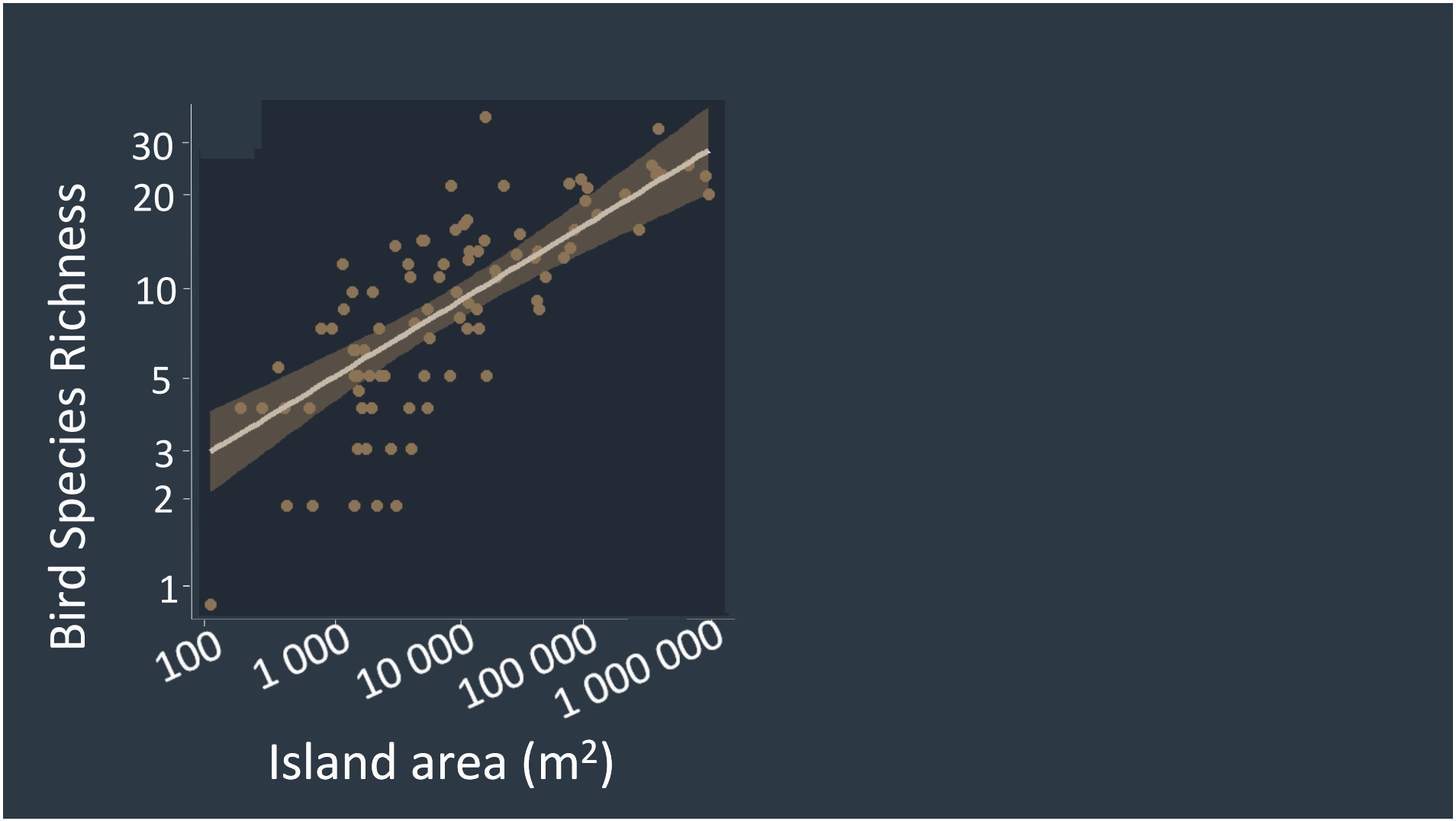
100
1 000
10 000
100 000
1 000 000
Island area (m²)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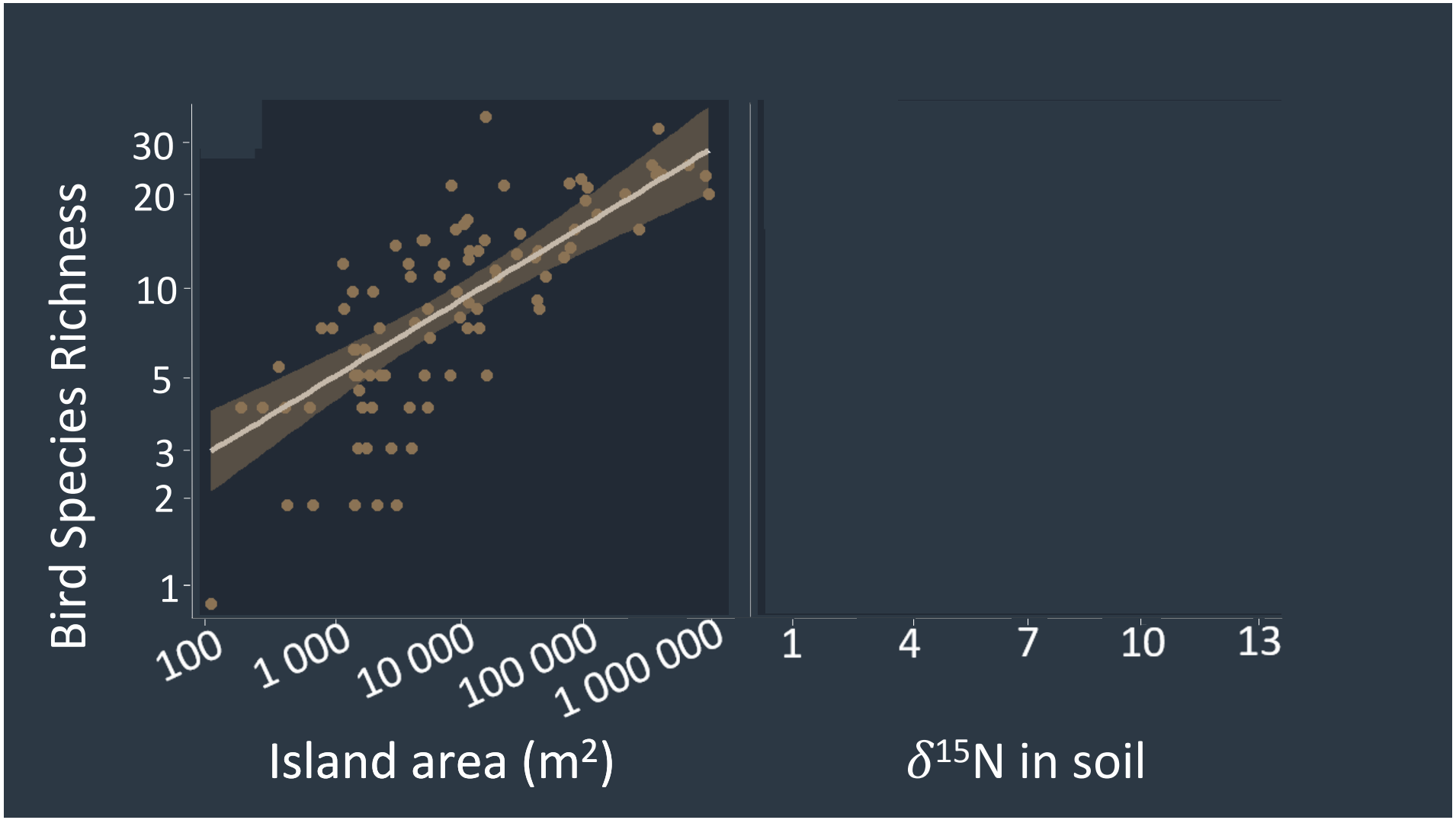
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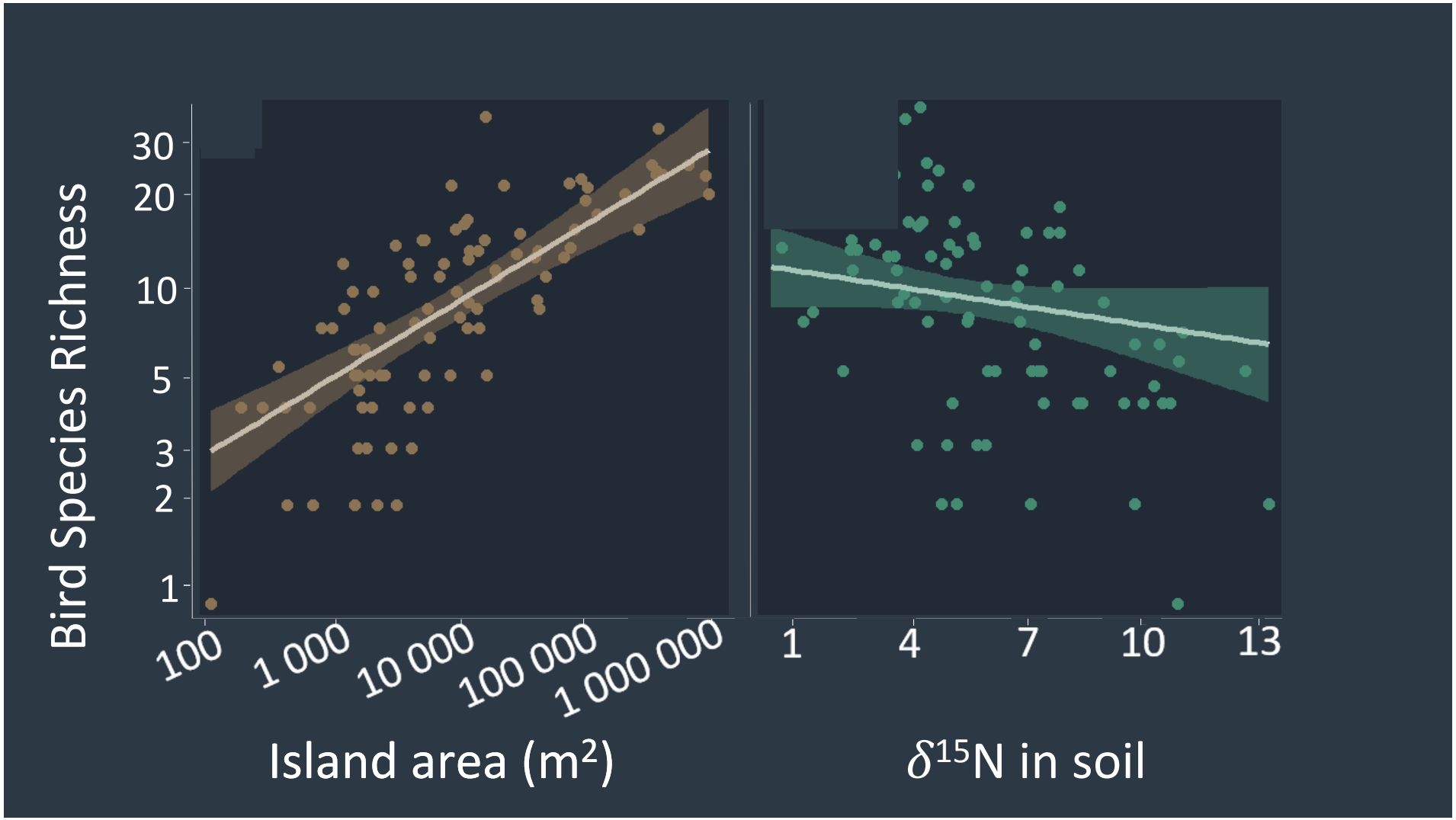
Island area (m²)
1
4
7
10
13
δ15N in soil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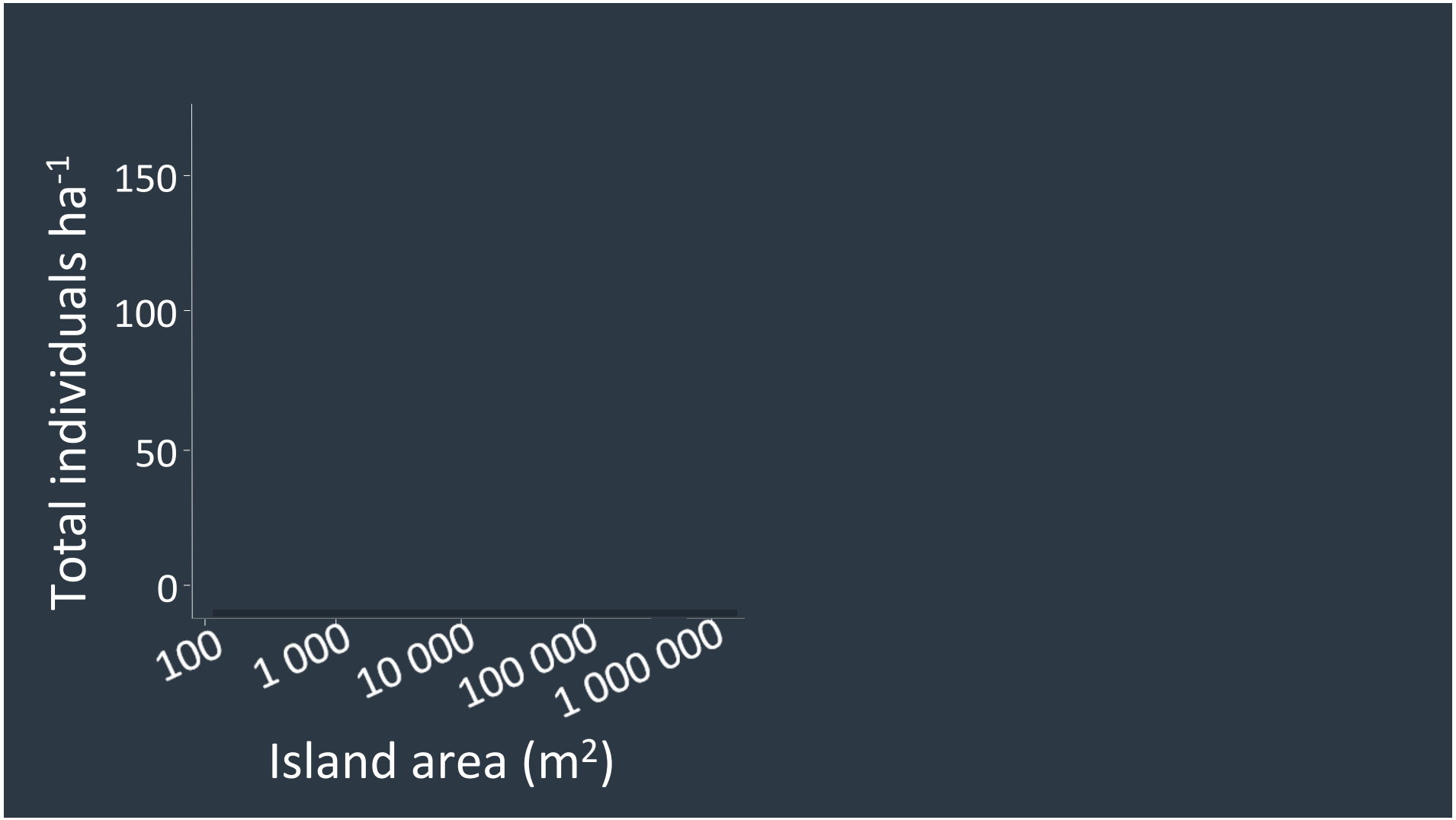
Total individuals ha-1
150
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50
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100
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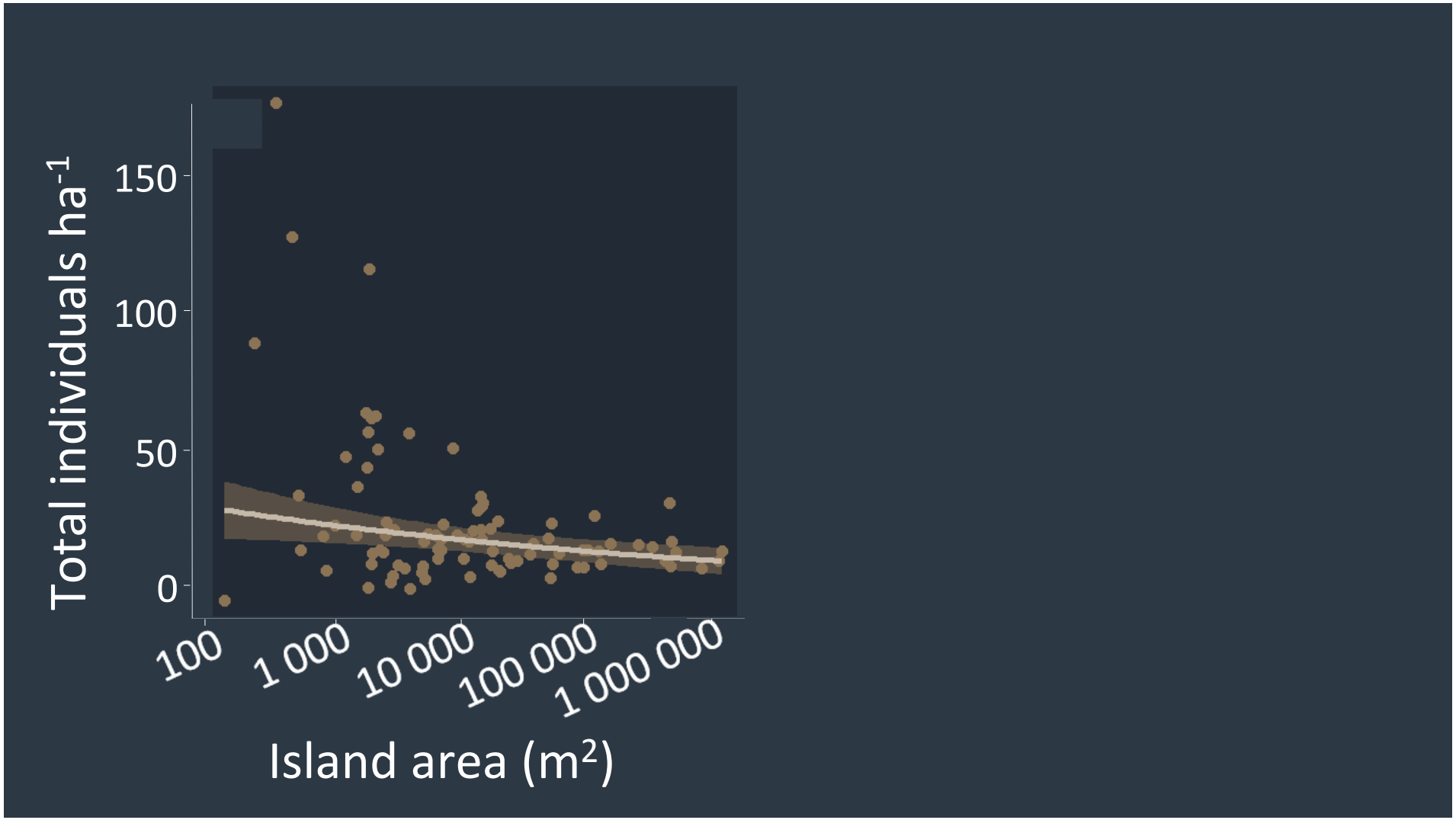
100 000
1 000 000
Island area (m2)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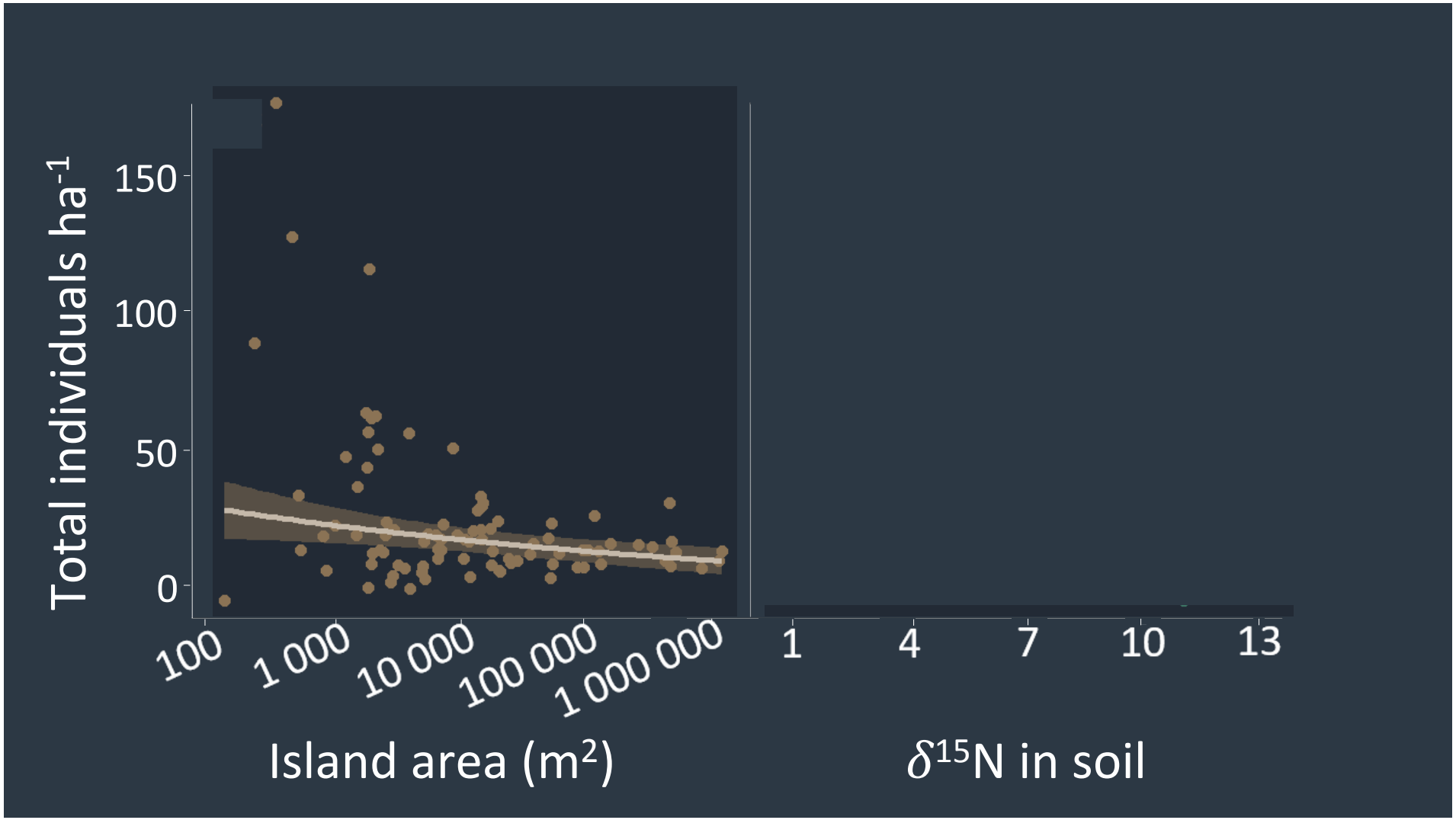
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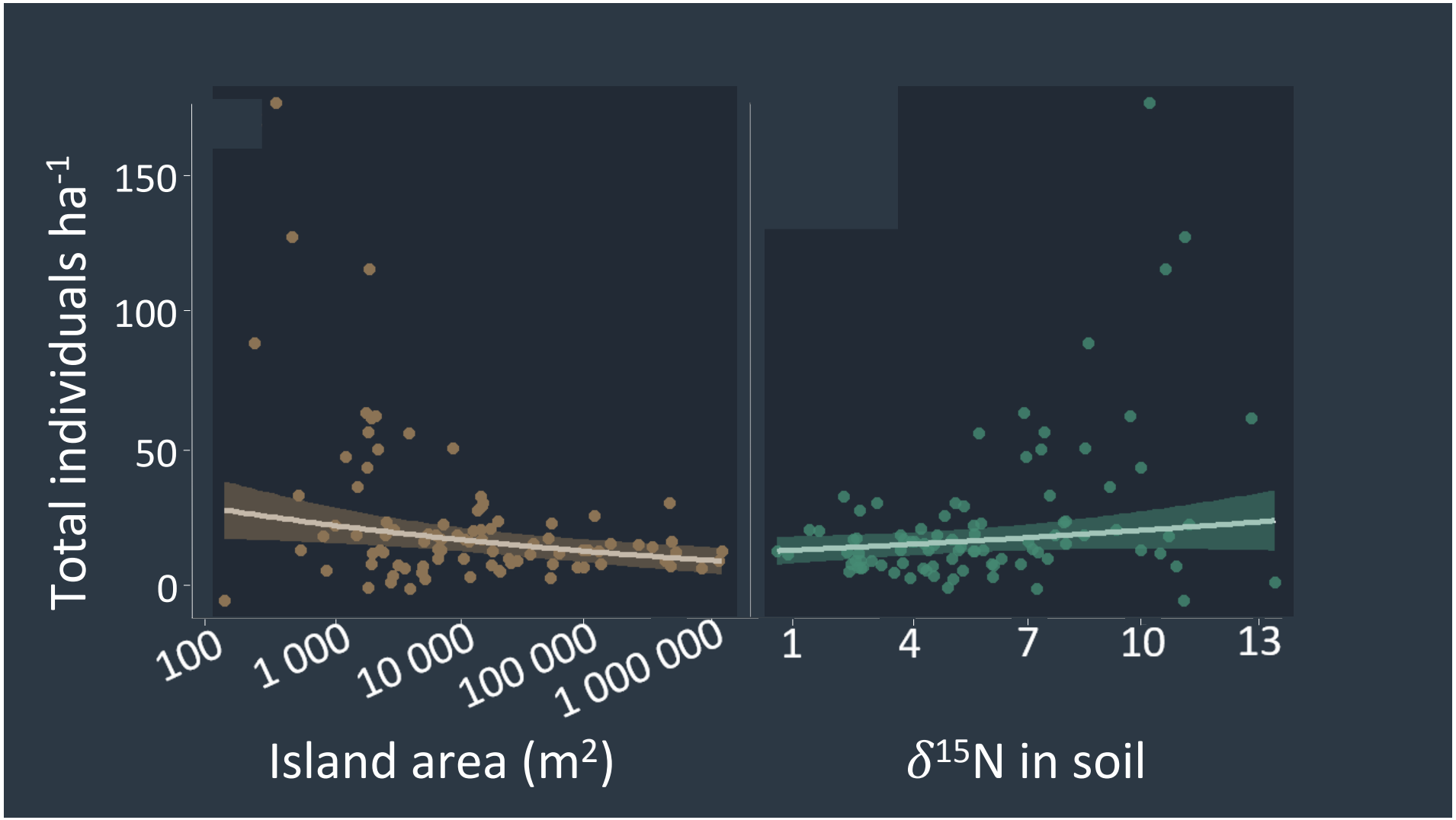
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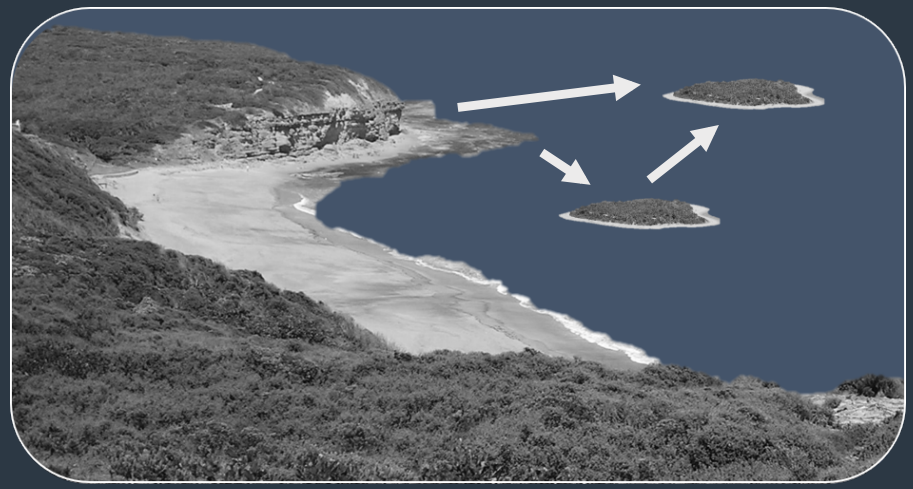
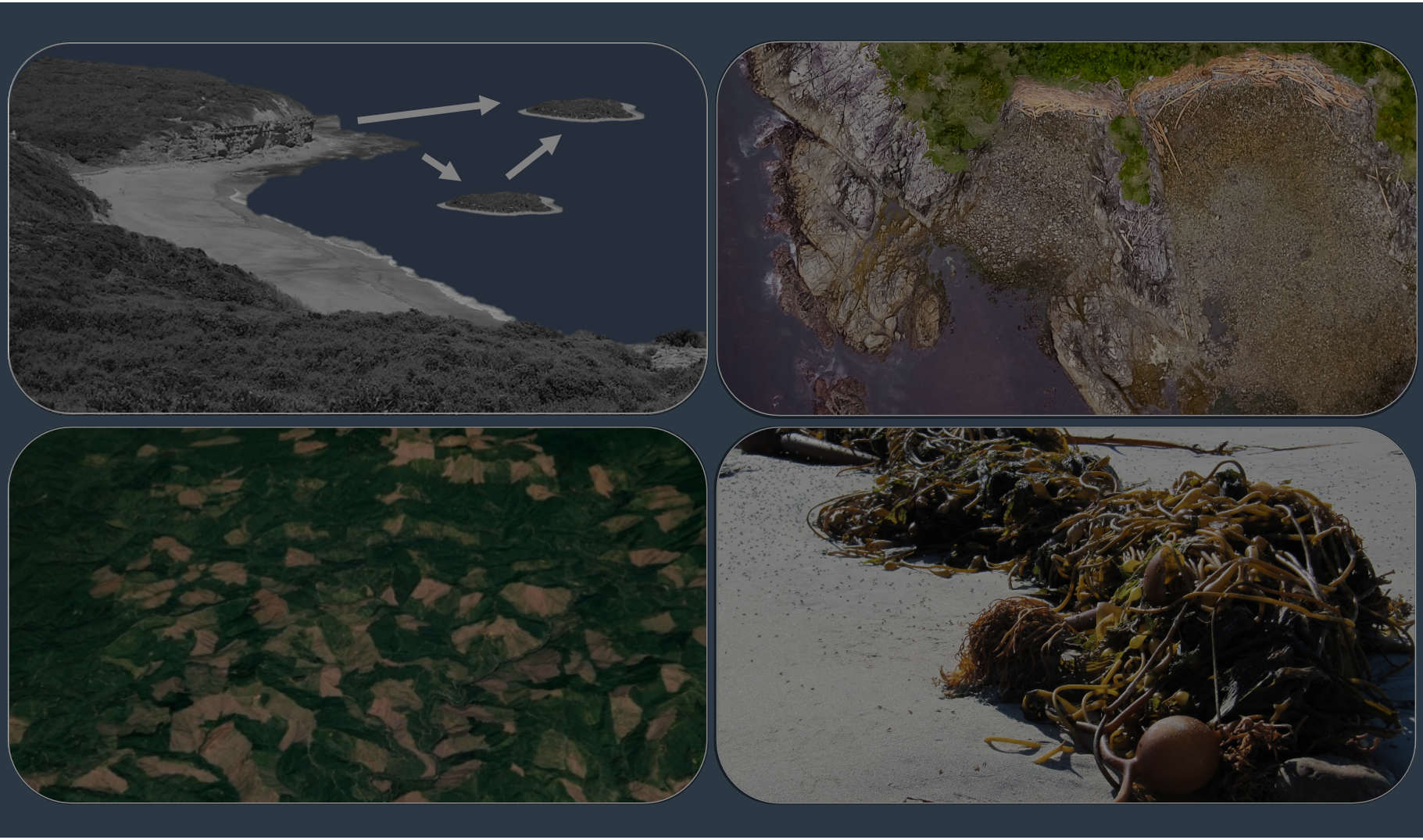
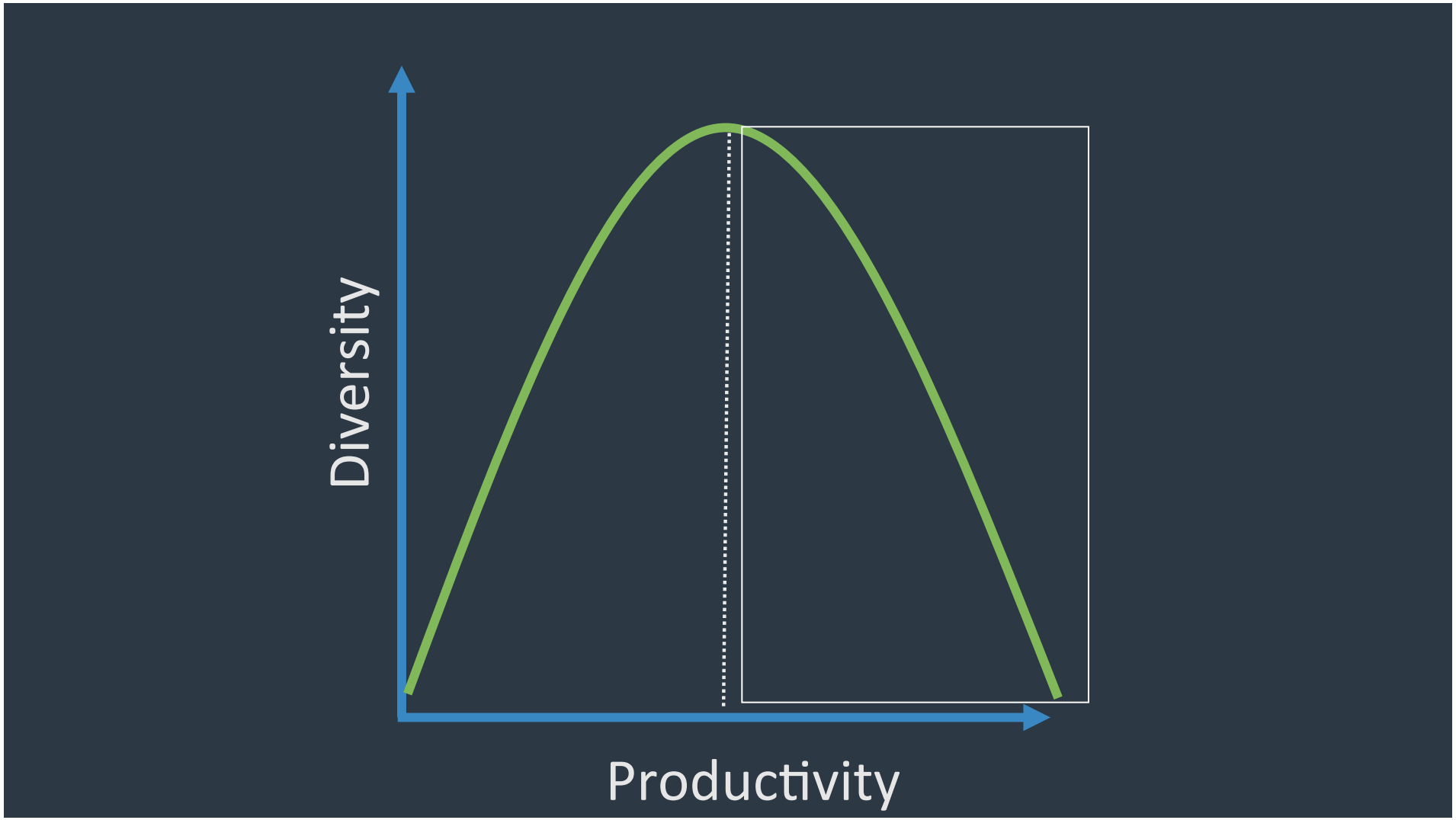
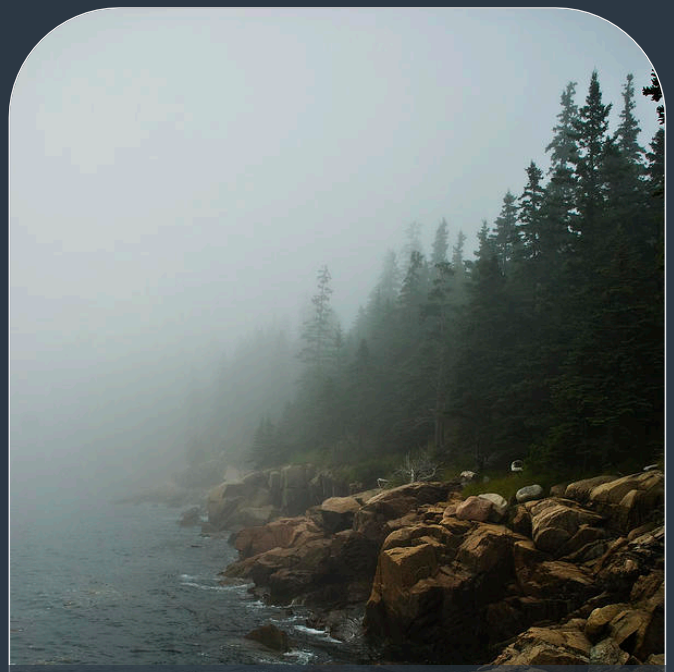





Diversity
Productivity

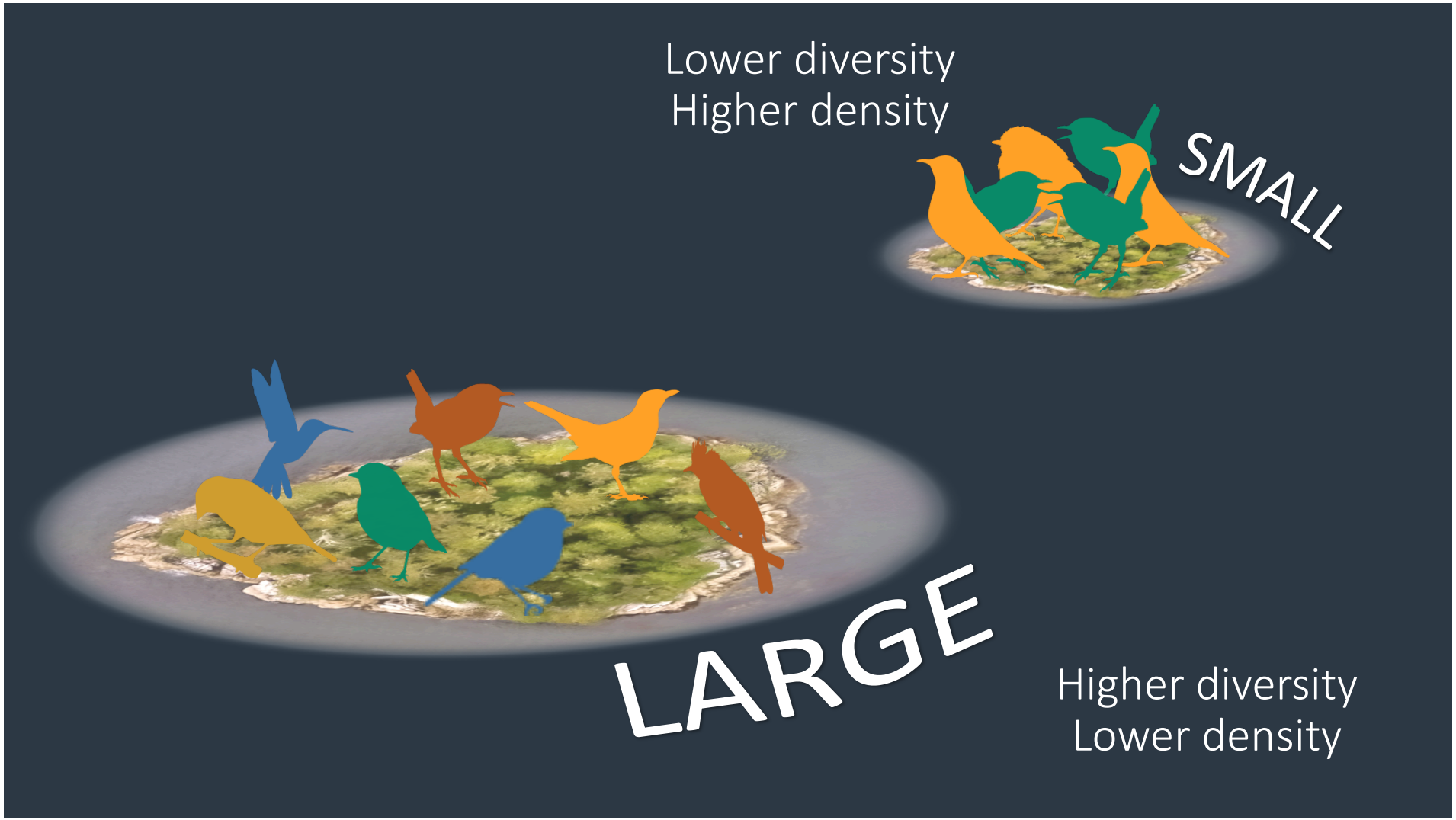
The effect could be due to river otters:

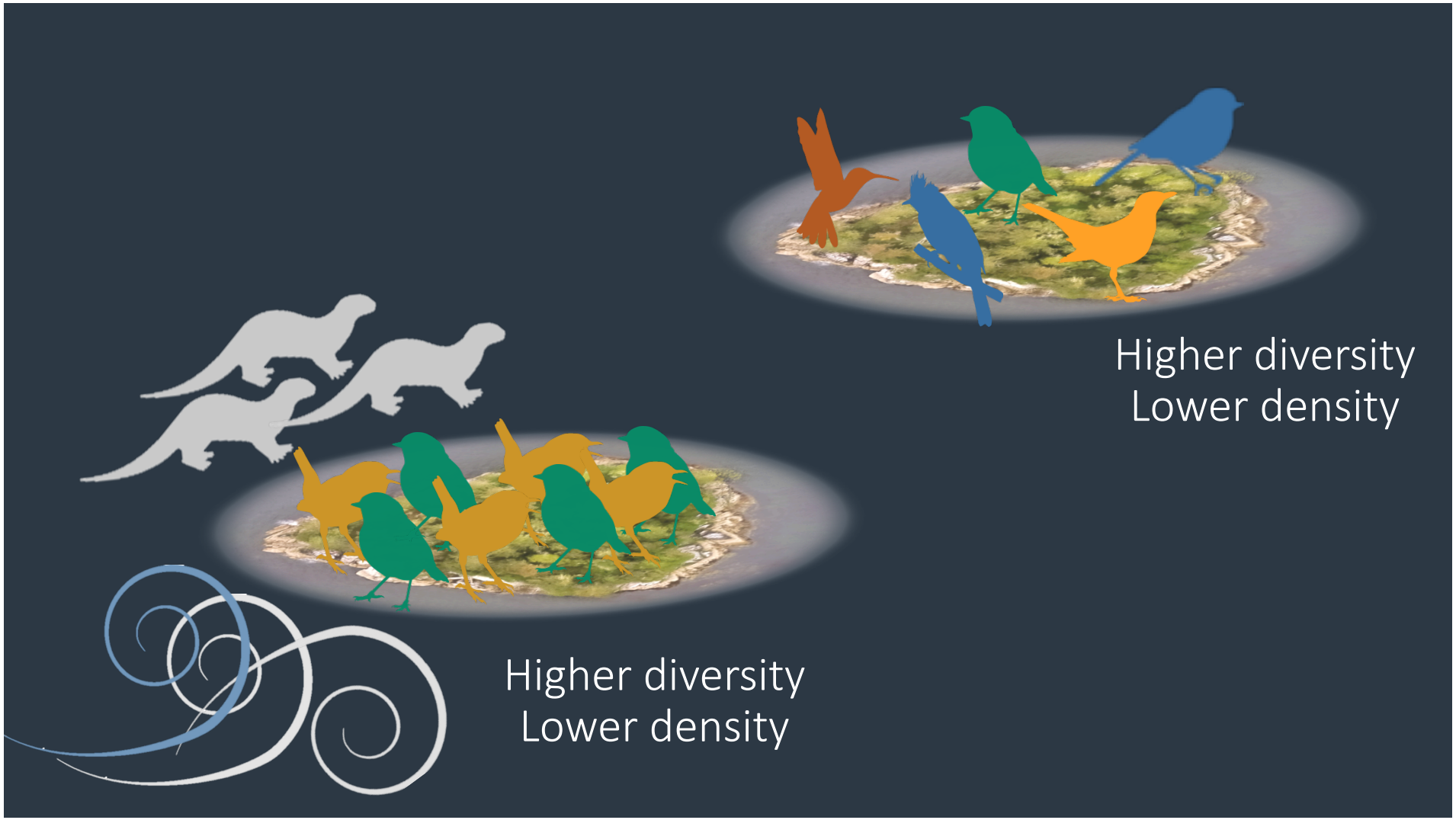
- Avoiding direct predation and/or nest predation
- Habitat disturbances → less structural variation

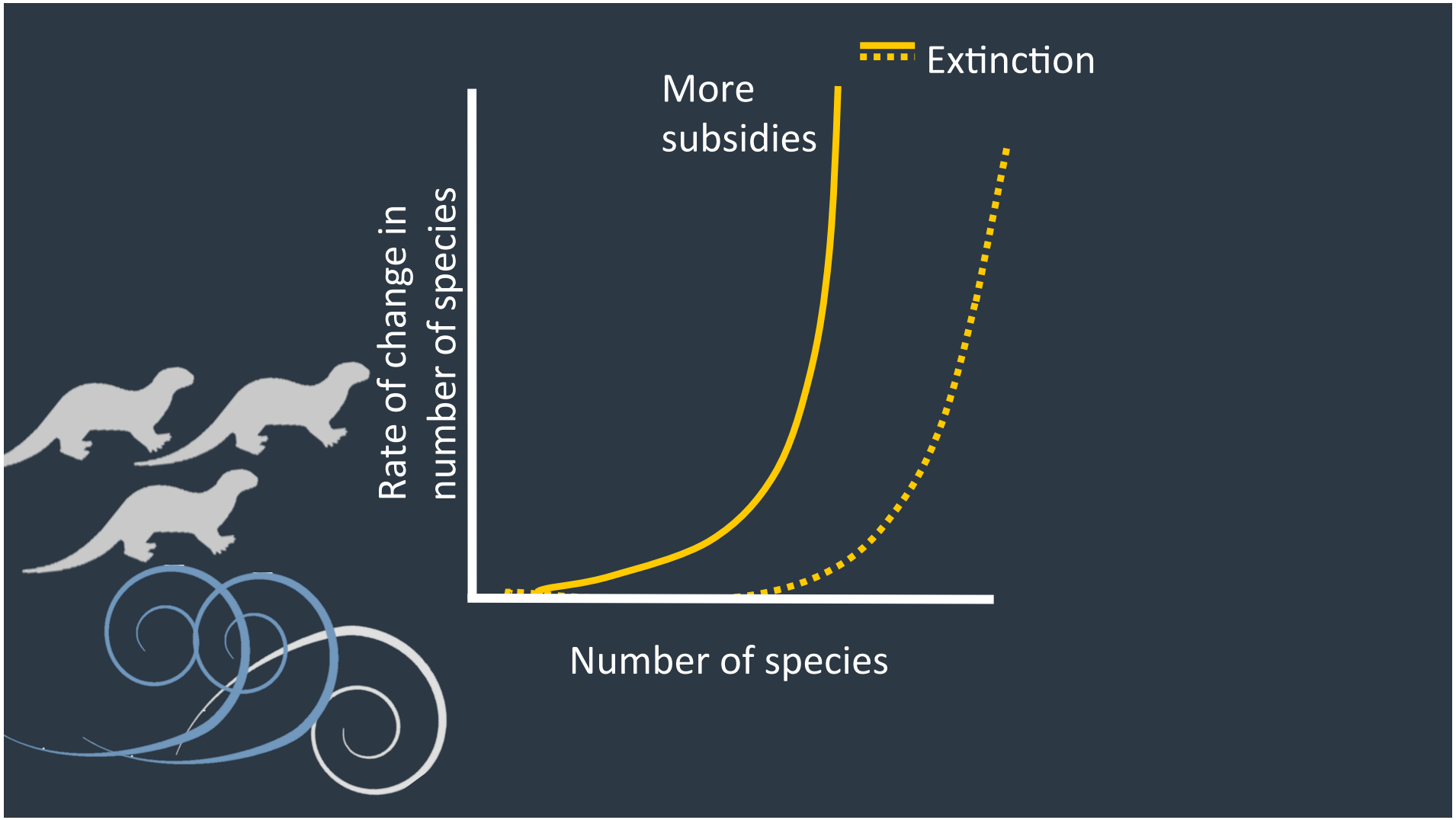


The effect could be due to exposure:

- Marine fog, sea spray, and wind could cause increases in soil marine-derived nitrogen but cause unfavourable conditions for birds.


Lower diversity
Higher density
SMALL
LARGE
Higher diversity
Lower density


Higher diversity
Lower density
Higher diversity
Lower density


Extinction
More
subsidies
Rate of change in
number of species
Number of species