Dunes in Puerto Rico: Importance of geography for restoration

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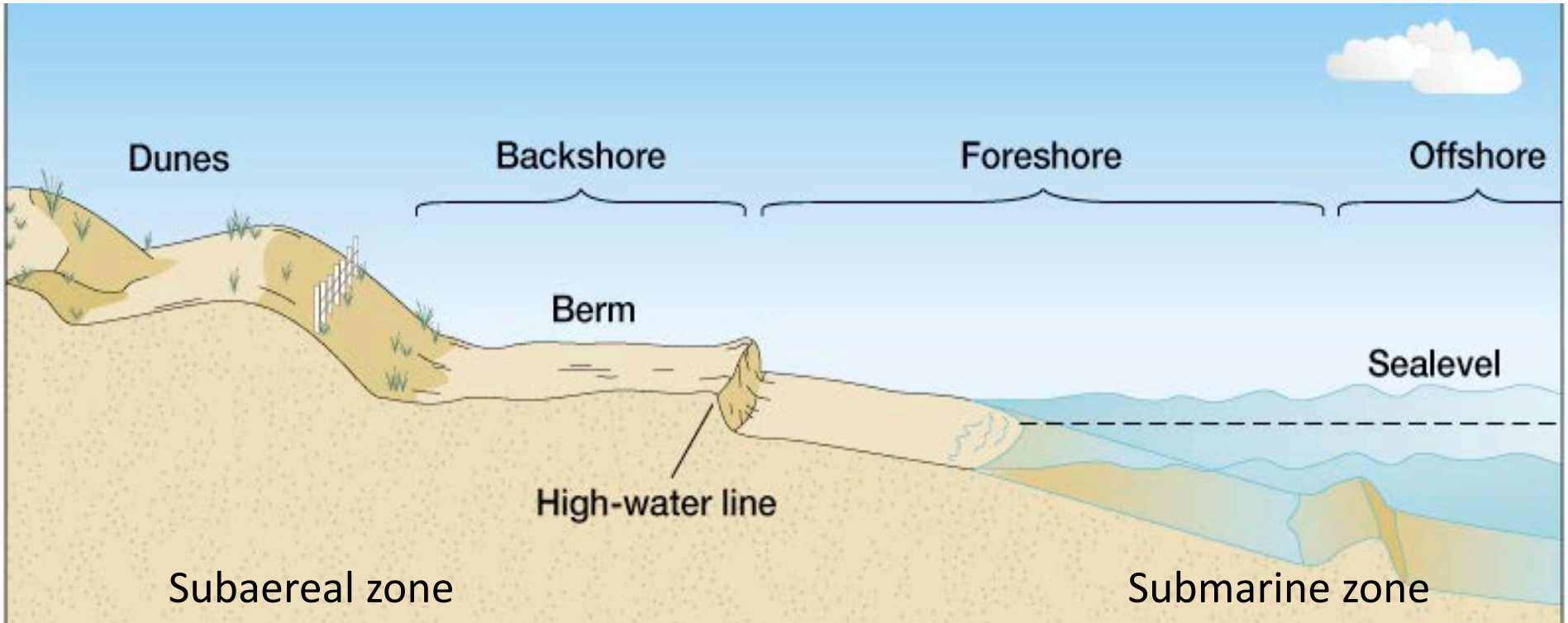
¿What is a coastal dune?

- Geomorphic depositional feature resulting from wind sediment transport landward of the beach

Beach-dune relationship

- Most dune forming criteria depend on beach characteristics
  - No beach = no dune
  - Dunes are sediment reservoir for the beach



- Benefits of coastal dunes
  - Provide habitat for coastal species
  - Coastal erosion control (Barbier 2011)
  - Protect coastal settlements against erosion and flooding (Carboni, Carranza & Acosta 2008)
  - Provide space for landward beach migration
  - Provide sand reserve during storm conditions (UN 1998)

Threats that cause erosion problems

- Reduction or elimination of dunes
- Reduction or elimination of sediment source
  - River dams
  - Obstructions to the littoral drift
    - Breakwaters and groins
  - Vehicle use and trampling on beaches and dunes
  - Sand extraction or mining
  - Sea level rise
  - **Storms** and cold fronts

Huracán María

Loíza P.R. Foto de Martiza Barreto Orta.

Restoration

- The society for ecological restoration (SER) defines restoration as

  - "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed"

- Coastal dune restoration has many motivations and goals that lead to a variety of restoration actions

(Martinez, Hesp and Gallego-Fernandez 2015)

Dune protection and restoration

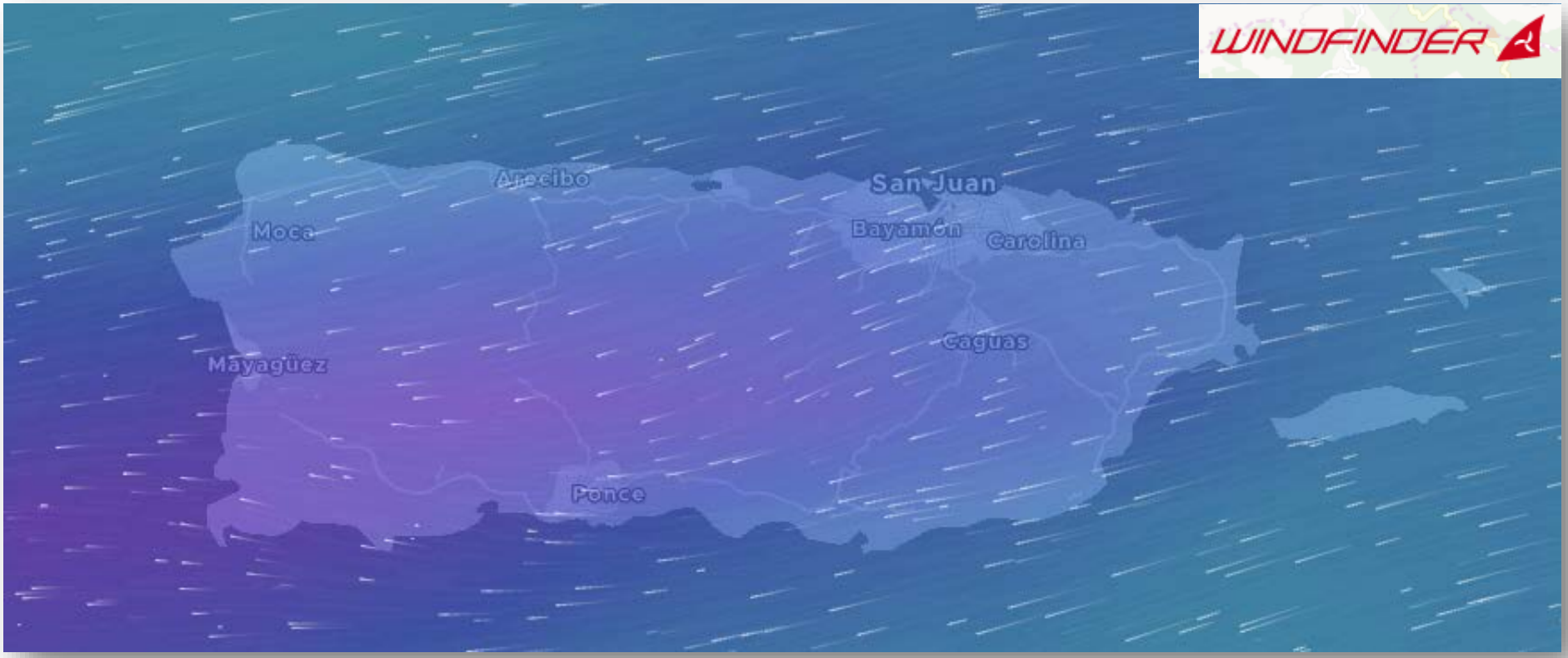
- USA
- New Zealand
- Denmark
- Israel
- Spain
- UK
- Mexico
- Australia
- Netherlands
- Italy
- South Africa

Dune forming criteria

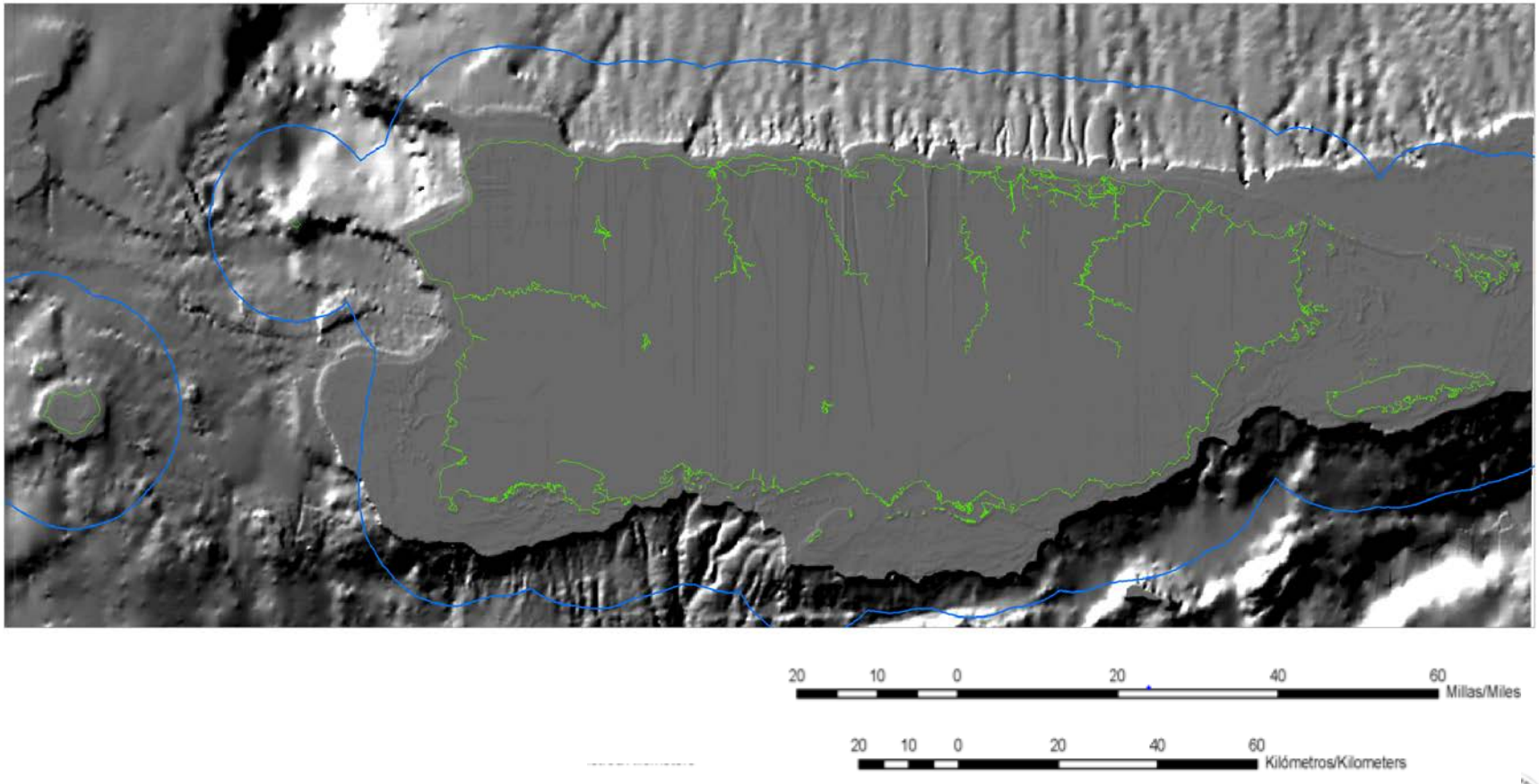
- Sediment (small grain size)
- Wide beach sediment source
- Strong constant wind energy
- High wave energy
- Beach orientation
- Depositional barriers
- **Time**
- **Space***

Wind/wave criteria

- Strong constant wind energy: trade winds
- High wave energy: Atlantic ocean fetch distance
  - Where: <u>North and East Coast</u>



Wide beach criteria

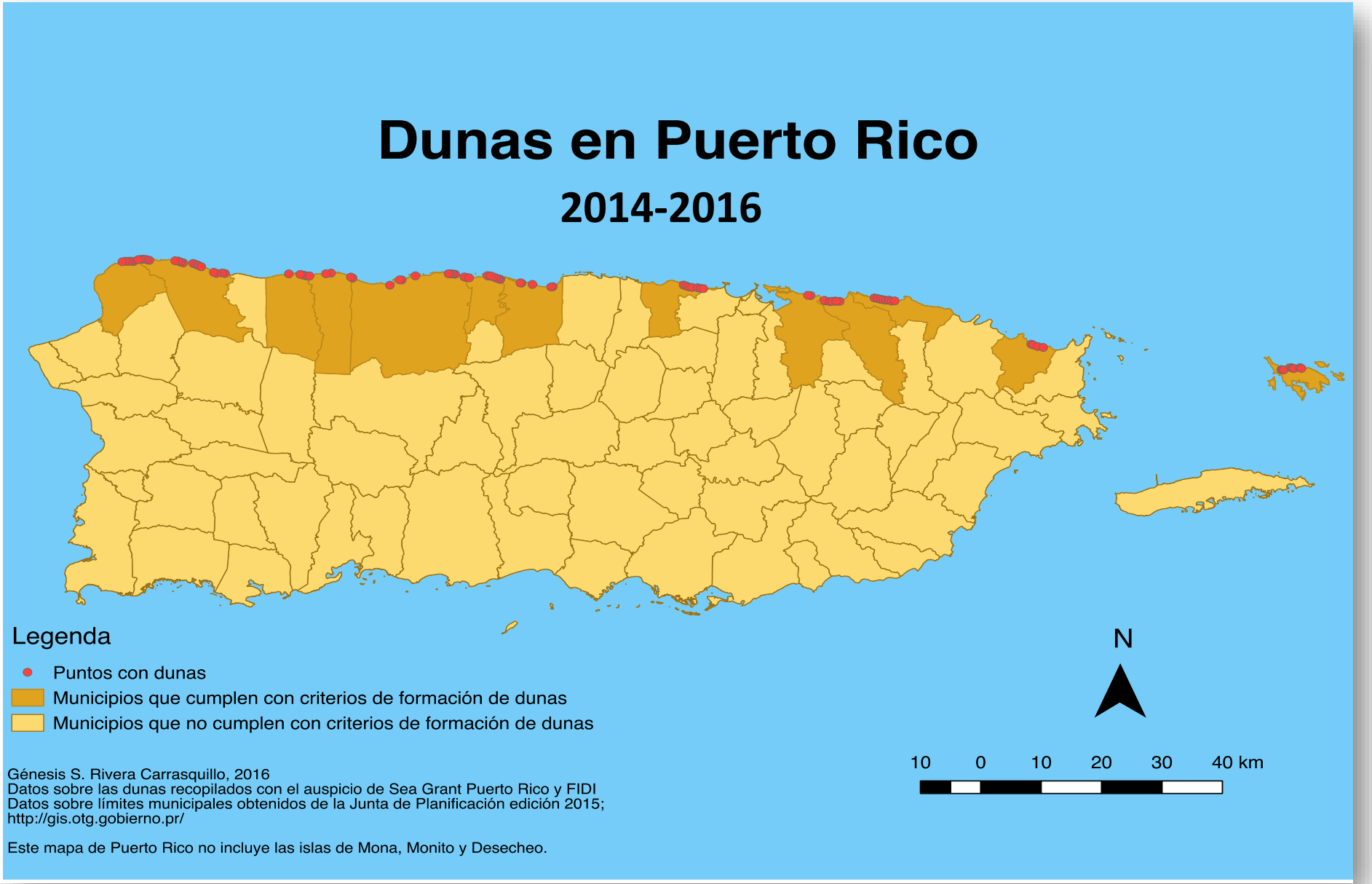


Beach orientation criteria

Beach orientation criteria

Beach orientation criteria

Sediment grain size



25.85 km of coast with dunes in 13 municipalities

Diverse characteristics

Dune restoration in Puerto Rico: Consider…

- Diverse geomorphology over short distance
- Variety of dune characteristics
- Rapid and continuous vegetation growth
- River: sediment source

Dune restoration in Puerto Rico: Consider…

Lack of space due to presence of human structures and sea level rise

History of short-term economic priorities

Lack of knowledge about dunes among population

What is the objective of the restoration project?

- Protection or recovery of
    - Human infrastructure
    - Recreation values
    - Aesthetic values
    - Habitat
  - Restoring dune mobility
  - Creating environmental tourism alternatives
- Who will use/maintain the dune space?

Dune restoration in Puerto Rico: Summary

- Puerto Rico has diverse
  - Coastal landscape
  - Beach/dune characteristics
  - Erosion problems
- Define objectives and priorities to determine restoration actions
- Consider challenges related to
  - Diversity of space usage
  - Knowledge among population

San Juan Bay Estuary

Vida Marina UPR

DUNAS: Climate Science Alliance

Para la Naturaleza
Yo Amo al Tinglar
UPR

Siete Quillas

Examples of dune protection and restoration in P.R.

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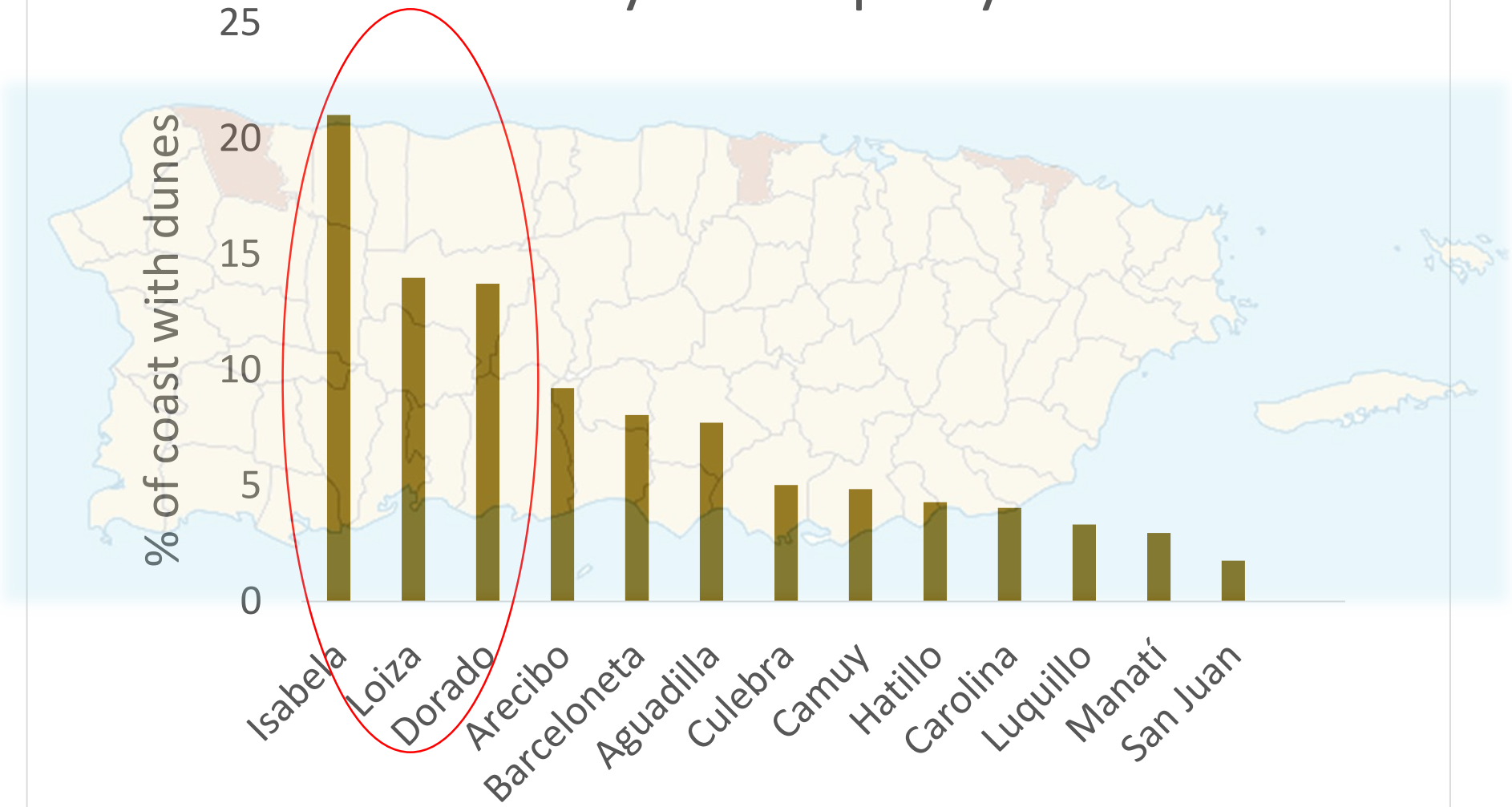
San Juan, P.R. agosto 2019 Foto de Martiza Barreto Orta

% of total coast with dunes by municipality



General Puerto Rico dune characteristics 2014 - 2016

Characteristic	Average (m)	Maximum (m)	Minimum (m)
Beach width	28	5.5	68
Dune width	30	3	90
Tides	0.34	0.05	0.65

General Puerto Rico dune characteristics 2014 - 2016

Characteristic	Average (%)	Maximum (%)	Minimum (%)
Vegetation cover	64	5	100

Common vegetation species

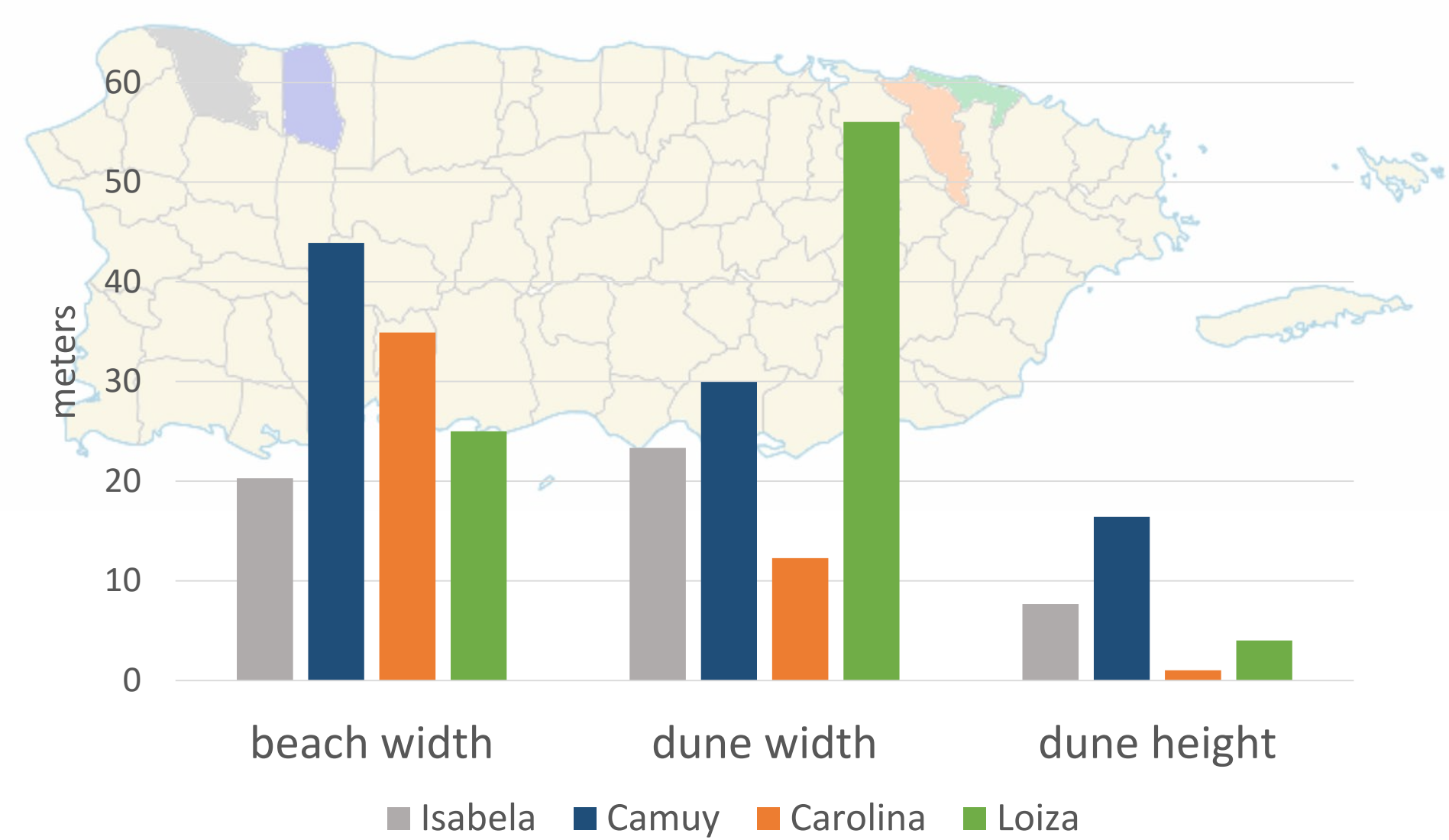
Preliminary Results

Isabela

Image © 2015 DigitalGlobe
Google earth
Imagery Date: 6/18/2015 18°30'50.50" N 67°01'56.41" W elev -1 m eye alt 2.98 km

Camuy

Beach/dune measurement averages by municipality



Isabela

Isabela

Camuy

Loíza

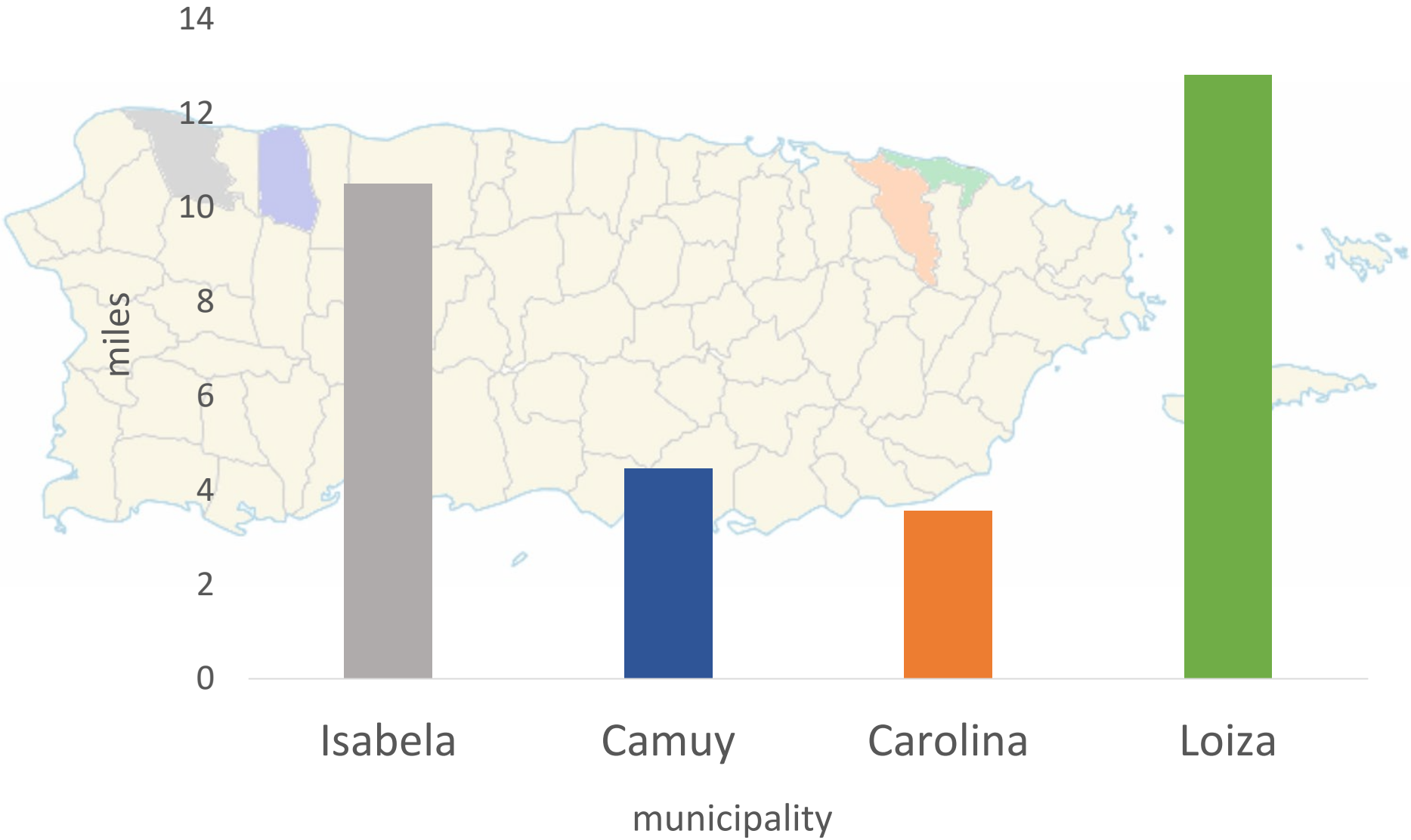
Loíza

Carolina

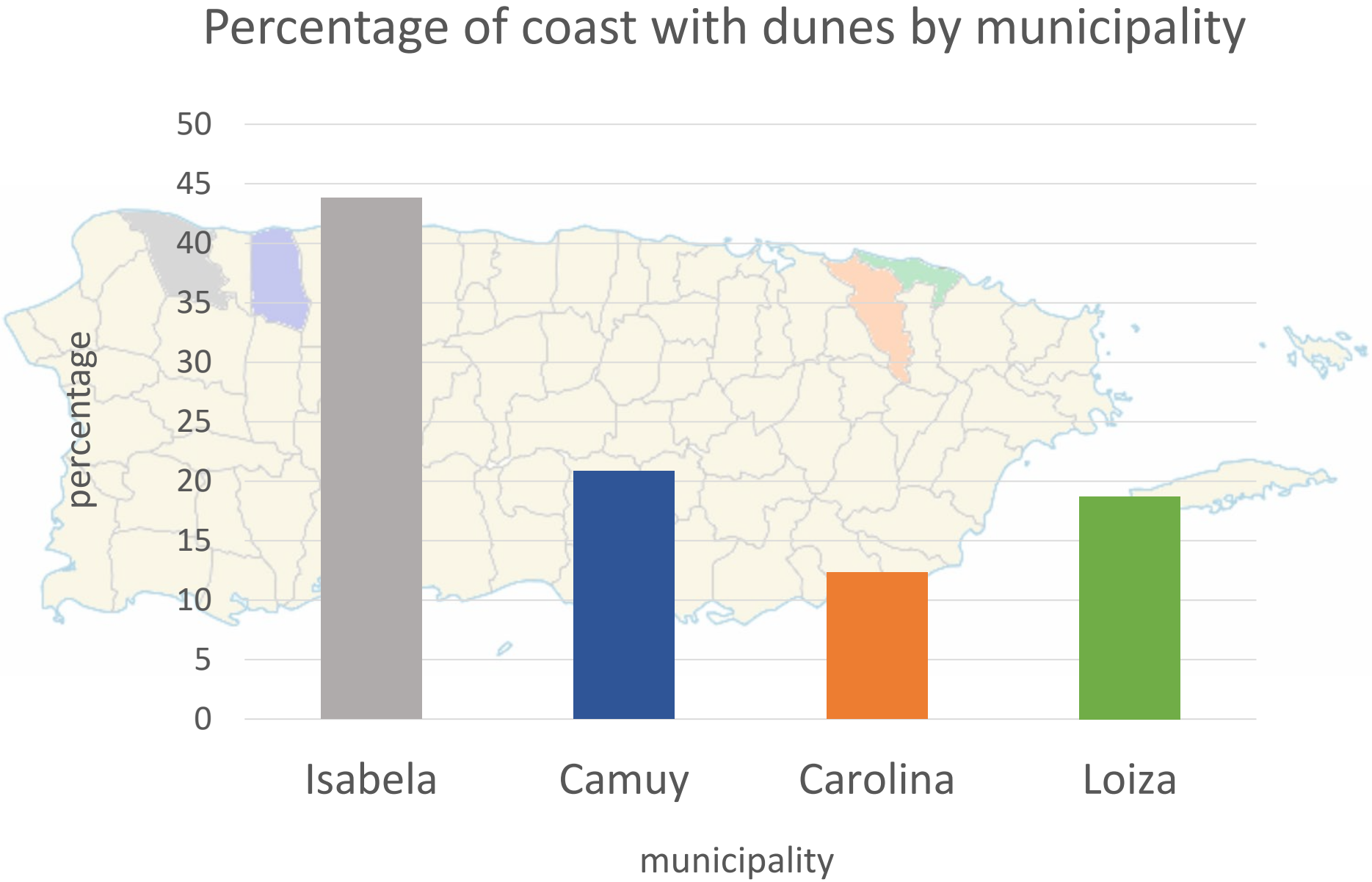
Carolina

Carolina

Length of coast by municipality



42% of Carolina's coastal length mets the criteria for dune formation


Percentage of coast with dunes by municipality
50
45
40
35
30
25
20
15
10
5
0
percentage
Isabela
Camuy
Carolina
Loiza
municipality

References

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- Pye K. Dune Formation on the Humid Tropical Sector of the North Queensland Coast, Australia. Earth Surface Processes and Landforms 1983;8:371-381.