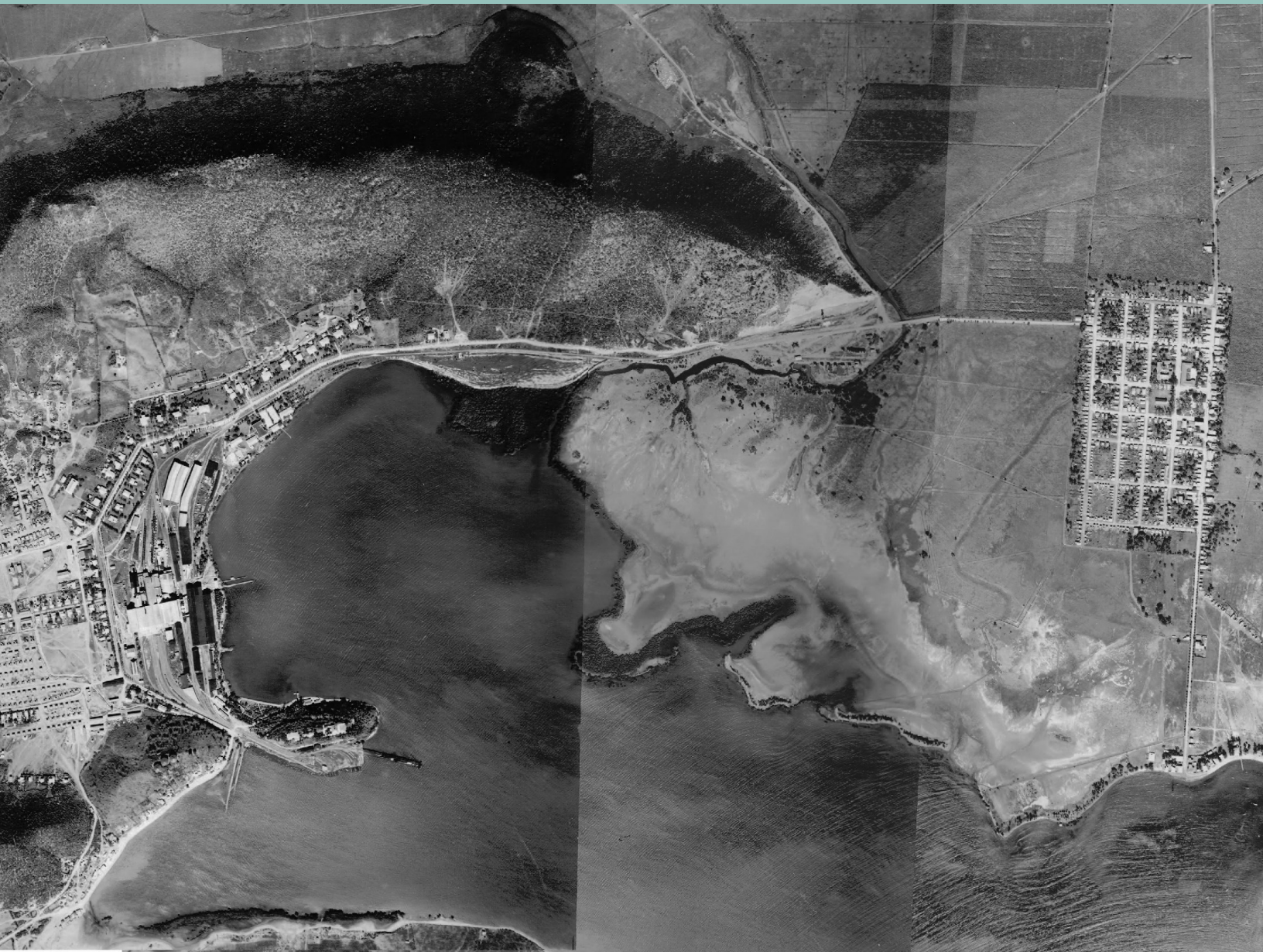


Puerto Rico 1930 Georeferenced: A Coastal Mosaic

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Bahía de Guánica, 1930



Introduction

The 1930 aerial photographs of Puerto Rico are the oldest set of known aerial photographs for the Island. These were taken between 1930 and 1931 by the United State Government (*Departamento de Marina de los Estados Unidos de América*) at a scale of 1:10,000. The printed version of the aerial photographs were digitalized and made available in JPEG format through the website ***Porto Rico 1930 Aerial Image Database*** (<http://pr1930.revistatp.com/>); a project coordinated by Professor Linda Vélez Rodríguez from the Department of Civil Engineering and Surveying of the University of Puerto Rico at Mayagüez.

The objective of the project ***Puerto Rico 1930 Georeferenced: A Costal Photomosaic*** was to georeference the 1930 aerial photographs for the coastal areas of Puerto Rico—specifically the area covering at least 1km inland from the coastline—to a geographic coordinate system (NAD 83 PR State Plane). The georeferenced photographs allow for their use into a Geographic Information System (GIS) and, consequently, can be used for spatial analysis with other geographic data of the island.

The georeferenced 1930 aerial photographs can be downloaded from the website: <http://www.prgeoref.org/>. In the remaining of this report we describe the procedure that was used for georeferencing the aerial photographs, provide a summary of the resulting aerial photographs coverage for the coastal areas of Puerto Rico, and list some of the limitations and use constraints of the georeferenced photographs.



Puerto Rico 1930 Georeferenced: A Costal Mosaic website.

Georeferrence of 1930 coastal aerial photographs

The project consisted on identifying all the available 1930 aerial photographs for the coastal areas of Puerto Rico from the *Porto Rico 1930 Aerial Image Database*. A total of 432 photographs were selected and the following steps were performed to georeference them:

1. Edition/enhancement of the 432 aerial photographs, in Photoshop, prior to their georeferencing. This was done to enhance the gray tone of some of the photographs; some which were originally too light or too dark.
2. Creation of Geographic Information System line coverages (shapefile) with features (e.g., roads, trails, rivers) that were used to georeference the aerial photographs (Figure 1). For this, the topographic maps for coastal areas of Puerto Rico for the decade of 1940 were downloaded from the USGS Map Locator & Downloader (32 topographic maps in total). These maps were georeferenced using the North American Datum 1983, Puerto Rico State Plane coordinate system. Such maps have a scale of 1:30,000 and were published between 1938 and 1953; although they were developed based on field work and aerial photographs taken between 1935 and 1949. The topographic maps from the 1940s were used as they are the closest to the date of the 1930 aerial photographs and, hence, have more features that can be identified in both, the aerial photographs and the maps, for the georeference process.

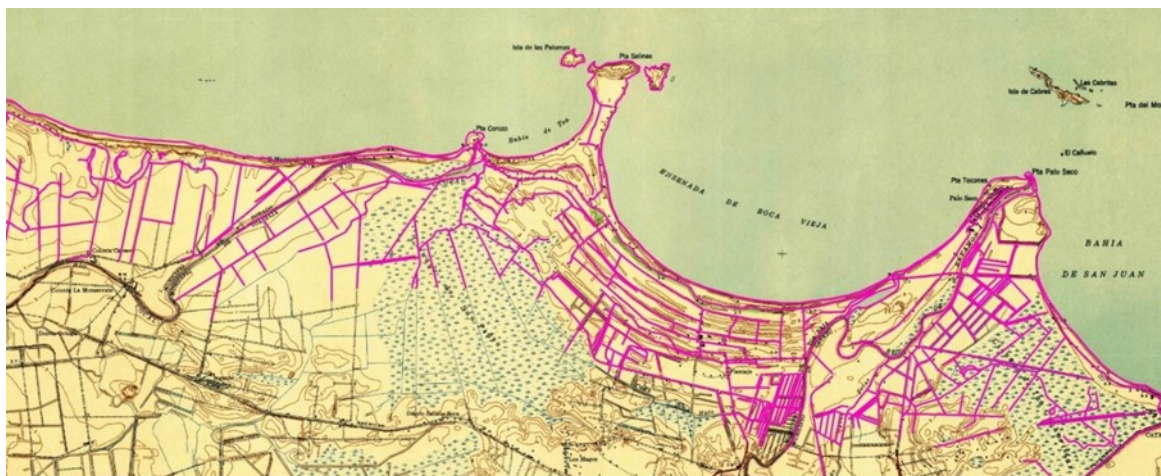


Figure 1. Example of a GIS vector line feature (in magenta) created using a georeferenced topographic map.

3. The georeference of aerial photographs was done using the Georeferencing tool of the GIS software ArcGIS 10.3.1 for Desktop. The vector line feature (Step 2) was used to georeference the aerial photographs. For this, several control point (an average of 30 for each aerial photograph) were used to align each photograph to a spatially correct location relative to the North American Datum 1983, Puerto Rico State Plane coordinate system (Figure 2). The default transformation method used by ArcGIS 10.3.1 was applied.

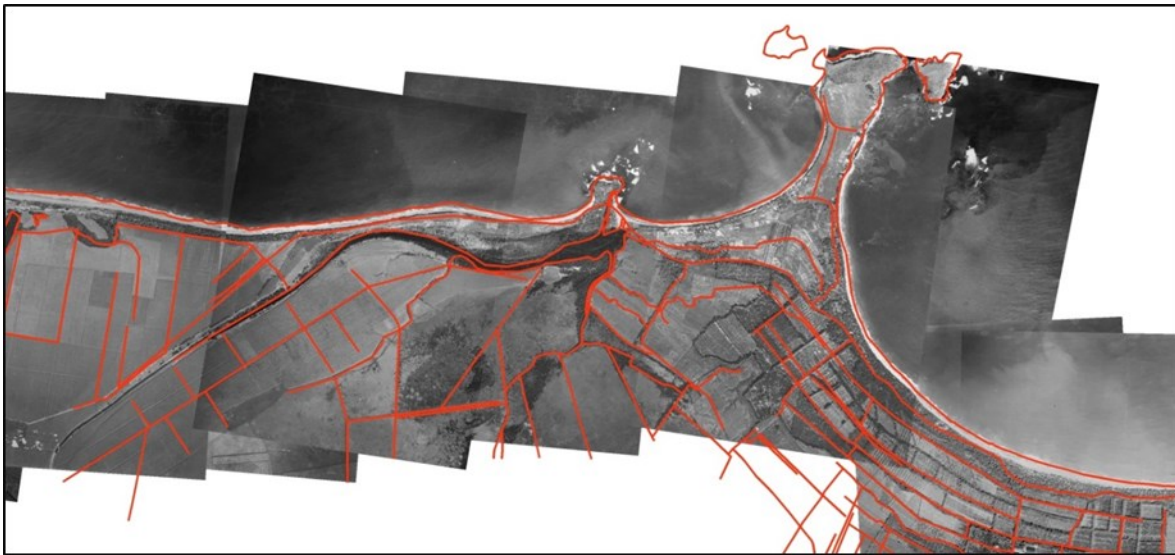


Figure 2. Example of a georeferenced aerial photograph using a GIS vector line feature for georeferencing.

4. A total of 15 mosaics were created using the GIS program Global Mapper version 18.1. Mosaics were created for continuous photographs and gaps between aerial photographs (because of non-existing or unavailable photographs) were used to determine the extent of the mosaics. Each mosaic is composed by a different number of aerial photographs, ranging from 13 to 46 photographs each (Figure 3, Table 1).

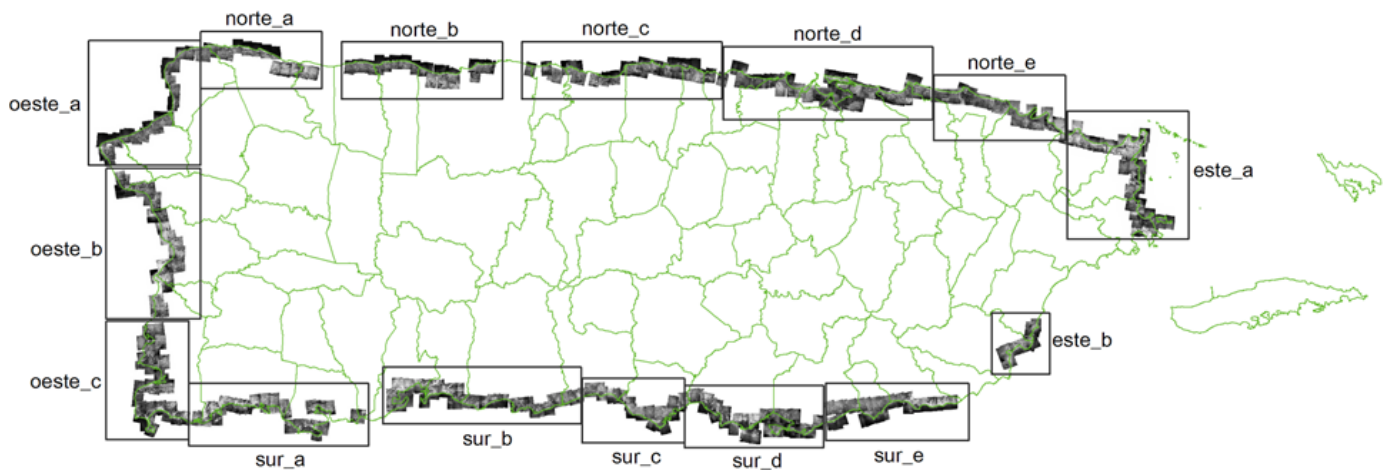


Figure 3. Spatial extent of the fifteen (15) mosaics.

Table 1. Mosaic name, number of aerial photographs composing each mosaic, and municipalities comprised within each mosaic.

Mosaic name	# of photos	Municipalities*
norte_a	18	Aguadilla, Isabela, Quebradillas
norte_b	27	Camuy, Hatillo, Arecibo
norte_c	34	Arecibo, Barceloneta, Manatí, Vega Alta, Vega Baja, Dorado
norte_d	46	Dorado, Toa Baja, Cataño, Guaynabo, San Juan, Carolina, Loíza
norte_e	23	Loíza, Río Grande
este_a	40	Luquillo, Fajardo, Ceiba
este_b	13	Humacao, Yabucoa
sur_a	31	Cabo Rojo, Lajas, Guanica, Yauco
sur_b	38	Guayanilla, Peñuelas, Ponce, Juana Díaz
sur_c	21	Juana Díaz, Santa Isabel
sur_d	28	Salinas, Guayama
sur_e	25	Guayama, Arroyo, Patillas
oeste_a	23	Aguadilla, Aguada, Rincón
oeste_b	31	Rincón, Añasco, Mayagüez, Cabo Rojo
oeste_c	34	Cabo Rojo

* Entire or portions of each municipality.

Coastal aerial photographs coverage

A total of 432 aerial photographs for the coast of Puerto Rico were georeferenced to the North American Datum 1983, Puerto Rico State Plane coordinate system

(NAD_1983_StatePlane_Puerto_Rico_Virgin_Islands_FIPS_5200) (Figure 4). These 432 photographs represent a total of 775 km² of inland coverage (Table 2, Figure 5). Because of non-existing or unavailable photographs, some municipalities did not have aerial photograph coverage (this was the case for the municipalities of Culebra, Naguabo and Vieques), and others only had portions of their coastal area covered (like Arecibo, Humacao and Naguabo). In terms of coverage within a 1 km buffer zone from the coastline, most of the municipalities (30 of 44) had more of 86% of that area covered by aerial photographs (Table 2, Figure 6). Finally, regarding aerial coverage of the coastline, 29 of 44 municipalities had more than 88% of the extension of their coastline covered by aerial photographs (Table 2).

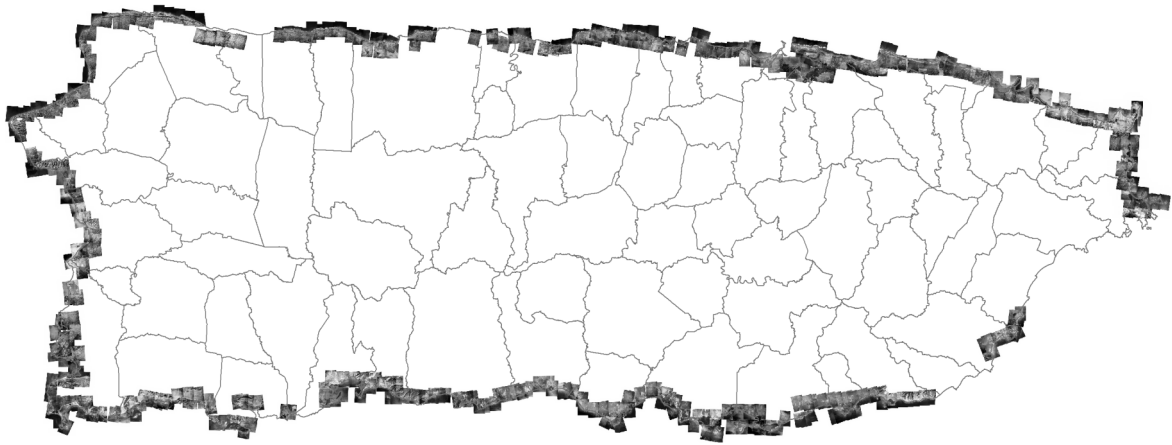


Figure 4. Georectified 1930 coastal aerial photographs.

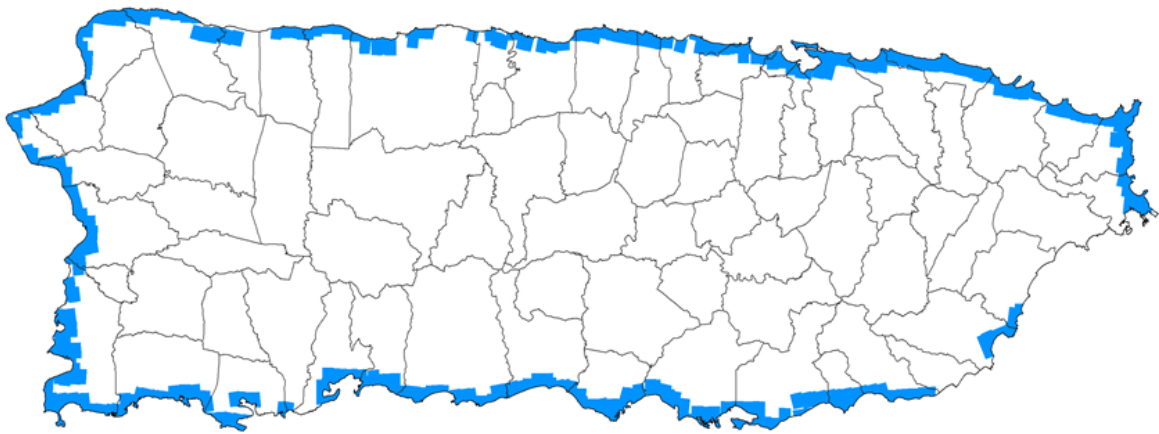


Figure 5. Georectified 1930 coastal aerial photographs: Inland coverage.

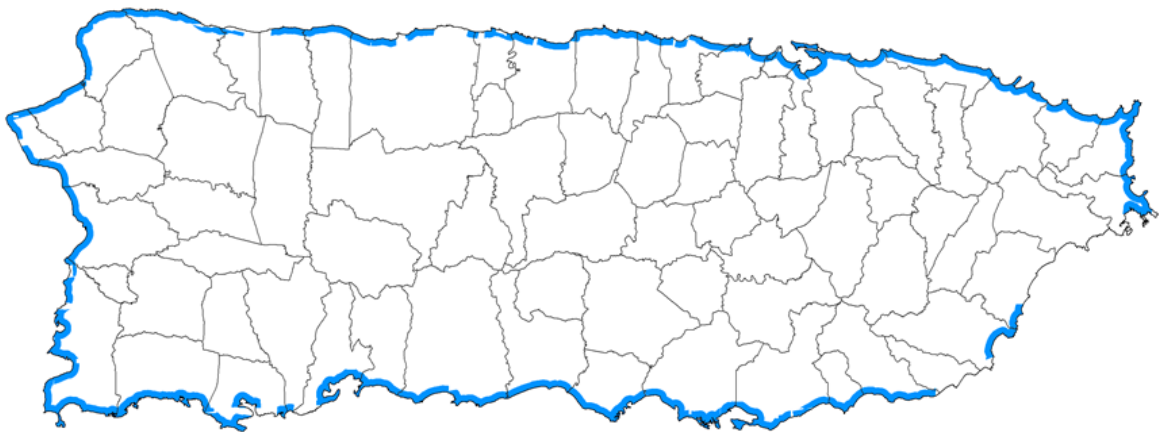
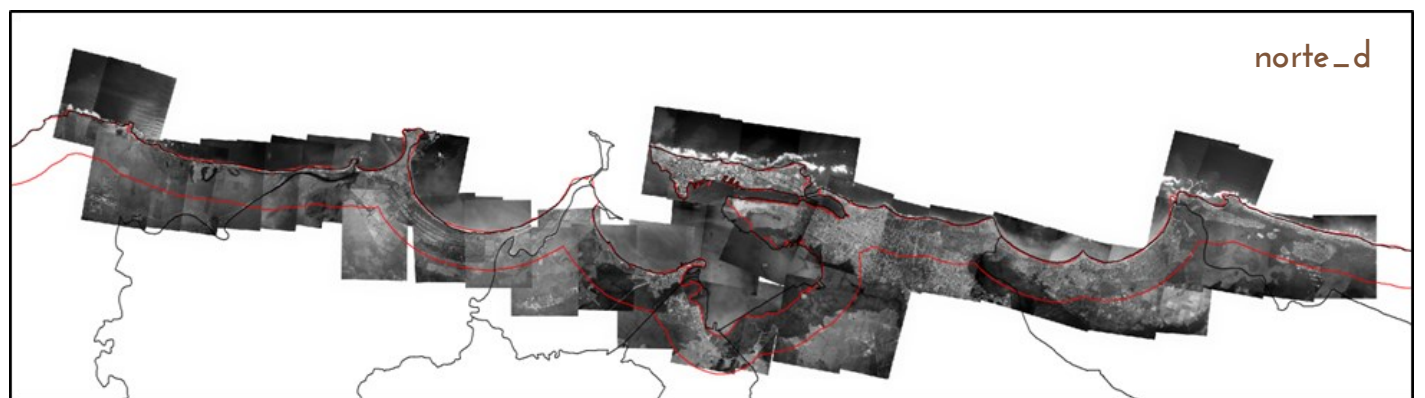
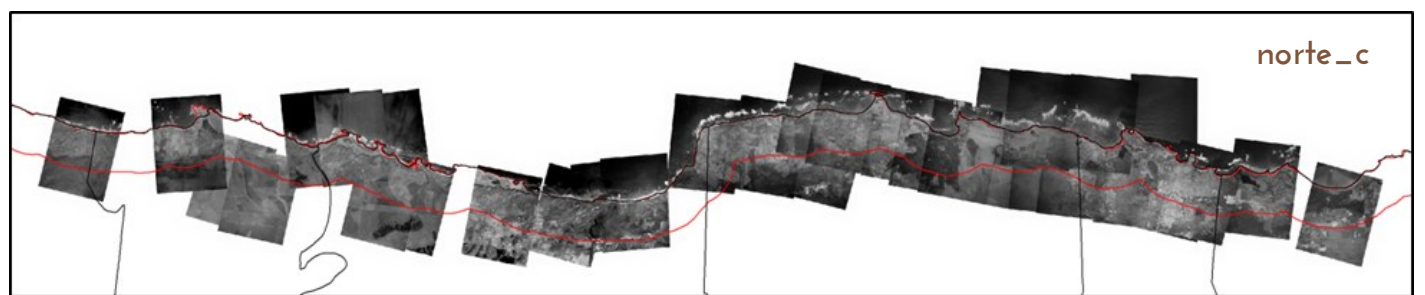
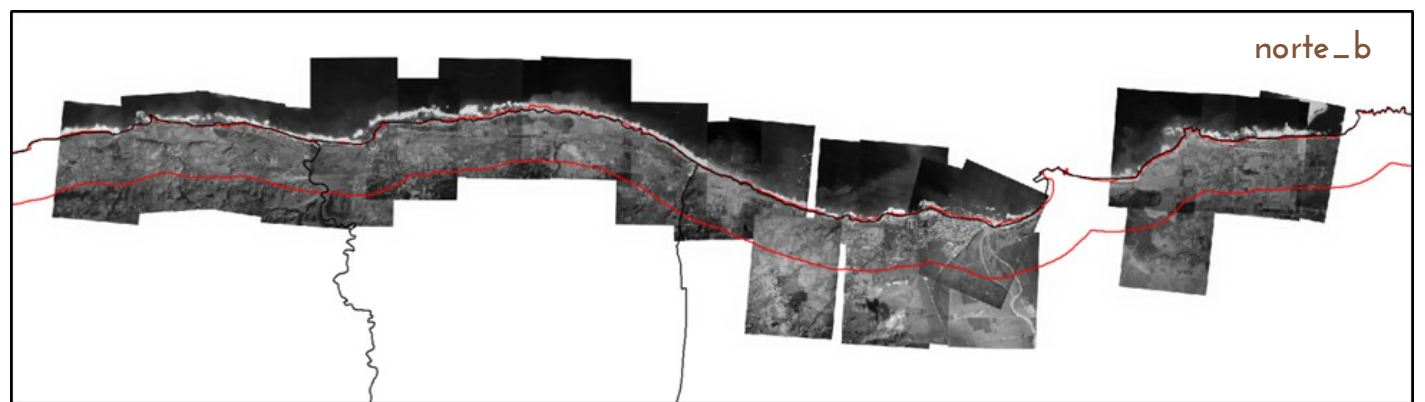
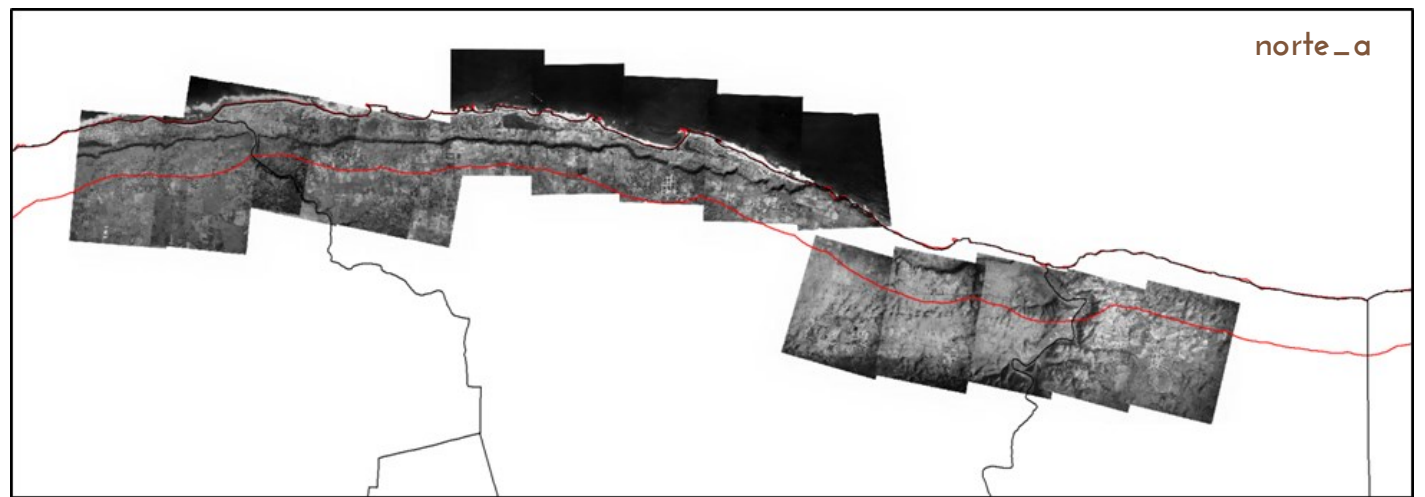


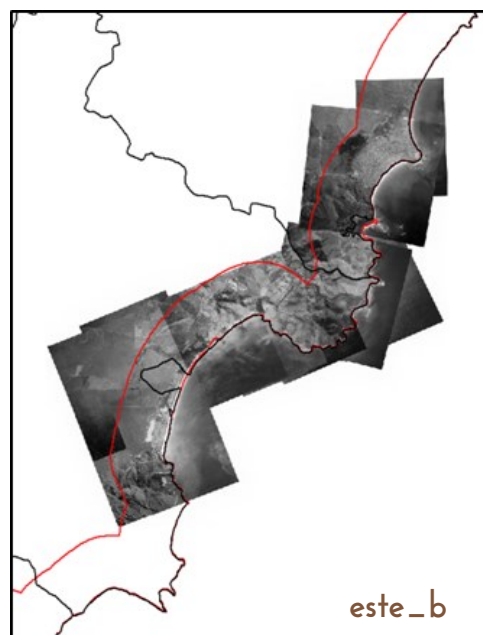
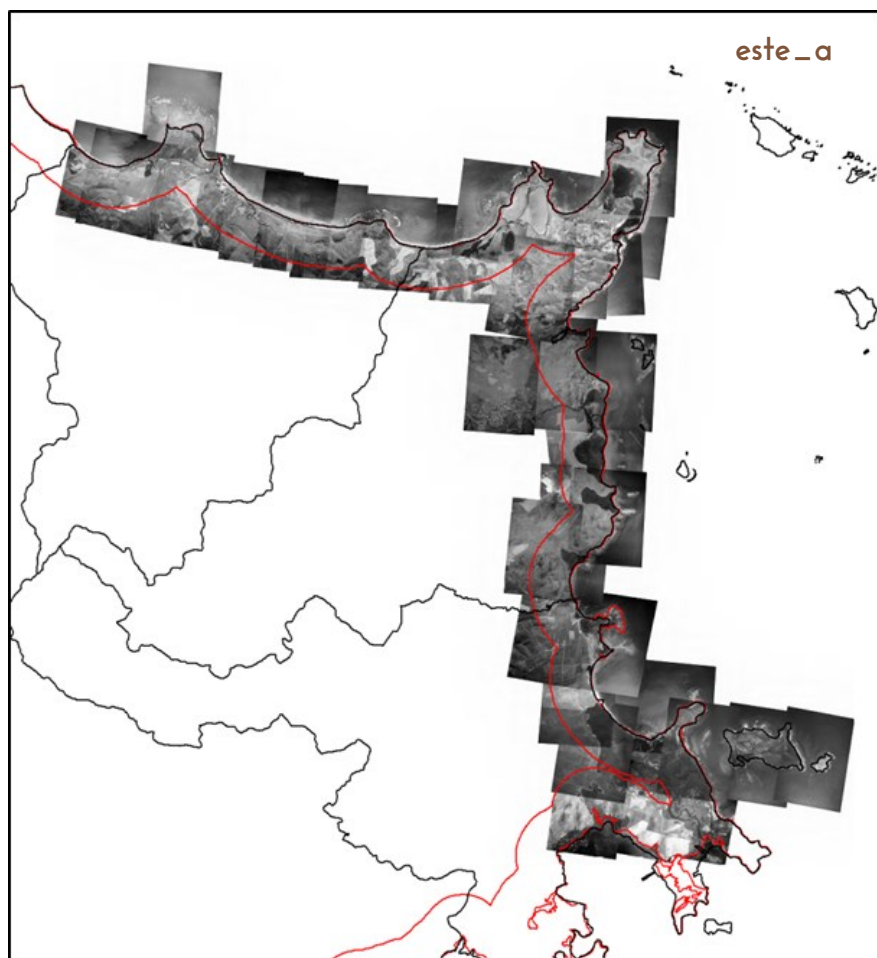
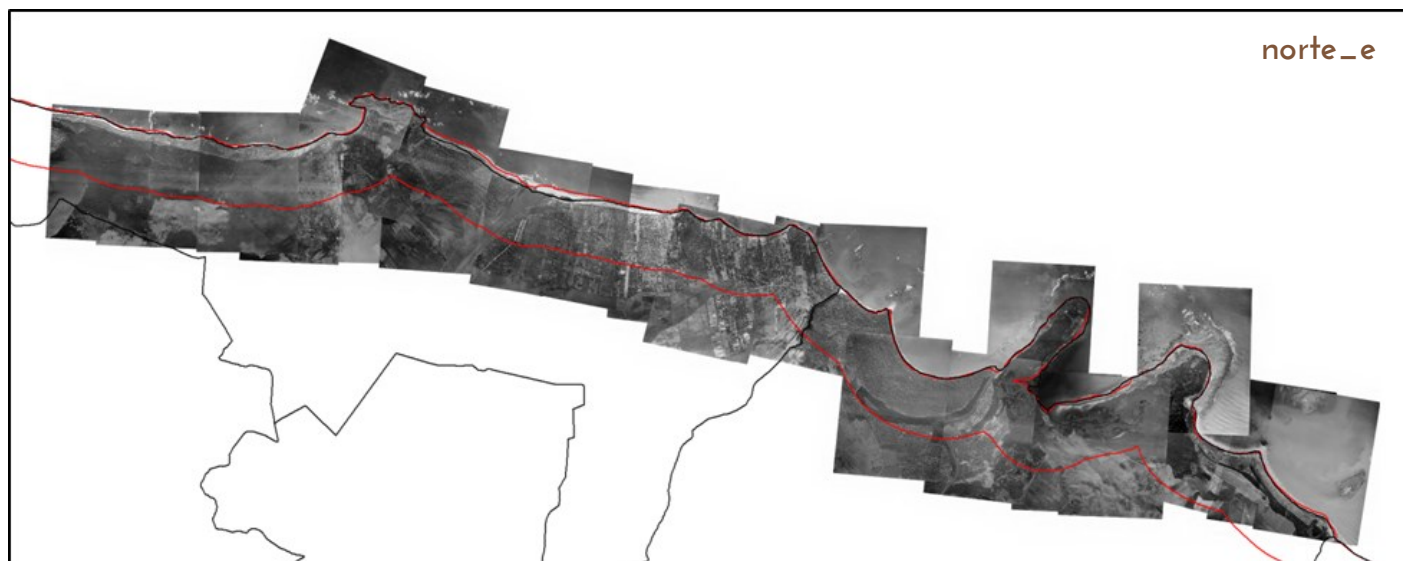
Figure 6. Georectified 1930 coastal aerial photographs: One kilometer inland buffer zone coverage.

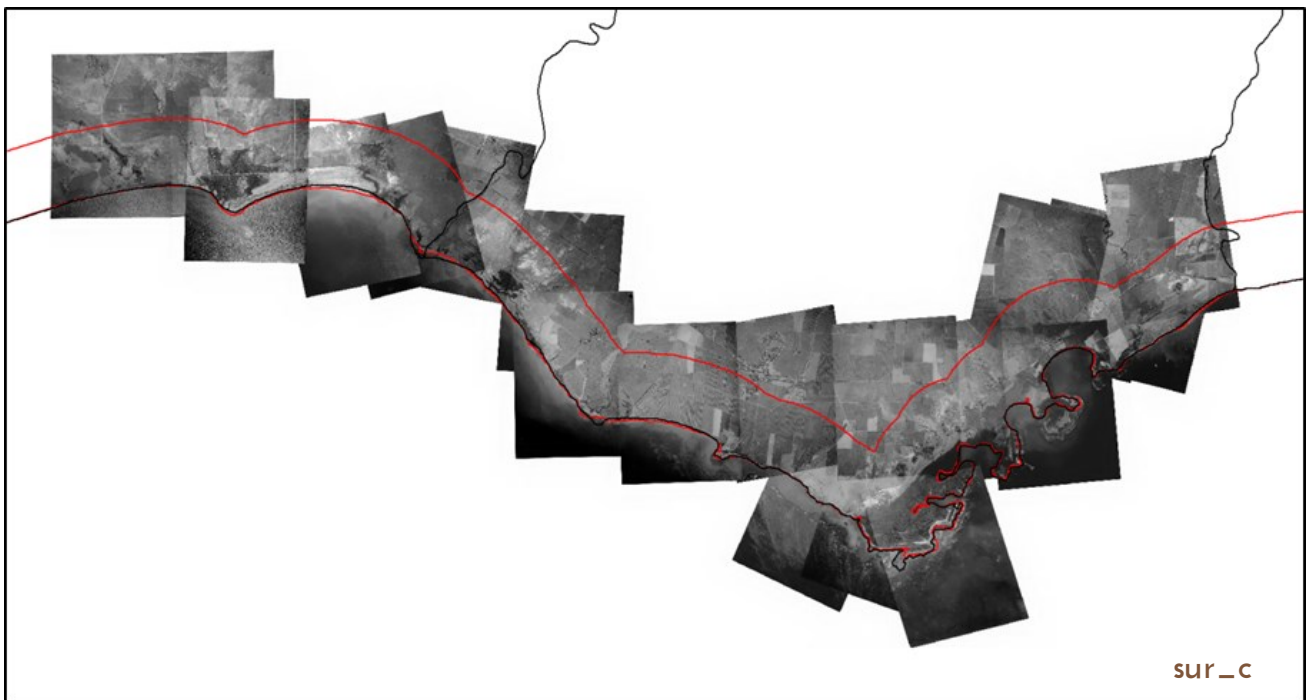
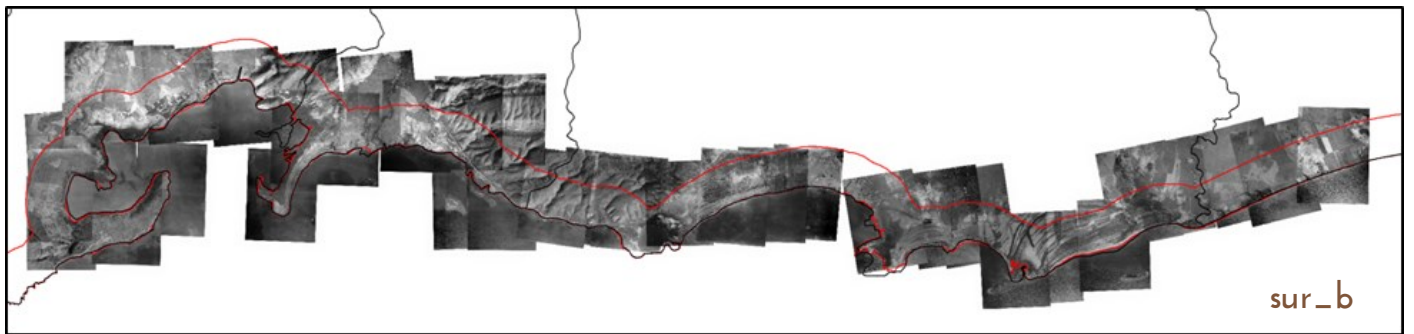
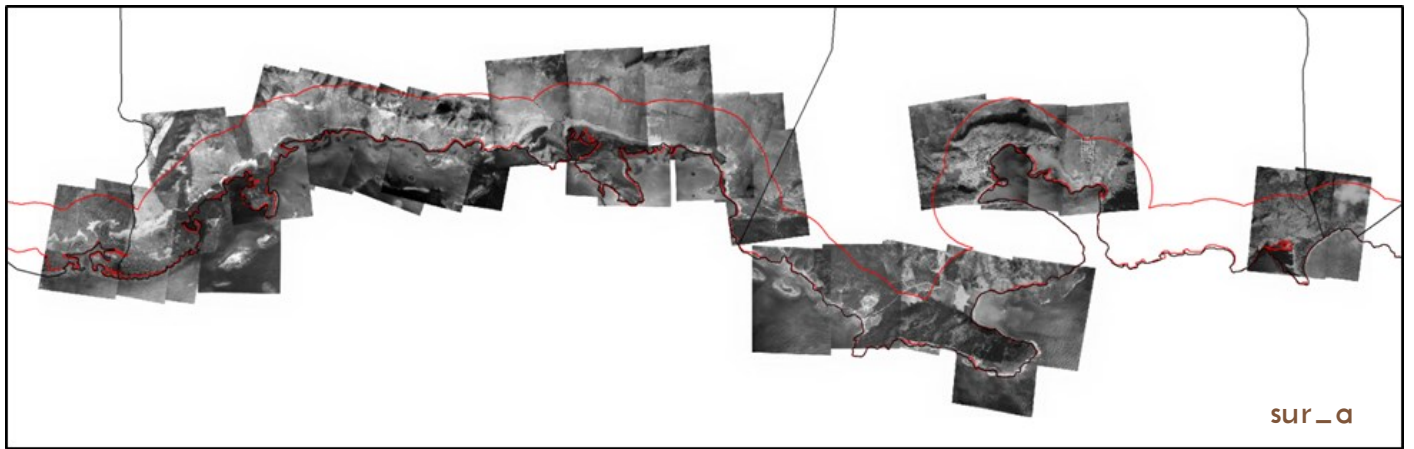
Table 2. Inland coverage, coverage within a 1 km buffer zone and coastline coverage for each of Puerto Rico's coastal municipalities.

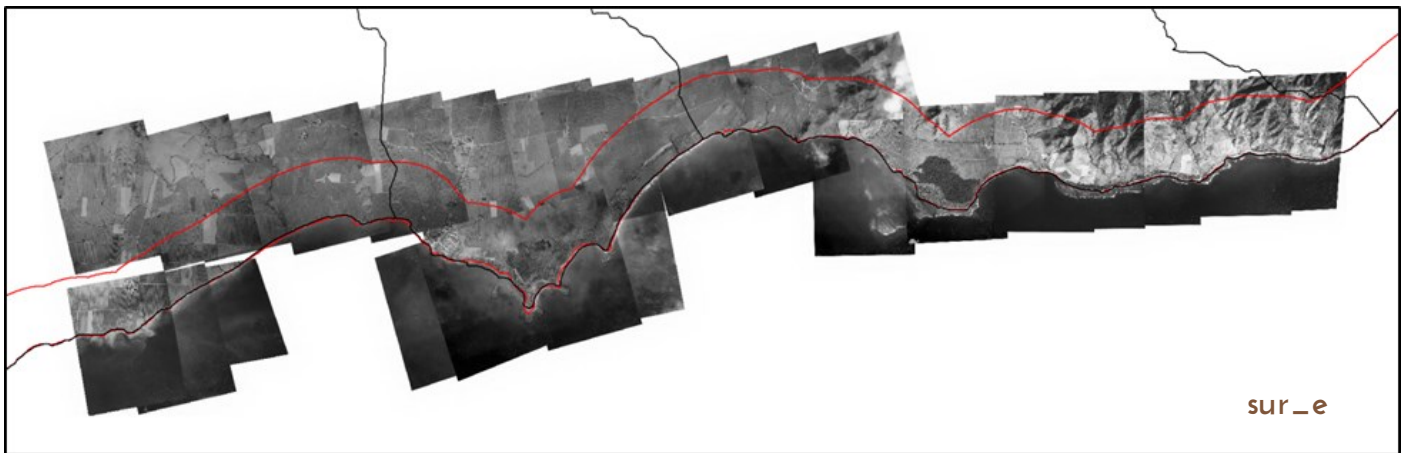
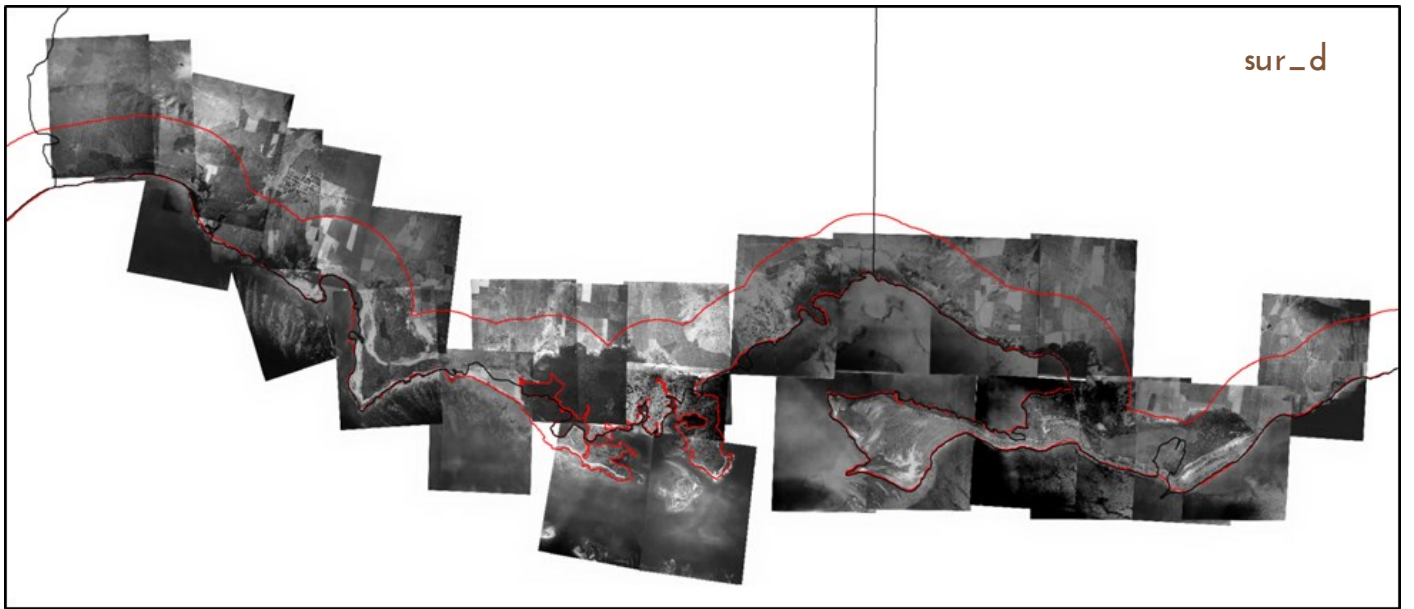
Municipality	Inland coverage (km ²)	1 km buffer zone (% coverage)	Coastline coverage (% of municipality coastline)
Aguada	16.6	99.9	99.7
Aguadilla	25.0	95.3	96.9
Añasco	11.3	100.0	100.0
Arecibo	26.5	63.2	57.0
Arroyo	13.8	99.8	97.4
Barceloneta	9.7	71.6	55.1
Cabo Rojo	74.3	93.7	92.7
Camuy	9.0	73.5	73.3
Carolina	13.6	100.0	99.3
Cataño	8.7	93.4	88.9
Ceiba	16.5	60.8	40.3
Culebra	0.0	0.0	0.0
Dorado	16.7	89.4	90.2
Fajardo	29.4	100.0	98.9
Guánica	23.9	69.4	74.6
Guayama	34.2	94.8	97.2
Guayanilla	18.2	75.5	72.9
Guaynabo	3.6	98.0	100.0
Hatillo	11.0	100.0	100.0
Humacao	5.9	28.4	32.5
Isabela	27.5	92.5	76.1
Juana Díaz	18.7	99.7	100.0
Lajas	29.4	99.7	97.9
Loíza	33.1	100.0	99.1
Luquillo	14.9	98.1	100.0
Manatí	15.7	86.5	94.2
Maunabo	0.5	0.7	0.0
Mayagüez	27.7	99.9	98.5
Naguabo	0.0	0.0	0.0
Patillas	17.0	97.0	93.8
Peñuelas	16.1	100.0	99.5
Ponce	28.7	96.8	92.8
Quebradillas	7.4	33.4	0.4
Rincón	14.9	86.6	90.9
Río Grande	17.4	95.0	99.8
Salinas	33.4	96.3	95.0
San Juan	22.9	99.9	100.0
Santa Isabel	28.4	99.9	99.9
Toa Baja	13.8	94.5	76.5
Vega Alta	7.4	100.0	100.0
Vega Baja	18.7	99.3	100.0
Vieques	0.0	0.0	0.0
Yabucoa	12.3	71.8	64.0
Yauco	1.6	77.4	100.0
Total	775.4	84.9	82.5

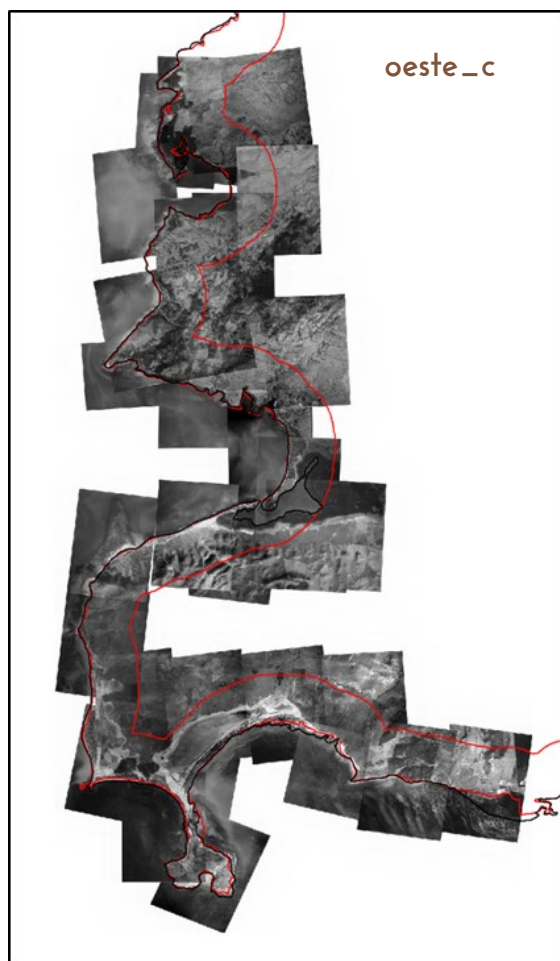
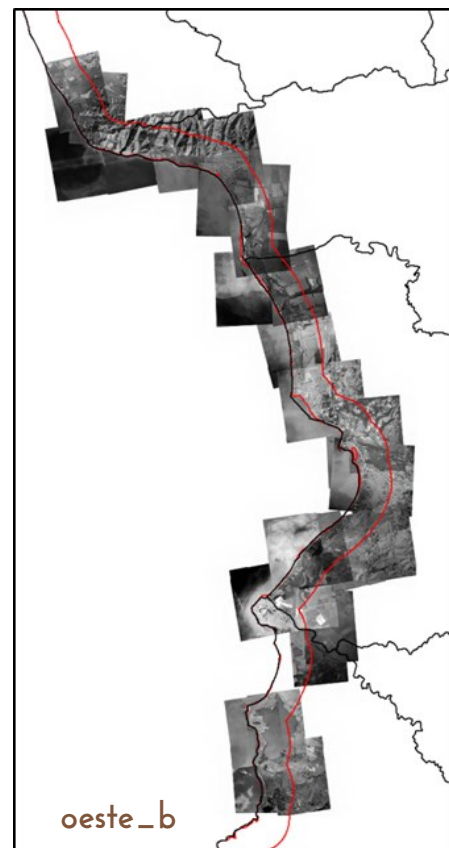
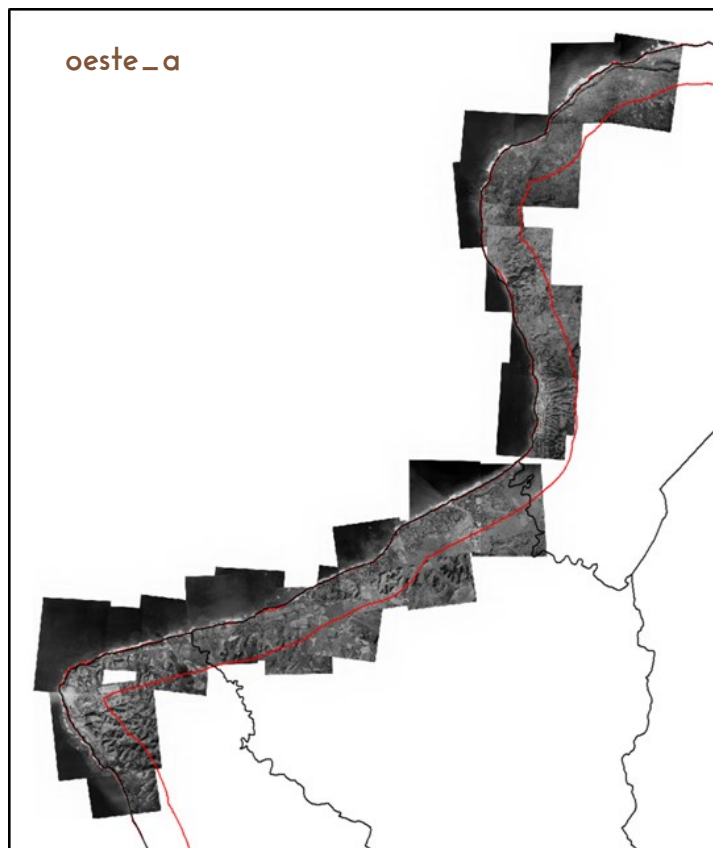
The following images show each of the fifteen (15) photo mosaics. The red line represents a 1km distance from the coastline.











Limitations and use constraints

Caution should be taken when using the georeferenced photo mosaic for analysis, particularly if the analysis requires high precision mapping measurements or when comparing with aerial photographs with different scales and of different types.

We advise to take into consideration the following when using the 1930 photo mosaics:

- Since the USGS topographic maps with scale of 1:30,000 were used for georeferencing, the mosaics are not suitable for analysis requiring a more detailed (larger) scale than 1:30,000.
- The 1930 aerial photographs used to create the photo mosaics are not orthophotos, hence the photomosaics still contain relief-related displacements.
- The scale of the 1930 aerial photos is 1:10,000, hence caution should be taken when conducting comparative analysis between the 1930 mosaics and aerial photographs from other years at other scales.
- The data should be visualized at a scale of 1:10,000 or more.

References and GIS resources

Blue Marble Geographics. 2017. Global Mapper 18.2. Gardiner, Maine: Blue Marble Geographics.

ESRI. 2015. ArcGIS 10.3.1 for Desktop. Redlands, CA: Environmental Systems Research Institute, Inc.

Sepúlveda Rivera, A. 2004. Puerto Rico Urbano: Atlas Histórico de la Ciudad Puertorriqueña (Tomo IV). San Juan, Puerto Rico: Carimar.

Vélez-Rodríguez L. , A. Acosta, J. Alayón, R. Díaz. 'About Porto Rico 1930'. Class Project: INCI 4998 'Partnership for Spatial and Computational Research' [http://revistatp.com/index.php?option=com_docman&task=doc_download&gid=26&Itemid=69]. Last accessed June 26, 2017.

Vélez-Rodríguez L. 'Turning Point: Avances en la tecnología geoespecial'. [<http://revistatp.com>]. Last accessed June 26, 2017.

Vélez-Rodríguez L. Professor, Department of Civil Engineering and Surveying. Personal communication, April 4, 2017.

Vicente, M.L. 1931. [El Mapa Topográfico de Puerto Rico](#). Revista de Obras Públicas de Puerto Rico 8(5): 117-118.

Acknowledgements

This Project was funded by the Coastal Management Zone Program of the Puerto Rico Department of Natural and Environmental Resources and the University of Puerto Rico Sea Grant Program, including its Center for the Education on Environmental Climate Change. The Faculty of Arts and Sciences of the University of Puerto Rico at Mayagüez also provided support. A special thank goes to Professor Linda Vélez Rodríguez from the Department of Civil Engineering and Surveying, UPR-M and who originally took the lead to digitalized the 1930 aerial photographs. Linda was also available and willing to provided information regarding the photographs and the *Porto Rico 1930 Aerial Image Database* project.

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How to cite this publication

López Marrero, T., M.A. Lorenzo Pérez, C.F. Rivera López, A.C. González Toro, D. Rivera Santiago, H.I Nieves Crespo and P.N. Hernández González. 2017. Porto Rico 1930 Georeferenced: A Coastal Mosaic. Interdisciplinary Center for Coastal Studies. Mayagüez, PR: University of Puerto Rico, Mayagüez Campus. 15 p.

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