

Spatial Analysis of Puerto Rico's Terrestrial Protected Areas

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In 2010, almost 13 percent of the Earth's surface was designated as protected areas—areas legally reserved for the conservation of their natural resources and biodiversity (WDPA 2011). For developed countries, this ratio was 11.6 percent, and for Latin America and the Caribbean 20.3 percent (WDPA 2011). Puerto Rico, with a total extent of 893 000 ha, is part of the Greater Antilles in the Caribbean region. The country includes one main island, three smaller islands, and numerous cays characterized by great geologic and topographic complexity. The extraordinary variety of ecosystems found in the islands contribute to its rich biodiversity, which includes over 36,000 species of plants, fungi, and vertebrate and invertebrate animals, many of them endemic to the country or to the Caribbean (Joglar 2005). As of May 2011, 8 percent of Puerto Rico's land was designated for conservation within 95 terrestrial protected areas (Gould et al. 2011), ranging from less than 1 ha to 11 429 ha, and totaling over 72 000 ha. About 56 percent of this territory was managed by the Puerto Rico Department of Natural and Environmental Resources, 16 percent by the U.S. Forest Service, 13 percent by the Conservation Trust of Puerto Rico, and 15 percent by other governmental and nongovernmental entities (Gould et al. 2011). Understanding the natural resources and distribution of this network is essential for identifying gaps in conservation and assisting with management decisions and planning. Furthermore, protecting a wide range of ecosystems that represent Puerto Rico's diverse landscape is important to ensure the conservation of the country's biodiversity and ecosystem services.

This research map describes Puerto Rico's terrestrial protected areas based on natural and anthropogenic elements of the landscape. We used geospatial data, i.e., land cover (Gould et al. 2007), urban, suburban, and rural settlements (Martinuzzi et al. 2008), and physiography to illustrate landscape elements and analyze what and how much is protected in Puerto Rico. Pie and bar charts convey statistics about each landscape element's distribution and level of protection. We also analyzed the landscape context of the protected areas by classifying each one as coastal, forested, herbaceous, or urban based on the dominant land cover that surrounds each area in a 1 km buffer and tabulated the land cover within and other statistics for each classification. Additionally, we mapped the linear distance from the protected areas providing a visual reference of the distribution and connectivity between the protected areas and charted how the land cover distribution changes from within the protected areas across distance groups.

The protected areas in this publication were last updated in May 2011 using available data obtained from local and federal government agencies and nongovernmental organizations. The amount and distribution of protected land is very dynamic, changing as new areas are set aside or for designations and management change. For the purpose of this analysis, we excluded marine protected areas as well as the marine portion of some coastal protected areas. Additional lands may be protected by laws and zoning regulations, e.g., steep slopes, wetlands, riparian zones, or the coastal zone, but were not included in this study.

Findings

Land cover:

- The protected natural areas network of Puerto Rico mainly shelters forest ecosystems (60 percent) with patches of woodland and shrubland (14 percent), grasslands (8 percent), forested wetlands (7 percent), and herbaceous wetlands (6 percent), inland water (4 percent), and natural barriers (1 percent).
- The most protected land cover type is forested wetlands (primarily mangroves) with 60 percent found inside protected areas, and followed by inland water bodies (33 percent), natural barriers (i.e., salt/mud flats, rocky cliffs, and beaches; 32 percent), herbaceous wetlands (15 percent), forest (13 percent), woodland and shrublands (8 percent), and grasslands (2 percent).
- Based on the landscape context classification, where we identified the dominant land cover in a buffer zone of 1 km around each protected area, we found that the areas predominantly bordered by forest enclose mostly forest (93 percent), while areas surrounded by coastal ecosystems, grasslands, or urban protect a wider range of land cover types.
- Nine terrestrial protected areas were classified as urban—areas mainly bordered by built-up surface. Although these amount to 9.5 percent of the 95 protected areas analyzed here, their average size is significantly smaller than those found outside urban spaces. Hence, urban protected areas constitute only 1 percent of Puerto Rico's total land cover.

Distance from protected areas:

- The distribution of the protected areas across the main island of Puerto Rico shows that there are three large regions with no protected areas in a radius of at least 5 km. Connectivity among the protected areas can also be observed where areas conglomerate presenting potential ecological corridors.
- The percentage of forest, wetlands, and inland water decreases the farther away from a protected area, while the percentage of grasslands and, less notably, built-up surface increases.

Urban, suburban, and rural settlements:

- The great majority of the protected land is located in rural lands (85 percent), followed by the suburban (13 percent) and urban (2 percent) regions.

Physiography:

- The protected areas are found across all physiographic regions of Puerto Rico with 38 percent of the protected land located in the mountains, 28 percent in the plains, 27 percent in the hills, and 7 percent in the plateau region. The three predominant physiographic regions (i.e., mountains, hills, and plains) have a similar level of protection from 7 to 9 percent, while the plateau region, found solely in the Natural Reserve of Mona Island and Monito, is fully protected.

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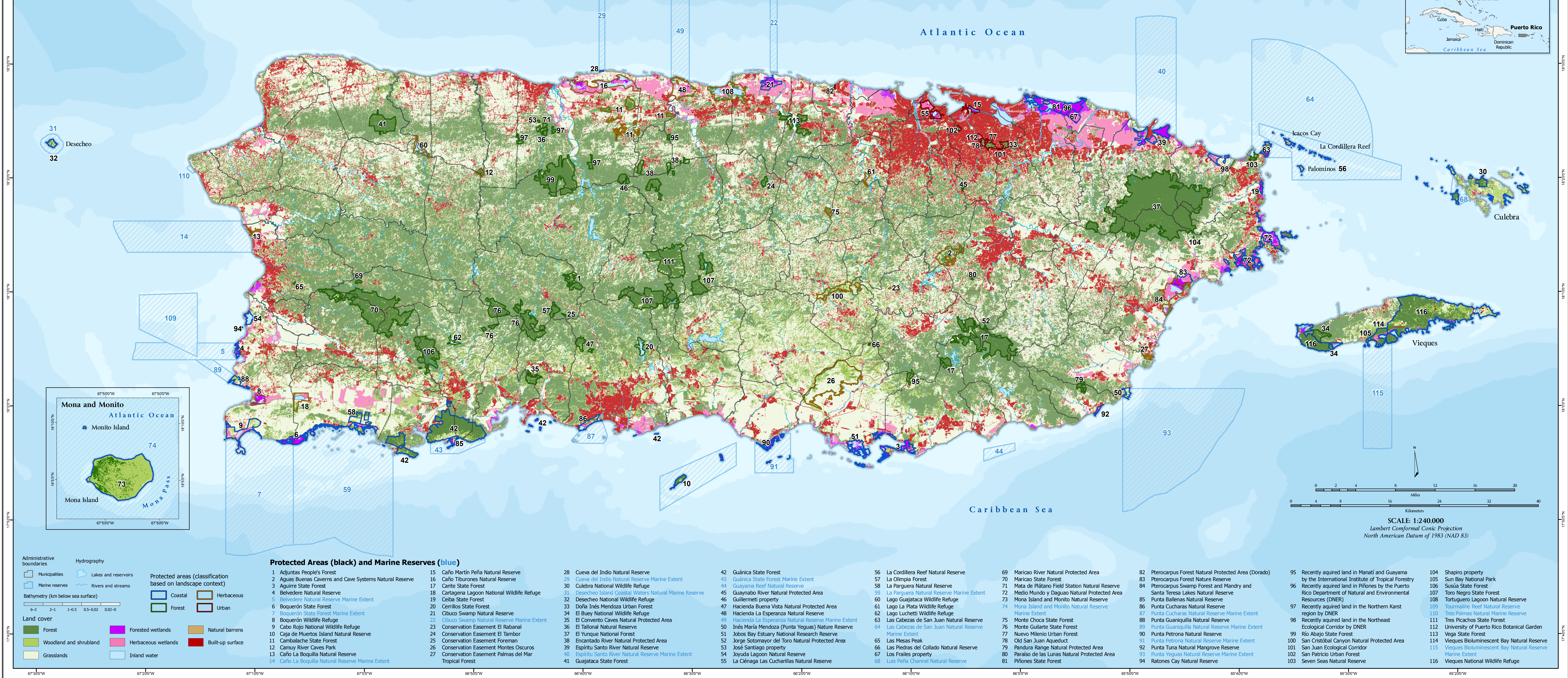
World Database of Protected Areas. 2011. The World Database of Protected Areas (WDPA). A project of the United Nations Environment Programme (UNEP) - World Conservation Monitoring Centre (WCMC) and the International Union for Conservation of Nature (IUCN), Cambridge, United Kingdom. (<http://www.wdpa.org/>). (data accessed 12 December 2012).

Geospatial data: All geospatial data was created or modified at the International Institute of Tropical Forestry (IITF) Geographic Information Systems (GIS) and Remote Sensing Laboratory.

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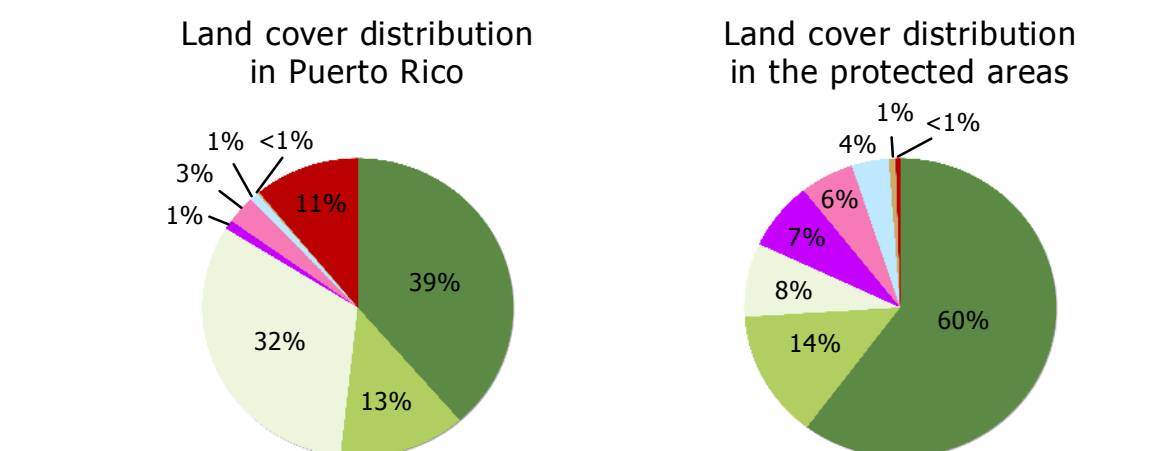
Acknowledgments
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Distribution and classification of the protected areas and the 2000 simplified land cover of Puerto Rico

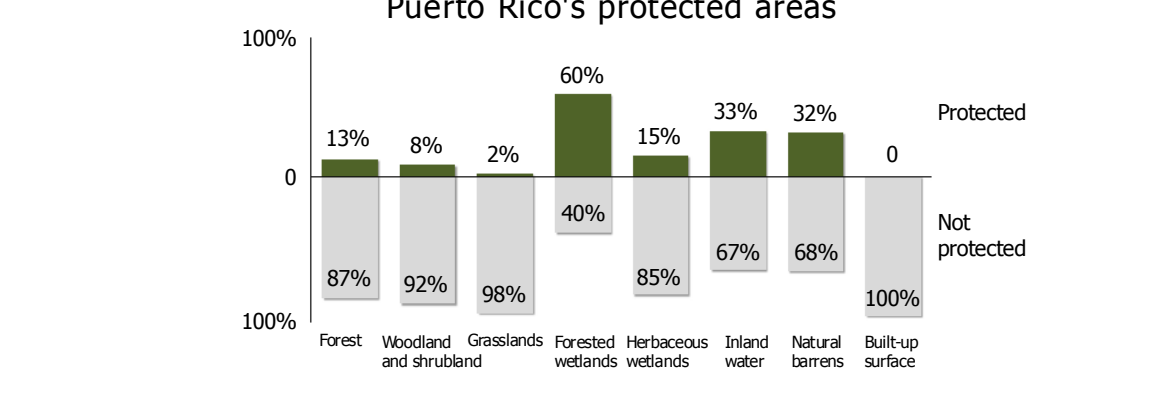


Simplified land cover of Puerto Rico in 2000

The Puerto Rico land cover of 2000 describes the dominant land cover type based on the classification of Landsat 7 ETM+ satellite imagery from 1999 to 2003 and information on climate, geology, topography, hydrology, and land use history. The land cover was simplified from the Puerto Rico Gap Analysis Project land cover (Gould et al. 2007) with a spatial resolution of 15 m.



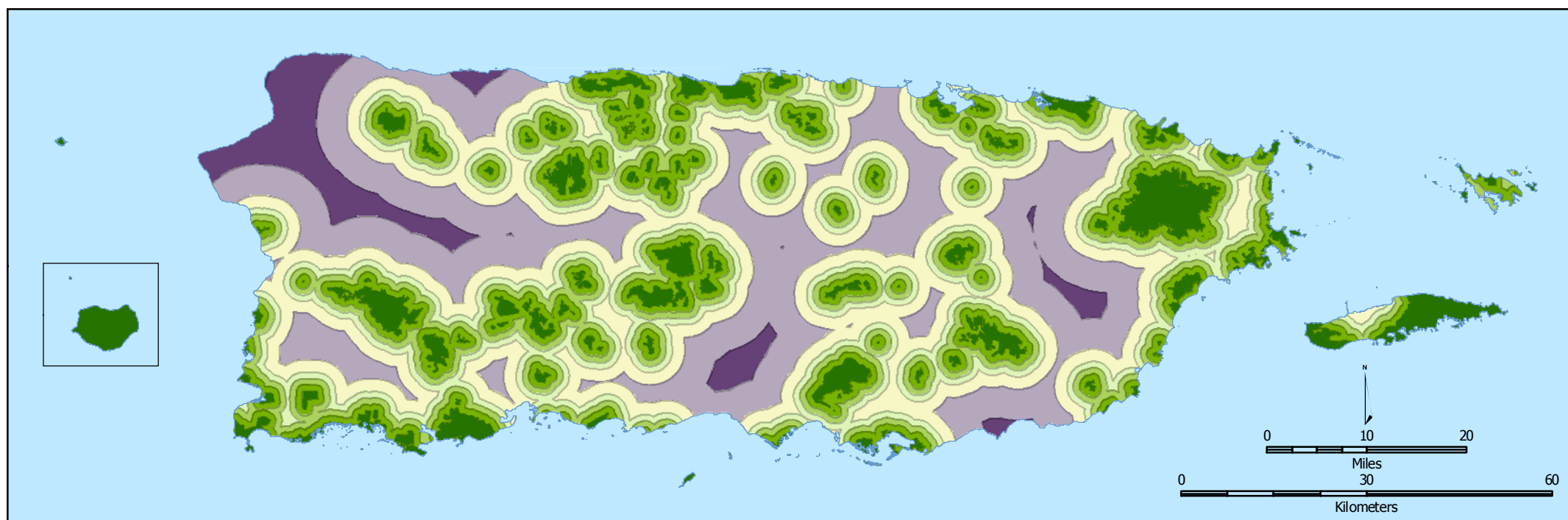
The percentage of each land cover type inside Puerto Rico's protected areas



Protected areas landscape context classification analysis

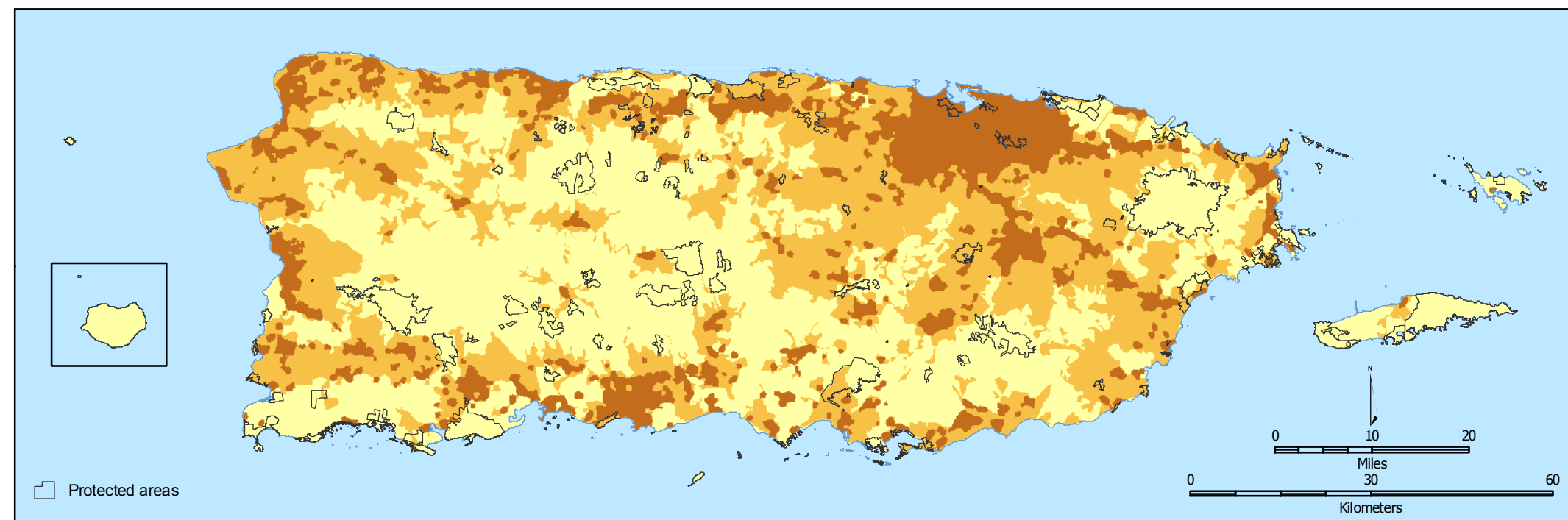
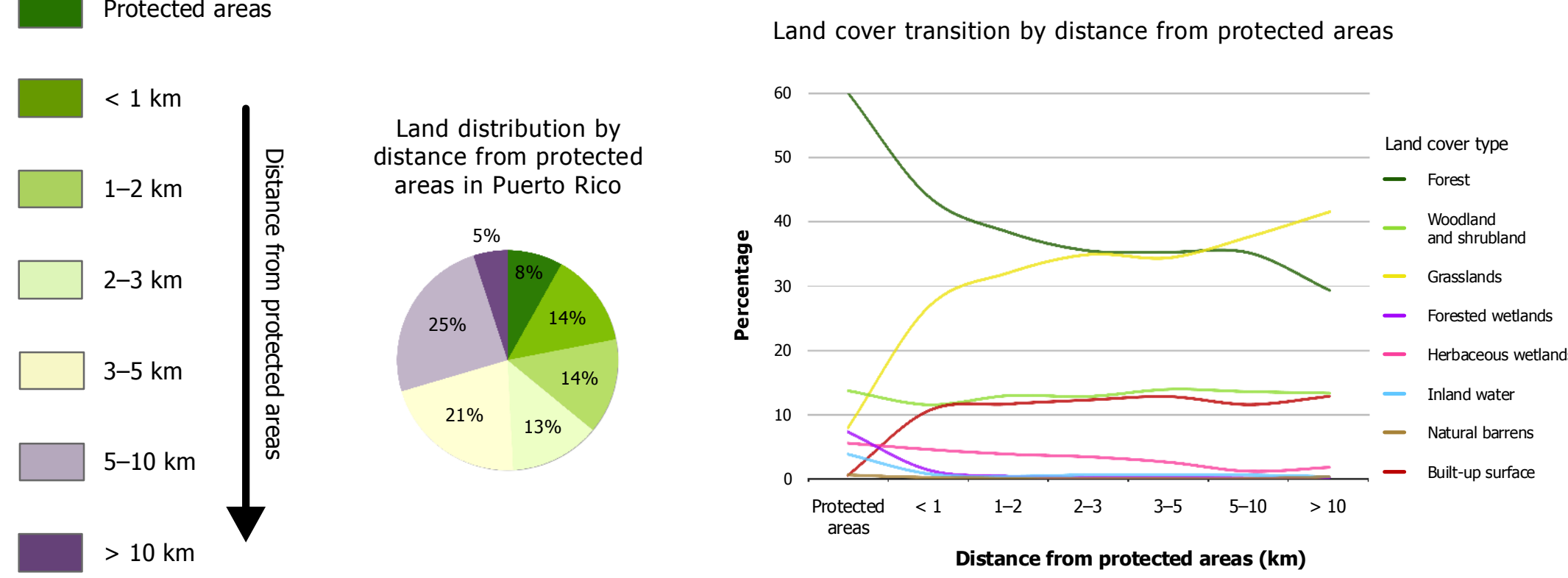
	Coastal	Forest	Herbaceous	Urban	Total
Number of protected areas	37	35	14	9	95
Protected land area (ha)	30 196	33 309	7786	1007	72 299
Protected land (%)	42	46	11	1	100
Average size of protected areas (ha)	816	952	556	112	761

	Coastal	Forest	Herbaceous	Urban	Total
Land cover distribution within the protected areas (%)					
Forest	28	60	19	2	35
Woodland and shrubland	24	4	18	7	14
Grasslands	8	2	33	9	8
Forested wetland	16	<1	5	11	7
Herbaceous wetland	10	<1	11	27	4
Inland water	5	1	13	7	4
Natural barriers	1	<1	<1	<1	1



Distance from protected areas

This supplemental map presents distance zones from the protected areas in Puerto Rico. The distances were calculated using the Euclidean distance algorithm tool in ArcGIS 9.3, which computes the linear distance between multiple areas. These distances do not take topography into account. The distribution of protected areas across the main island of Puerto Rico is not uniform, leaving large regions unprotected through this conservation mechanism. The linear graph below shows an analysis of the general land cover types inside each distance zone, where a general pattern can be observed: the percentage of forest, wetlands, and inland water decreases the further away from a protected area, while the percentage of grasslands and, less notably, built-up surface increases.



Urban, suburban, and rural settlements

The urban, suburban, and rural settlement of Puerto Rico integrates patterns of development in the landscape with population census data to describe population distribution across the country (Martinuzzi et al. 2007). The regions were classified as follows:

Urban

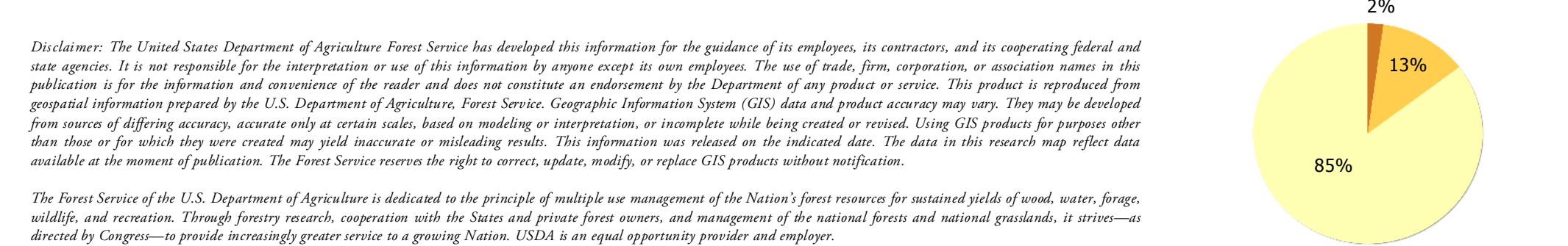
Places where built-up surface per square kilometer is more than 20 percent.

Suburban

Places where built-up surface per square kilometer is lower than 20 percent and core census block groups have a population density higher than 1000 people per square mile, plus surrounding census blocks with overall density of at least 500 people per square mile.

Rural

Places where built-up surface per square kilometer is lower than 20 percent and core census block groups have a population density lower than suburban areas.



Where is the protected land?

The percentage of each settlement region inside Puerto Rico's protected areas is shown in the pie charts. The Urban region accounts for 1% of the protected land, the Suburban region for 3%, and the Rural region for 14%.