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Defining and Mapping the Wildland-Urban Interface of Puerto Rico and the U.S. Virgin Islands: 2010 Distribution and Implications

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Defining and Mapping the Wildland-Urban Interface of Puerto Rico and the U.S. Virgin Islands: 2010 Distribution and Implications

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Abstract

The wildland-urban interface (WUI) is the area where houses are in or near wildland vegetation and where many environmental problems concentrate. Consistent WUI maps across all U.S. lands and territories are therefore needed for effective environmental management and policy efforts. However, such maps are lacking for Puerto Rico and the U.S. Virgin Islands. Here, we mapped the WUI in Puerto Rico and the U.S. Virgin Islands for 2010 using the same mapping approach as in the conterminous United States and integrating population census, land cover, and land ownership information. We found that the WUI in these territories is widespread, encompassing 65.3 percent of the land, 61.5 percent of the houses, and 63.6 percent of the people in Puerto Rico, and 52.3 percent of the land, 93.4 percent of the houses, and 91.2 percent of the people in the U.S. Virgin Islands. We summarized the WUI by municipality (for Puerto Rico) and district (for U.S. Virgin Islands), compared the amount of WUI in Puerto Rico and the U.S. Virgin Islands to that of the conterminous United States, and discussed four WUI cases of local environmental relevance related to urbanization, hydrology, and wildfire. The dataset generated here covers an important gap in WUI data for the United States, providing valuable information for understanding patterns in human land use and guiding environmental management and policy.

Keywords: wildland-urban interface, Caribbean, tropical, census, land cover

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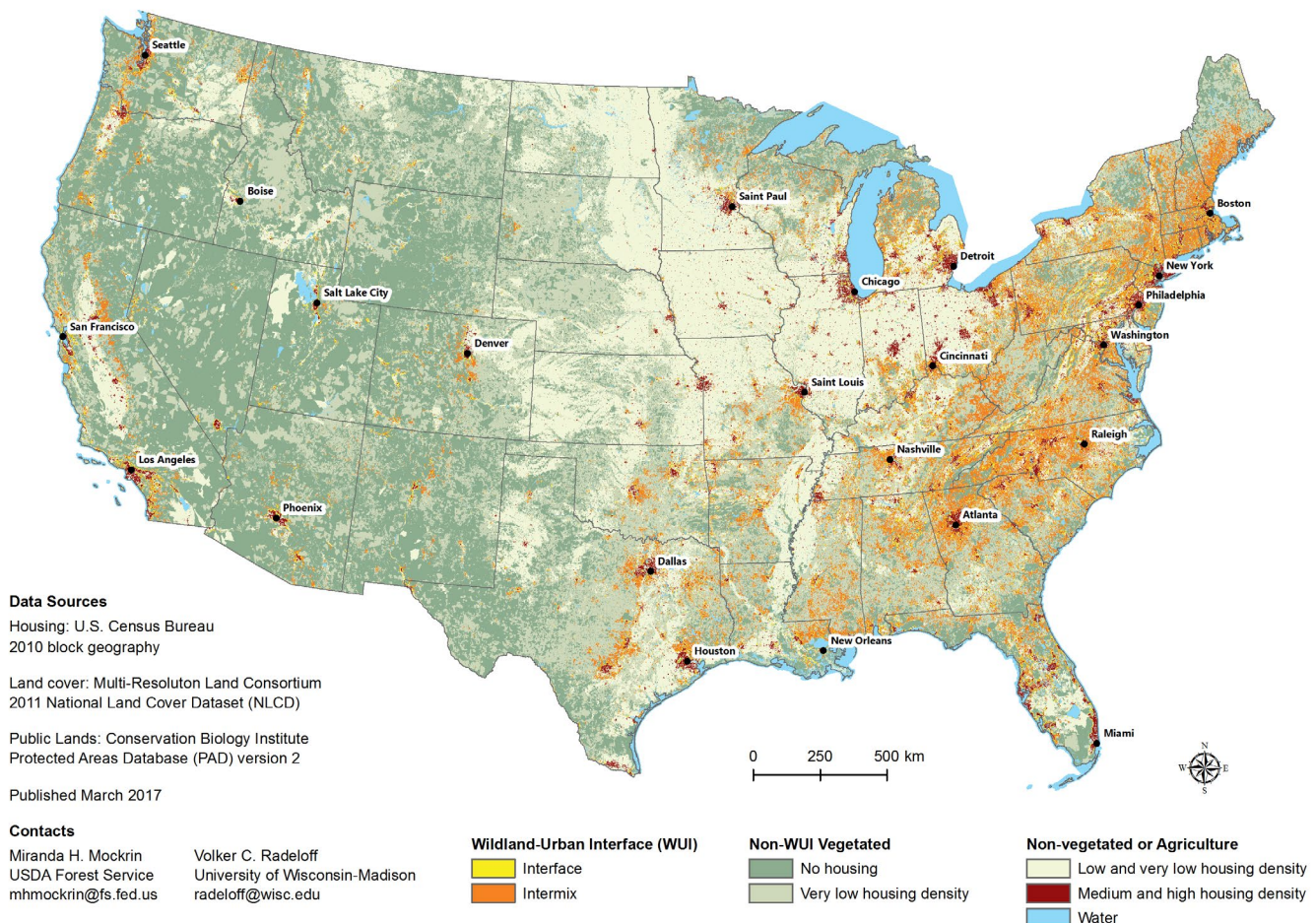
1. Introduction

1.1. What Is the WUI?

In the United States, and over the last decades, human population is becoming less concentrated in urban centers as more people decide to live out in the suburbs, exurbs, and rural areas (Brown et al. 2005, Sonti et al. 2023). This trend has resulted in rapid development of the periphery of metropolitan areas, and into rural areas with attractive aesthetic and recreational amenities, like forests (Johnson et al. 2005, Radeloff et al. 2005a). In turn, this has caused a steady expansion of the **wildland-urban interface (WUI)**,

the area where houses are in or near wildland vegetation (Radeloff et al. 2005b, 2018). In the conterminous United States in 2010, the WUI covered about 10 percent of the land (fig. 1-1) and one-third of all houses occurred in the WUI (Martinuzzi et al. 2015). But the WUI is not exclusive to the United States and is also widespread in many countries around the world (Schug et al. 2023), such as Australia (Buxton et al. 2011), Chile (Buxton et al. 2011), France (Lampin-Maillet et al. 2010), South Africa (van Wilgen et al. 2012), and others (Godoy et al. 2019, Kaim et al. 2018, Modugno et al. 2016).

Figure 1-1. The wildland-urban interface (WUI) in the conterminous United States in 2010. The WUI is composed of both interface and intermix. Intermix WUI refers to areas where housing and wildland vegetation intermingle, while interface WUI refers to areas where housing is in the vicinity of a large area of dense wildland vegetation. Source: University of Wisconsin-Madison's SILVIS Lab (<https://silvis.forest.wisc.edu/data/wui-change>). Updated contact information for Miranda Mockrin is miranda.h.mockrin@usda.gov.



1. Introduction

1.2. Why Is There Interest in the WUI and Mapping Its Location?

The WUI is an important concept and landscape component to understand because it is where many environmental problems concentrate. Traditionally, the WUI has received major attention from a wildfire perspective because it is where wildfires pose the greatest risk to people, as houses and flammable vegetation are in close proximity, and because most fires are human caused (Kramer et al. 2019; Mietkiewicz et al. 2020; Radeloff et al. 2005b, 2023). However, housing in the WUI affects the surrounding ecosystems in many ways that go beyond fires (Bar-Massada et al. 2014). Increases in housing density and associated development have been linked to increases in habitat loss and fragmentation (González-Abraham et al. 2007), introduction and spread of nonnative species (Gavier-Pizarro et al. 2010), transmission of zoonotic disease (e.g., Lyme disease; Larsen et al. 2014), and reduced water quality, forest carbon storage, timber production, and recreational benefits (Stein et al. 2005), among others. Thus, delineating the WUI is important for various management and policy goals. A comprehensive review of the WUI in the United States in terms of mapping, fire, policy, and human health implications can be found in Zipperer et al. (in preparation).

For the 48 States in the conterminous United States and the District of Columbia, the U.S. Department of Agriculture, Forest Service, in collaboration with the University of Wisconsin-Madison's SILVIS Lab (fig. 1-1; data available at <https://silvis.forest.wisc.edu/data/wui-change> and <https://www.fs.usda.gov/rds/archive/catalog/RDS-2015-0012-3>) has operationalized the mapping of the WUI using a standard method that integrates population census, land cover, and land ownership spatial datasets (Martinuzzi et al. 2015; Radeloff et al. 2005b, 2018). Because no WUI maps existed for the U.S. territories in the Caribbean (including Puerto Rico and U.S. Virgin Islands), this report fills that gap via a new collaboration of the Forest Service's International Institute of Tropical Forestry and the University of Wisconsin-Madison's SILVIS Lab.

1.3. Defining and Mapping the WUI in Puerto Rico and the U.S. Virgin Islands

This report focuses on the mapping of the 2010 WUI in Puerto Rico and the U.S. Virgin Islands using the standard method developed by Radeloff et al. (2005b, 2018) and complements the previous work by Martinuzzi et al. (2007). The report by Gould et al. (in preparation) provides the most recent review of the ecological, sociological, and management issues of the WUI for Puerto Rico and the

U.S. Virgin Islands, which is summarized in box 1-1. In addition, Martinuzzi et al. (2007) provided estimates of the geographic extent of the WUI for Puerto Rico and the U.S. Virgin Islands. However, those estimates did not follow a formal definition of WUI, and instead were proxies based on land use or land cover data. Unfortunately, the differences in methodologies make these estimates difficult to compare to other places in the United States. Consistent WUI information across all U.S. lands is needed for effective environmental management and policy efforts at the national level. We mapped the WUI based on housing data from the 2010 U.S. census because the 2020 census was not available when we started this report. However, this should not be a problem for representing the “current” WUI because the number of housing units changed only a little between 2010 and 2020, including a 2.4-percent decline in Puerto Rico and 2.4-percent increase in the U.S. Virgin Islands.

1.4. Goal and Objectives

Our goal is to map and describe the WUI in Puerto Rico and the U.S. Virgin Islands using the same approach as in the conterminous United States. We provide in this report:

- WUI maps for Puerto Rico and the U.S. Virgin Islands, as well as for each municipality and district in Puerto Rico and the U.S. Virgin Islands, respectively
- Summary statistics describing the WUI in terms of area, number of houses, and people
- A comparison of the WUI in Puerto Rico and the U.S. Virgin Islands versus the States in the conterminous United States
- Special cases of WUI relevant for local managers and policy makers:
 - WUI around El Yunque National Forest
 - WUI in the San Juan Metropolitan Area
 - Hydrology and WUI
 - Fires and WUI

Box 1-1. Ecological, sociological, and management issues of the WUI in the U.S. Caribbean.**Ecological considerations**

- Vegetated areas in the WUI of the U.S. Caribbean contain high numbers of species and various vegetation associations.
- WUI vegetation includes a range of novel species assemblages, combining nonnative and ruderal or actively managed subsistence agriculture species, along with native wind-dispersed and fauna-dispersed species.
- Many of the green spaces in the WUI provide various ecological services, including food provision.
- Vegetated areas in the WUI are habitats for faunal communities, which in turn disperse and maintain a range of vegetation associations and novel species assemblages.
- Urban heat island conditions occur in part of the WUI, with effects reaching wildland areas, raising concerns about projected warming temperatures and decreasing precipitation for the U.S. Caribbean.
- Management of storm waters and used waters in the WUI has implications for downstream urban water quality and upstream wildland migratory aquatic fauna.
- Management of surface water channels, streams, rivers, and roads and the spatial configuration of vegetated areas influence the ecology of the WUI, and in turn, the capacity to provide ecosystem services.

Social issues

- Population and economic conditions are social drivers that influence WUI landscape dynamics.
- The populations of Puerto Rico and the U.S. Virgin Islands are declining.
- In both territories, high poverty rates reflect in part the local economy that has languished since the mid-2000s, particularly since the 2008 recession.

- Population demography and economic changes in Puerto Rico and the U.S. Virgin Islands result in housing vacancies and declines in public services.
- More research is needed on resident/stakeholder attitudes toward vegetation cover in the WUI, which affect the management of those vegetated areas, and in turn, ecological and social conditions in the WUI.

Management and governance actions and constraints

- Consistent planning and zoning implementation is lacking in the WUI of Puerto Rico and the U.S. Virgin Islands. WUI is managed and protected to varying degrees across the islands as it is perceived as valuable extensions of green spaces.
- Urban areas continue to be developed within and around existing wildlands.
- Inconsistencies in planning, zoning, and enforcement affect ecosystem services from forests and other vegetated areas in the WUI.
- Changes in zoning result in alterations to permitted uses, mostly affecting natural and wildland areas, altering the distribution of WUI.

Disturbances and resilience of green areas in the WUI

- Droughts and hurricanes affect vegetated areas in the WUI differently than in wildland areas.
- There are differences in the amount and type of vegetation loss and associated capacity for resilience in the WUI after disturbances such as hurricanes, but the factors that contribute to these differences have not been thoroughly studied.
- The disturbance and resilience dynamics of vegetated areas in the WUI are thought to be influenced by their extent, shape, configuration in combination with previous land use legacies, and current management policies.

Source: Summarized from Gould et al. (in preparation).

2. Methods

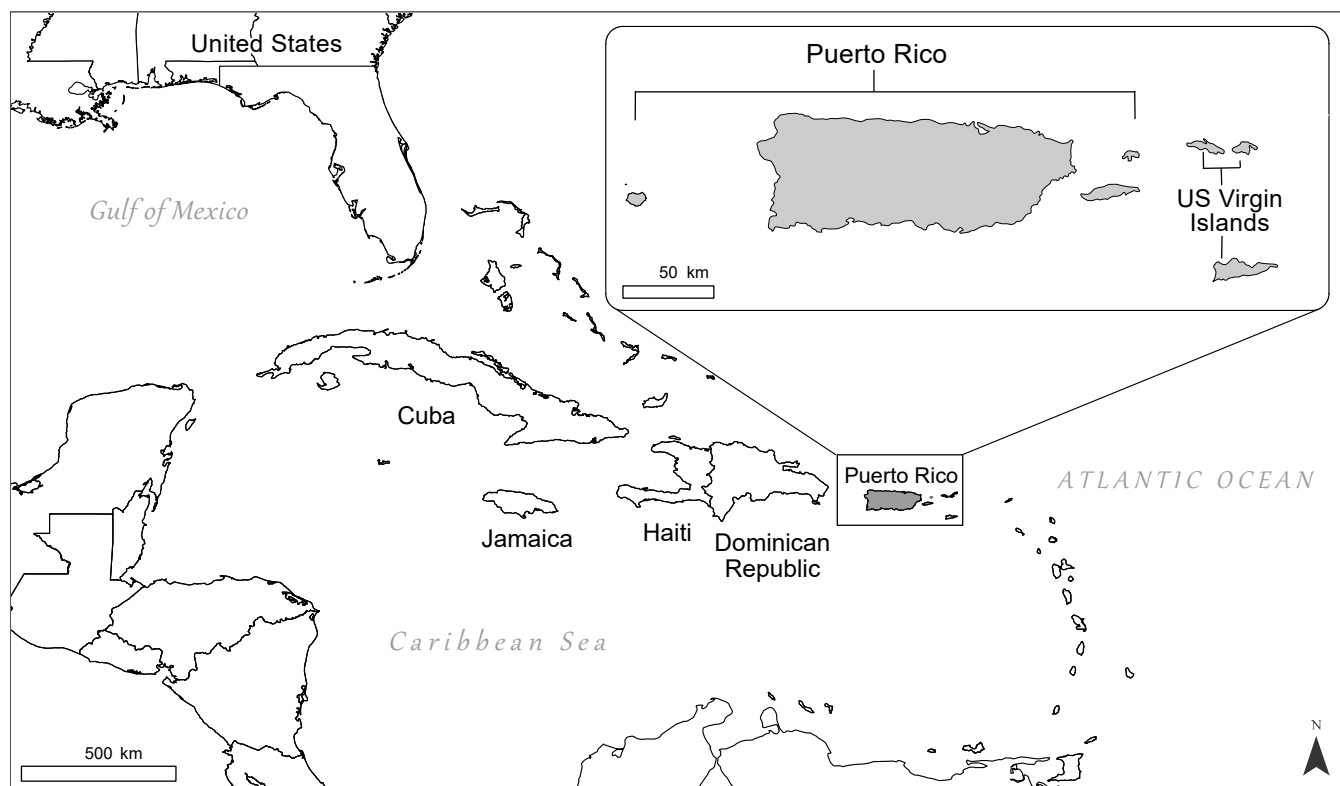
The information in this section follows our previous report mapping the WUI in the conterminous United States for 2010 (Martinuzzi et al. 2015). For consistency, some standard definitions, explanations, and steps are also presented here.

2.1. Study Area

The islands and archipelagos of the Commonwealth of Puerto Rico and the territories of the U.S. Virgin Islands are located in the eastern part of the insular Caribbean, between the island of Hispaniola (containing Haiti and Dominican Republic) to the east, and the British Virgin Islands to the west (fig. 2-1). The Commonwealth of Puerto Rico (hereafter Puerto Rico) includes the main populated islands of Puerto Rico, Culebra, and Vieques, along with numerous cays and islets. The territories of the U.S. Virgin Islands (hereafter U.S. Virgin Islands) include three populated islands: St. Thomas, St. John, and St. Croix, and numerous cays and

islets, some of which are populated. The climate in this Caribbean region is tropical and predominantly maritime-derived, with rainfall associated to Atlantic Inter-Tropical Convergence Zone, and land-sea interactions (Martinez et al. 2019). This region is defined as vulnerable to climate due to population being concentrated in urbanized coastal areas and economic dependence on industries associated with tourism and agriculture (López-Marrero and Wisner 2012). This region is also subject to Saharan dust events, increasingly severe droughts, several cyclonic events per year (storms, hurricanes), major floods, and occasional earthquakes (López-Marrero and Heartsill-Scalley 2012).

Figure 2-1. Location of Puerto Rico and the U.S. Virgin Islands in the Caribbean.



2.1.1. Puerto Rico

According to the 2010 U.S. census, Puerto Rico covered 8,563 km² and had a population of 3,725,789 people and 1,636,946 housing units.¹ The island's physiography is characterized by the presence of a central mountain range running east to west with a maximum elevation of 1,338 m, surrounded by coastal plains and crossed by a large network of perennial streams and rivers. About 30 percent of the island, especially in the north, is characterized by surficial karst landforms with very rugged topography. The majority of the population is distributed along the coast and interior valleys throughout Puerto Rico, with the greatest concentrations in the San Juan metropolitan area (in the north) and Caguas (in the center-east), and high levels of urban sprawl characterizing the island as a whole (Martinuzzi et al. 2007) (fig. 2-2). Forest covers 55 percent of the island (Marcano-Vega 2017), the largest areas of which occur in the central mountains and karst areas, with forest types ranging from dry forests in the southeast, moist forests covering the major proportion of the island, and wet, rain, and cloud forests at higher elevations. The forests of Puerto Rico are mostly second-growth forests that have recovered naturally after the abandonment of agriculture and pastures since the 1940s, mainly in mountainous areas. Currently, agriculture and pastures are concentrated in the coastal plains, sharing the land with wetlands and many urban areas.

In 2010, the gross domestic product (GDP) per capita in Puerto Rico was about half that of the United States (World Bank 2023), with an industrial sector larger than the agricultural sector, complemented by tourism as an important component and driver of the economy. Beyond the issues specifically identified in the U.S. Caribbean WUI (box 1-1), additional environmental issues in the landscape of Puerto Rico include solid waste management, soil erosion, increasing occurrence and severity of droughts, heavy dependence on oil for production of electricity, management of industrial pollution (Brinton et al. 2023), and vulnerability of coastal zones pressured by urban development and sea-level rise (Gould et al. 2018, Yu et al. 2019). Small-scale fires for land management are common in some parts of the island, especially in the southern, driest part, but wildfires are rare (for more details, see "Case study 4: Considerations for fire potential in the U.S. Caribbean").

¹ According to the U.S. census, a housing unit is a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied, or, if vacant, is intended for occupancy as separate living quarters. Both occupied and vacant housing units are included in the housing unit inventory. More information can be found in <https://www.census.gov>.

2.1.2. U.S. Virgin Islands

According to the 2010 U.S. census, the U.S. Virgin Islands covered 346 km² and had a population of 106,405 people and 55,901 housing units. The GDP per capita was about 80 percent that of the United States (World Bank 2023). The physiography is characterized by hills and ridges that reach a maximum elevation of 475 m, with steep gradients for St. Thomas and St. John, while the island of St. Croix has a coastal plain toward the south. Unlike Puerto Rico, there are no permanent freshwater bodies. Population density is concentrated in the towns of Charlotte Amalie on St. Thomas (fig. 2-3) and Christiansted and Frederiksted on St. Croix. Forest cover averages 57 percent and ranges between 43.6 percent in St. Thomas to 81.3 percent in St. John, with most being dry (71 percent) and some moist (29 percent) forests (Marcano-Vega 2020). Tourism is an important economic activity, particularly in coastal areas. Agriculture is a small sector of the economy, with most food being imported, similar to Puerto Rico. As in Puerto Rico, terrestrial land management issues include solid waste management and coastal development, both of which are affecting near-shore resources and ecosystems (coral reefs and fisheries), in addition to global sea-level rise and warming sea surface temperatures (Gould et al. 2018).

2.2. Definition of WUI and Non-WUI Classes for Mapping Purposes

Our definition of WUI is based on a report on WUI fire risk prepared for the Council of Western State Foresters (Teie and Weatherford 2000) and later published in the Federal Register.² The WUI is composed of both *interface* and *intermix* communities. The distinction between these is based on the characteristics and the distribution of houses and wildland vegetation across the landscape. Intermix WUI refers to areas where housing and wildland vegetation intermingle. Interface WUI refers to areas where housing is situated in the vicinity of a large area of dense wildland vegetation. Wildland vegetation refers to vegetation types for which human manipulation is minimal (e.g., forests, shrublands, grasslands, wetlands), so to distinguish from actively managed vegetation (e.g., pastures, hay, row crop, gardens) (Radeloff et al. 2005b).

² Urban wildland interface communities within the vicinity of federal lands that are at high risk from wildfire. Notice. 66. Federal Register 3(2001 January 4): 751–777.



Figure 2-2. Fajardo, PR, seen from the air, 2023. This photo depicts residential neighborhoods situated near large patches of natural vegetation, as observed in many areas of Puerto Rico. USDA Forest Service photo by Maya Quiñones.

Figure 2-3. View of Frenchtown, St. Thomas, VI, 2022. This photo captures the pattern of sprawled developments surrounded by forest in the hills around the town of Charlotte Amalie, the capital of the U.S. Virgin Islands. USDA Natural Resources Conservation Service photo by Julie Wright.



In both interface and intermix WUI, housing must meet or exceed a minimum density of 6.18 houses per km² (one structure per 40 acres) and meet particular vegetation conditions, as follows: Intermix WUI must have ≥ 6.18 houses per km² and ≥ 50 percent of its area covered in wildland vegetation (fig. 2-4). On the other hand, interface WUI must have ≥ 6.18 houses per km² and *less* than 50 percent vegetation cover, but be within 2.4 km of an area that is ≥ 5 km² in size and ≥ 75 percent vegetated (fig. 2-5). Box 2-1 outlines the characteristics of interface and intermix WUI. By requiring areas of adjacent wildland vegetation to meet the minimum size limit (≥ 5 km²), we ensure that urban neighborhoods surrounding small urban parks are not classified as interface WUI (Stewart et al. 2007).

Box 2-1. Definition of WUI and non-WUI land use classes.

WUI

Intermix

Areas with ≥ 6.18 houses per km² and ≥ 50 percent cover of wildland vegetation

Interface

Areas with ≥ 6.18 houses per km² and < 50 percent cover of vegetation located < 2.4 km of an area ≥ 5 km² in size that is ≥ 75 percent vegetated

Non-WUI Vegetated

No housing

Areas with ≥ 50 percent cover of wildland vegetation and no houses (e.g., protected areas, steep slopes, mountain tops)

Very low housing density

Areas with ≥ 50 percent cover of wildland vegetation and < 6.18 houses per km² (e.g., dispersed rural housing outside neighborhoods)

Non-Vegetated or Agriculture

Low and very low housing density

Areas with < 50 percent cover of wildland vegetation and < 49.42 houses per km² (e.g., agricultural lands, pasturelands, commercial and industrial areas)

Medium and high housing density

Areas with < 50 percent cover of wildland vegetation and ≥ 49.42 houses per km² (e.g., urban and suburban areas, which may have vegetation but not dense vegetation)

2. Methods

Figure 2-4. Aerial view of the intermix WUI in Naranjito, PR (A), and St. Croix, VI (B). Intermix WUI refers to areas where housing and wildland vegetation intermingle. Image source: Google Earth and Esri. The area depicted covers about 800 by 800 m.

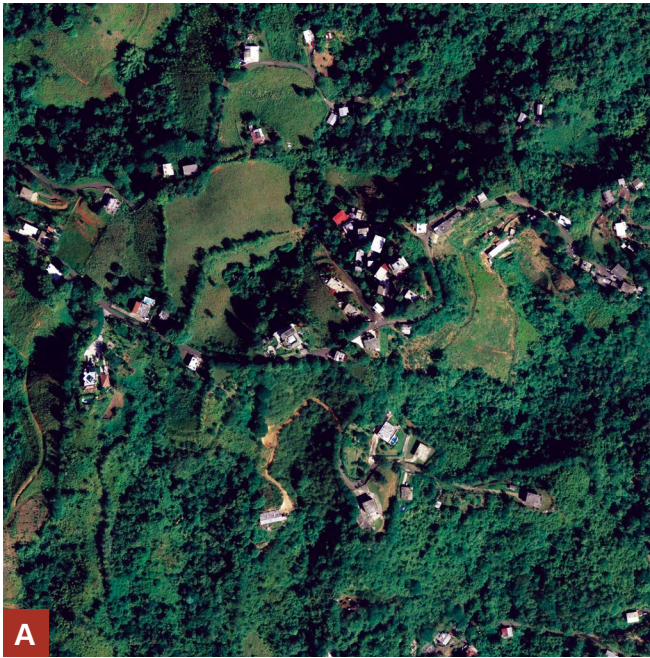


Figure 2-5. Aerial view of the interface WUI in San Germán, PR (A), and St. Thomas, VI (B). Interface WUI refers to areas where housing is in the vicinity of a large area of dense wildland vegetation. Image source: Google Earth and Esri. The area depicted covers about 800 by 800 m.



The buffer distance for the interface WUI (2.4 km) identifies residential areas in the vicinity of wildlands; it is the approximate distance that firebrands can be carried from a wildland fire (California Fire Alliance 2001). This buffer takes into account that homes situated near but not embedded within the forest are still at risk of being burned in a wildland fire. With minimum housing densities, vegetation types, and interface buffer distances determined, the operational definition of the WUI for mapping purposes is complete. Areas that do not meet the WUI requirements are not included in the WUI categories and are identified as non-WUI land use classes (box 2-1 and figs. 2-6, 2-7, 2-8, and 2-9).

Figure 2-6. Example of the class Non-WUI Vegetated—No housing, in the karst region near Arecibo, PR (A), and in Virgin Islands National Park, St. John, VI (B). This non-WUI class corresponds to areas with ≥ 50 percent cover of wildland vegetation and no houses. Image source: Google Earth and Esri. The area depicted covers about 800 by 800 m.

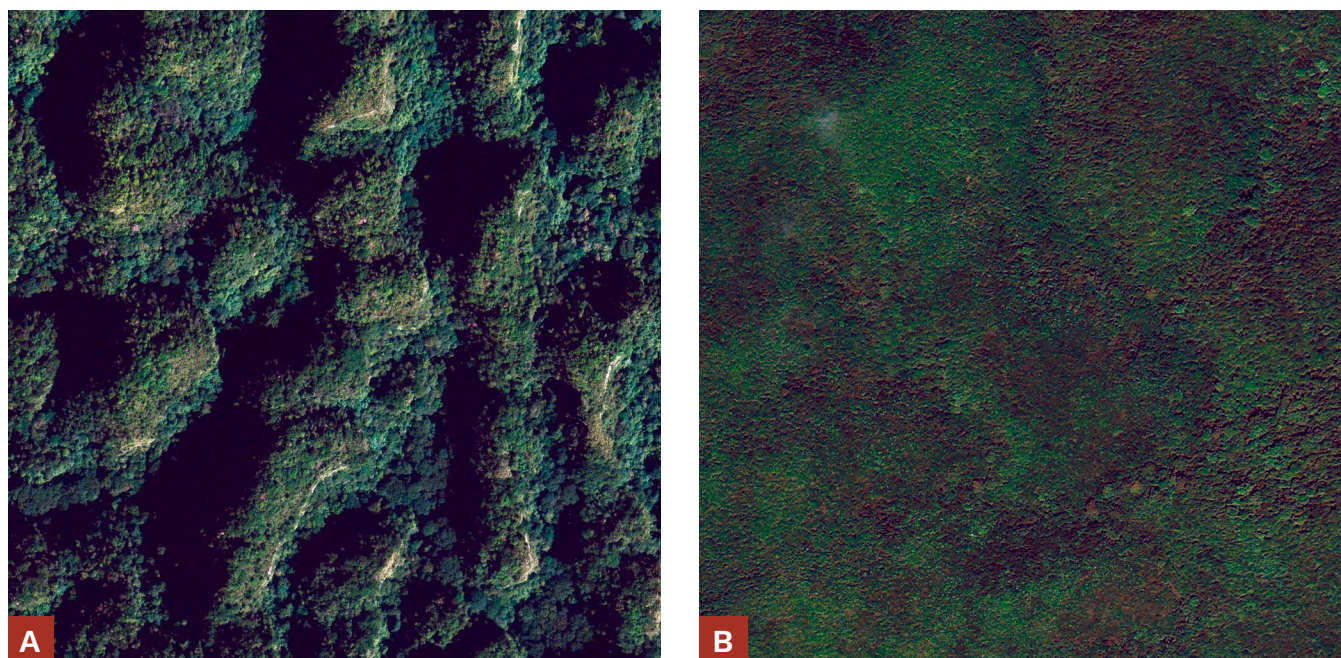
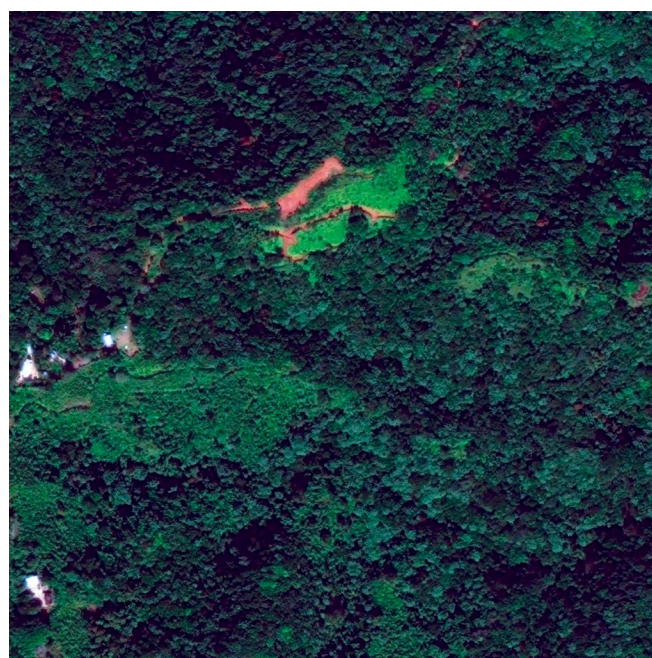


Figure 2-7. Example of the class Non-WUI Vegetated—Very low housing density, in the region of Maricao, PR. This non-WUI class corresponds to areas with ≥ 50 percent cover of wildland vegetation and < 6.18 houses per km^2 . Image source: Google Earth. The area depicted covers about 800 by 800 m.



2. Methods

Figure 2-8. Examples of the class Non-Vegetated or Agriculture—Low and very low housing density, in Santa Isabel, PR (A); St. Croix, VI (B); Bayamón, PR (C); and St. Thomas, VI (D). This non-WUI class corresponds to areas with <50 percent cover of wildland vegetation and <49.42 houses per km² (e.g., agricultural lands, pasturelands, commercial and industrial areas). Image source: Google Earth and Esri. The area depicted covers about 800 by 800 m.



Figure 2-9. Example of the class Non-Vegetated or Agriculture—Medium and high housing density, in San Juan (A) and Aguada, PR (B). This non-WUI class corresponds to areas with <50 percent cover of wildland vegetation and ≥ 49.42 houses per km^2 (e.g., urban and suburban areas, which may have vegetation, but not dense vegetation). Image source: Google Earth and Esri. The area depicted covers about 800 by 800 m.



2.2.1. Additional WUI classes applied to Puerto Rico and U.S. Virgin Islands

Although in previous reports for the United States the WUI is presented as a two-class feature (i.e., intermix versus interface WUI; Radeloff et al. 2005b, 2018; Martinuzzi et al. 2015), additional classes can be recognized within the intermix and interface. Specifically, there are three classes within both the intermix and interface, based on different levels of housing density: low, medium, and high housing density classes (box 2-2). Here we report the WUI in terms of intermix and interface, consistent with previous reports, and we present the three different intermix and interface classes for further understanding WUI patterns across the landscape of Puerto Rico and the U.S. Virgin Islands.

Box 2-2. Classes within intermix and interface WUI based on housing density.

Low-density housing

≥ 6.18 houses per km^2 and < 49.42 houses per km^2

Medium-density housing

≥ 49.42 houses per km^2 and < 741.32 houses per km^2

High-density housing

≥ 741.32 houses per km^2

2. Methods

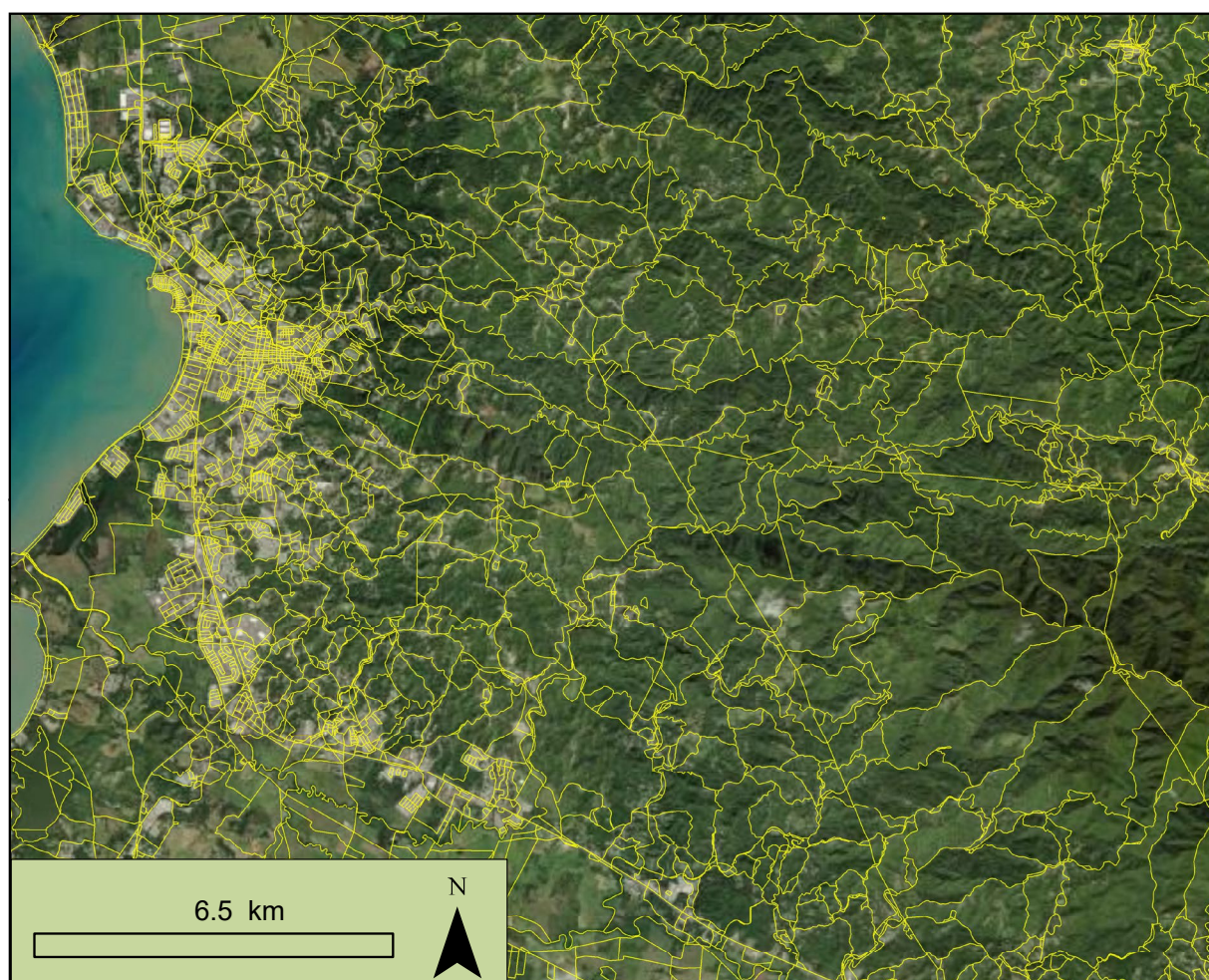
2.3. Mapping the WUI

Mapping the WUI requires spatially explicit data on housing density and wildland vegetation cover, and a geographic information system (GIS) to process and integrate these datasets. The WUI maps in this report depict the WUI for Puerto Rico and the U.S. Virgin Islands for 2010, using the 2010 national information on housing density from the U.S. census and wildland vegetation cover for 2010–2012 from land cover datasets. We excluded the unpopulated islands of Mona, Monito, and Desecheo (combined area of 57 km²), which are strictly protected areas located west of the main island of Puerto Rico. The 2010 census reports nine people (i.e., rangers) and three housing units for these islands.

2.3.1. Information resources

Housing. We derived housing density information from the 2010 U.S. census (U.S. Census Bureau 2012) and conducted our analyses at the finest demographic spatial scale available, the census block (fig. 2-10). There were 76,104 census blocks in Puerto Rico and 4,824 in the U.S. Virgin Islands, and for each census block the decennial census reports the number of housing units. A census block can include both private and public lands, such as local parks, national forests, or other public lands. In all census blocks where public lands were present, we divided the block by land ownership, creating a subblock of privately owned lands (i.e., with land owned by individuals, corporations, or other

Figure 2-10. Example of the census blocks (in yellow) near Mayagüez, PR.



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



U.S. Census blocks (2010)

nongovernmental entities) and a subblock of publicly owned lands (i.e., with lands owned by the local, State, or Federal government). Where both were present, we assigned the housing counts reported for these divided census blocks only to the privately owned subblock. Examples of public lands in Puerto Rico included territorial or commonwealth State forests and natural reserves (Puerto Rico Department of Natural and Environmental Resources), Federal national wildlife refuges (U.S. Fish and Wildlife Service, FWS), and El Yunque National Forest (Forest Service). Public-private land partnerships such as Zona de Conservación del Carso (Karst Conservation Zone) or Corredor Ecológico de San Juan (San Juan Ecological Corridor) were treated as private lands because they contain housing units. Examples of public lands in the U.S. Virgin Islands included local or territorial wildlife sanctuaries and reserves (U.S. Virgin Islands Department of Planning and Natural Resources), Virgin Islands National Park (National Park Service), national wildlife refuges (FWS), and Estate Thomas Experimental Forest (Forest Service) (fig. 2-11). Ownership data were derived from the Protected Areas Conservation Action Team (2018) and the U.S. Virgin Islands Gap Analysis Project (Gould et al. 2013).

Wildland vegetation. In the context of mapping the WUI, wildland vegetation corresponds to the vegetation cover types for which human manipulation is minimal. In the U.S. mainland, wildland vegetation cover is derived from the National Land Cover Database (NLCD), a satellite data classification produced by the U.S. Geological Survey with 30-m resolution and representing the status of land cover. The NLCD classes that correspond to wildlands include forests, grasslands, shrubs, and wetlands.

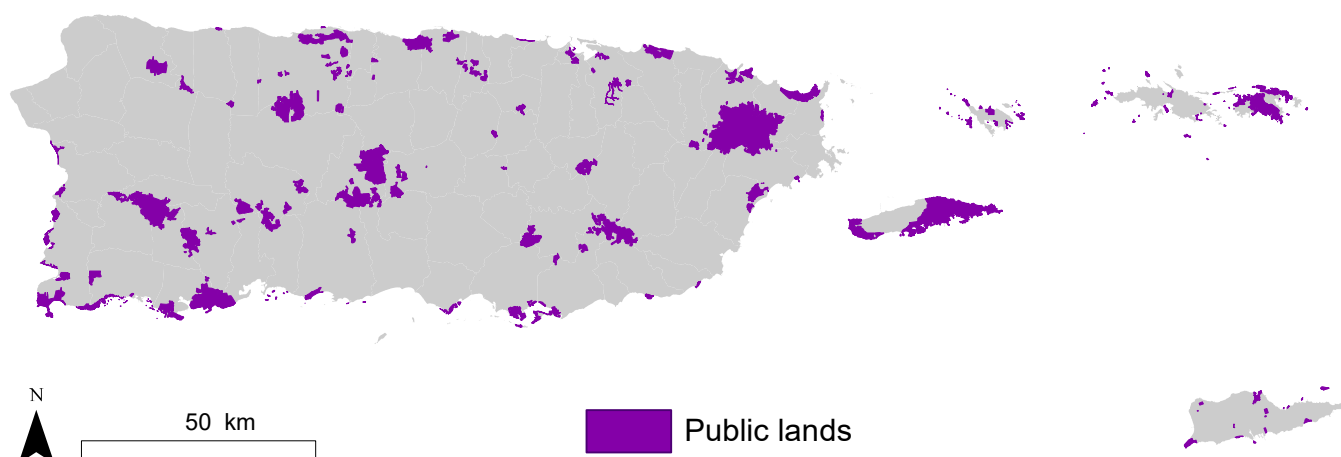
Unfortunately, the NLCD land cover classification is not available for Puerto Rico and the U.S. Virgin Islands, and

thus we derived our wildland vegetation cover from other available land cover products. For forests, we used the NLCD 2011 USFS Tree Canopy Cover, a 30-m-resolution, satellite-based product developed by the Forest Service with continuous values of tree canopy cover ranging from 0 to 100 percent (USDA Forest Service 2019). We considered forest pixels as those with ≥ 50 percent tree canopy cover. Herbaceous grasslands, on the other hand, occur only as human-managed areas such as pasture and lawn in our study area, so we did not include them within wildlands. For shrubs and wetlands, we used land cover information from the National Oceanic and Atmospheric Administration (NOAA) C-CAP (Coastal Change Analysis Program), a ≤ 2.4 -m satellite-based land cover product representing the status of land cover for 2010 for Puerto Rico, and 2012 for the U.S. Virgin Islands (<https://coast.noaa.gov/digitalcoast/data/ccaphighres.html>). Specifically, we used the classes scrub/shrub for shrubs, and the classes palustrine and estuarine wetlands for wetlands. However, to prevent a potential overestimation of shrub cover, we restricted the shrub area to the subtropical dry forest zone according to Holdridge (Ewel and Whitmore 1973), which is the ecological region where shrubs dominate the overstory vegetation. As a final step, we resampled the shrubs and wetlands cover classes to 30-m resolution to match the forest layer. By combining the 30-m-resolution spatial data layers of forest, shrub, and wetlands, our wildland vegetation cover data are complete (fig. 2-12).

2.3.2. Data processing

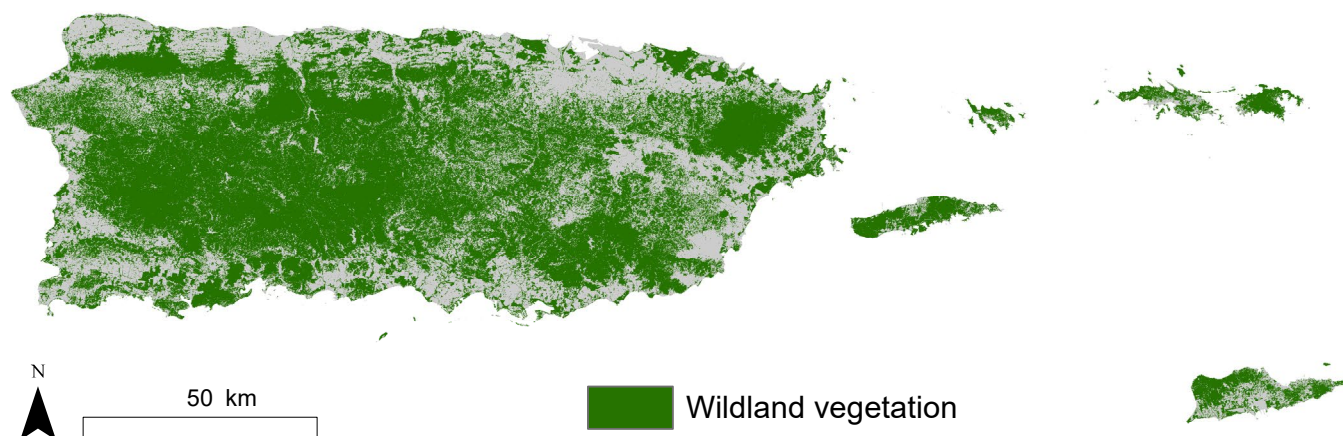
Mapping the WUI requires several processing steps using a GIS, specialized computer software designed for spatial analysis. The GIS procedures and specifications are described in detail in box 2-3.

Figure 2-11. Distribution of public lands considered for this study.



2. Methods

Figure 2-12. Distribution of wildland vegetation.



2.4. Comparison of WUI in Puerto Rico and U.S. Virgin Islands Versus U.S. States

We compared the WUI in Puerto Rico and the U.S. Virgin Islands to that in mainland States, in terms of WUI area, housing, and population. We obtained 2010 WUI

information for the conterminous United States plus the District of Columbia from the SILVIS Lab website (<https://silvis.forest.wisc.edu/data/wui-change>). We ranked the States and territories in descending order so that position 1 corresponds to the State or territory with the most WUI, and position 51 to that with the least amount of WUI.

Box 2-3. GIS process for generating the WUI map for Puerto Rico and U.S. Virgin Islands.

Hardware: 32-core server with 128 GB RAM.

Software: ArcGIS 10.1 Automated entirely using Python scripting (>800 lines of code, Python 2.7). This script is available upon request.

A. Preprocess housing data.

1. Download housing data and block geography shapefiles from Census Bureau website.
2. Match (join) census housing counts to blocks to create housing GIS datasets.
3. Download public lands boundaries from the Protected Areas Conservation Action Team and the U.S. Virgin Islands Gap Analysis Project.
4. Adjust for public land boundaries, subdividing blocks and moving houses out of publicly owned lands. Public and private ownership boundaries are intersected with block boundaries, and subblocks coded as public or private.
5. Calculate housing density for each privately owned subblock.

B. Preprocess land cover data.

1. Download the NLCD 2011 USFS Tree Canopy Cover and NOAA's C-CAP land cover.
2. Reclassify the land cover classes into wildland-vegetation and non-vegetation categories.

C. Process WUI.

1. Add land cover data to housing data: For each private subblock, tabulate the relative percentage of wildland vegetation.
2. Intermix classification: For each private subblock, assign an intermix WUI class based on vegetation and housing density.
3. Interface classification:
 - a. Select blocks with ≥ 75 percent vegetation; dissolve into contiguous regions of dense vegetation.
 - b. Remove any small regions ($< 5 \text{ km}^2$) of dense vegetation.
 - c. Buffer out 2.4 km from each large vegetation patch ($\geq 5 \text{ km}^2$).
 - d. Union the buffered dense vegetation with the intermix WUI classification.
 - e. Assign each block an interface WUI class based on housing density and location inside a dense vegetation buffer.

3. Results

3.1 The WUI in Puerto Rico and U.S. Virgin Islands: What It Contains and How It Is Distributed

3.1.1. Puerto Rico

The WUI in Puerto Rico covered 5,553.6 km², equivalent to 65.3 percent of Puerto Rico's total area in 2010 (table 3-1). In total, the WUI included more than 1 million housing units and more than 2.3 million people, equivalent to 61.5 percent and 63.6 percent of all houses and people, respectively (table 3-1). Within the WUI, intermix WUI was three times larger in area than interface WUI (i.e., 4,210.9 km² versus 1,342.7 km²). However, interface WUI included almost twice the number of housing units and people compared to intermix WUI (table 3-1).

The WUI map for Puerto Rico shows that the WUI is a common feature across the island and particularly within forested areas, as most forested areas were classified as intermix WUI (fig. 3-1). On the other hand, the interface WUI is visible around urbanized coastal areas, especially in the northern and eastern parts of the island. Non-WUI areas are mostly located in coastal areas and some interior valleys that have been transformed due to urbanization or agriculture, as well as in areas of rugged topography and in public lands such as El Yunque National Forest.

3.1.2. U.S. Virgin Islands

The WUI in the U.S. Virgin Islands covered 181.2 km², equivalent to 52.3 percent of the U.S. Virgin Islands' total area (table 3-2). In total, the WUI included 52,206 housing units and 97,038 people, equivalent to 93.4 percent and 91.2 percent of all housing units and people in the U.S. Virgin Islands, respectively (table 3-2). Within the WUI, intermix WUI was 1.5 times larger in area than interface WUI. However, interface WUI included about 2.5 times more housing units and people than intermix WUI (table 3-2).

The map for the U.S. Virgin Islands shows that the WUI is more common in St. Thomas than in St. John and St. Croix (fig. 3-1). This is due to the presence of a large protected area in St. John and many transformed lands (pasture and agriculture) in St. Croix, which are classified as non-WUI.

3.2. Variability Within the WUI

Although the WUI is typically presented as two classes—intermix and interface—our WUI database also distinguished three classes within the intermix and interface, based on different levels of housing density (see box 2-2). In Puerto Rico and the U.S. Virgin Islands as a whole, we found that the intermix WUI is composed mainly of two classes: low-density housing and medium-density housing, each of which covered about 2,000 km² (table 3-3). Indeed, each of

Table 3-1. Area, housing units, and population inside and outside the wildland-urban interface (WUI) in Puerto Rico. The WUI is composed of intermix WUI and interface WUI. Grand total represents Puerto Rico's total land area, housing units, and population from the 2010 census (excluding Mona, Monito, and Desecheo islands).

Puerto Rico	Area		Housing units		Population	
	km ²	%	Number	%	Count	%
Intermix WUI	4,210.9	49.5	363,857	22.2	872,718	23.4
Interface WUI	1,342.7	15.8	642,736	39.3	1,497,277	40.2
WUI (total)	5,553.6	65.3	1,006,593	61.5	2,369,995	63.6
Non-WUI	2,952.7	34.7	630,350	38.5	1,355,785	36.4
Grand total	8,506.3	100.0	1,636,943	100.0	3,725,780	100.0

3. Results

Figure 3-1. Distribution of wildland-urban interface (WUI) and non-WUI classes in Puerto Rico and the U.S. Virgin Islands.

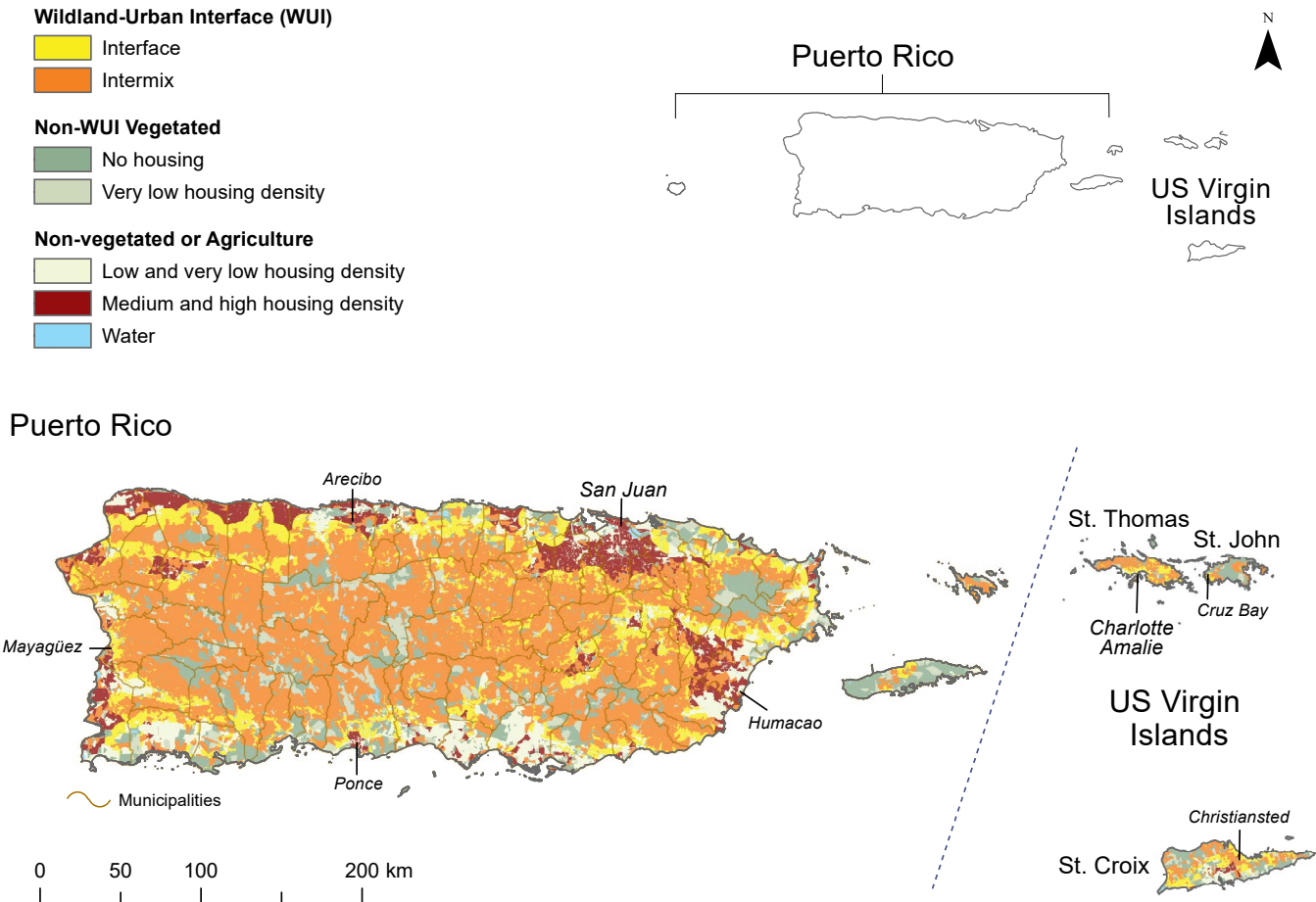


Table 3-2. Area, housing units, and population inside and outside the wildland-urban interface (WUI) in the U.S. Virgin Islands. The WUI is composed of intermix WUI and interface WUI. Grand total represents U.S. Virgin Islands' total area, housing units, and population from the 2010 census.

	Area		Housing units		Population	
	km ²	%	Number	%	Count	%
U.S. Virgin Islands						
Intermix WUI	113.3	32.7	14,562	26.0	25,881	24.3
Interface WUI	67.8	19.6	37,644	67.3	71,157	66.9
WUI (total)	181.2	52.3	52,206	93.4	97,038	91.2
Non-WUI	165.1	47.7	3,695	6.6	9,367	8.8
Grand total	346.3	100.0	55,901	100.0	106,405	100.0

these intermix classes alone is larger than the entire interface WUI (1,411 km²). On the other hand, the interface WUI was primarily composed of the medium-density subclass (~880 km²), followed by similar proportions of the low- and high-density subclasses (~240 and ~280 km², respectively).

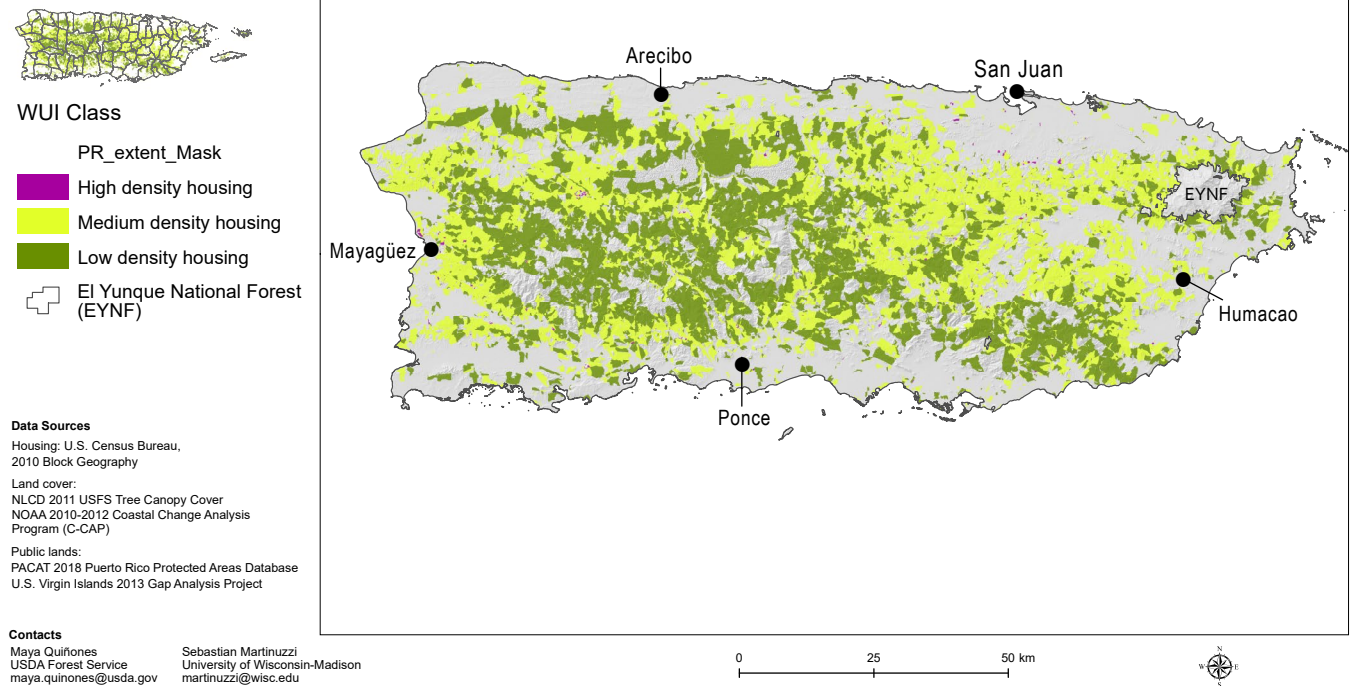
The intermix WUI is the largest WUI class in terms of area, and the most striking feature within the intermix WUI is the presence of a strong geographic gradient, particularly visible in Puerto Rico (fig. 3-2). Specifically, the low-density intermix is typically present at higher elevations, such as along the central mountains, Carite mountains (southeast), and some parts of the northern karst. In contrast, the medium-density intermix occurs around the most populated places, like the San Juan Metropolitan Area and Caguas, as well as in other low-elevation areas around the island (figs. 3-2 and 3-3). These WUI gradients are not visible when looking just at the interface versus intermix classes.

Table 3-3. Extent of the subclasses within the intermix and interface WUI for Puerto Rico and the U.S. Virgin Islands combined.

WUI subclasses	Area	
	km ²	%
Interface WUI		
Low-density housing	244.6	4.3
Medium-density housing	882.1	15.4
High-density housing	283.8	4.9
Intermix WUI		
Low-density housing	2,148.3	37.5
Medium-density housing	2,161.8	37.7
High-density housing	14.1	0.2

Figure 3-2. Spatial distribution of the intermix WUI subclasses for Puerto Rico.

Intermix WUI Subclasses 2010



3. Results

Figure 3-3. Examples of the two major intermix WUI subclasses: low-density housing (A and B) and medium-density housing (C and D). (A) shows intermix WUI—low-density housing in Orocovis, PR; (B) shows intermix WUI—low-density housing in St. John, VI; (C) shows intermix WUI—medium-density housing near Caguas, PR; and (D) shows intermix WUI—medium-density housing in St. Thomas, VI. Source: Google Earth and Esri. The area that is depicted covers about 800 by 800 m.



3.3. Comparison of WUI in Puerto Rico and U.S. Virgin Islands Versus U.S. States

Table 3-4 summarizes the 2010 WUI for each of the 51 U.S. States and territories considered here, in terms of area, housing units, and population. This information was used to rank Puerto Rico and the U.S. Virgin Islands relative to the other States.

Table 3-4. Summary of the wildland-urban interface (WUI) area, housing units, and population across U.S. States and territories. Source for State in the conterminous United States plus District of Columbia: University of Wisconsin-Madison's SILVIS Lab (<http://silvis.forest.wisc.edu/data/wui-change>). Source for Puerto Rico and U.S. Virgin Islands: this study. The States and territories are presented in alphabetical order.

State/Territory	WUI area		WUI housing units		WUI population	
	km ²	%	Number	%	Count	%
Alabama	31,044.0	22.9	1,269,955	58.5	2,793,033	58.4
Arizona	8,813.6	3.0	1,318,387	46.3	2,782,588	43.5
Arkansas	16,392.9	11.9	593,256	45.1	1,276,884	43.8
California	27,025.7	6.4	4,426,803	32.4	11,157,953	30.0
Colorado	9,437.9	3.5	940,552	42.5	2,036,984	40.5
Connecticut	8,512.2	59.3	800,454	53.8	1,922,027	53.8
Delaware	979.7	15.2	42,116	10.4	97,162	10.8
District of Columbia	8.0	4.5	4,371	1.5	7,219	1.2
Florida	26,159.0	15.4	2,628,053	29.2	5,454,653	29.0
Georgia	41,853.2	27.2	1,964,288	48.0	4,636,794	47.9
Idaho	4,220.2	1.9	273,601	41.0	551,124	35.2
Illinois	4,286.4	2.9	405,329	7.7	965,759	7.5
Indiana	10,490.8	11.1	348,300	12.5	791,582	12.2
Iowa	1,778.8	1.2	99,430	7.4	224,927	7.4
Kansas	2,539.4	1.2	175,872	14.3	397,295	13.9
Kentucky	25,691.4	24.5	691,215	35.9	1,541,846	35.5
Louisiana	16,467.5	12.1	838,021	42.6	2,008,834	44.3
Maine	17,760.8	19.4	576,989	79.9	1,059,550	79.8
Maryland	8,098.7	25.2	705,543	29.7	1,761,969	30.5
Massachusetts	11,465.9	41.9	1,219,921	43.4	2,853,750	43.6
Michigan	29,067.3	11.6	1,062,135	23.4	2,013,047	20.4
Minnesota	10,023.0	4.5	411,784	17.5	781,870	14.7
Mississippi	24,352.4	19.4	734,564	57.6	1,681,670	56.7
Missouri	15,499.2	8.6	571,359	21.1	1,201,712	20.1
Montana	5,303.6	1.4	308,567	63.9	616,057	62.3
Nebraska	1,232.7	0.6	117,513	14.7	246,928	13.5

3. Results

Table 3-4. Summary of the wildland-urban interface (WUI) area, housing units, and population across U.S. States and territories, continued.

State/Territory	WUI area		WUI housing units		WUI population	
	km ²	%	Number	%	Count	%
Nevada	2,440.3	0.9	536,403	45.7	1,227,453	45.5
New Hampshire	9,968.6	41.2	490,791	79.8	1,038,752	78.9
New Jersey	6,994.8	31.0	898,982	25.3	2,208,316	25.1
New Mexico	6,859.2	2.2	615,076	68.2	1,406,206	68.3
New York	39,519.2	28.0	1,797,720	22.2	3,913,620	20.2
North Carolina	54,956.3	39.4	2,256,276	52.1	4,843,169	50.8
North Dakota	673.5	0.4	52,234	16.5	111,826	16.6
Ohio	20,103.8	17.3	825,683	16.1	1,880,837	16.3
Oklahoma	13,683.6	7.6	620,122	37.3	1,377,991	36.7
Oregon	9,446.9	3.7	595,949	35.6	1,230,490	32.1
Pennsylvania	41,720.0	35.0	2,021,129	36.3	4,377,394	34.5
Puerto Rico	5,553.6	65.3	1,006,593	61.5	2,369,995	63.6
Rhode Island	1,633.6	40.8	142,751	30.8	327,152	31.1
South Carolina	27,873.9	33.6	1,302,246	60.9	2,833,411	61.3
South Dakota	1,398.8	0.7	96,660	26.6	210,972	25.9
Tennessee	30,721.7	28.1	1,034,597	36.8	2,250,286	35.5
Texas	46,448.8	6.7	3,042,930	30.5	7,555,644	30.0
U.S. Virgin Islands	181.2	52.3	52,206	93.4	97,038	91.2
Utah	3,549.0	1.6	467,828	47.8	1,251,484	45.3
Vermont	8,662.7	34.8	229,140	71.0	427,373	68.3
Virginia	35,832.0	32.3	1,446,470	43.0	3,370,927	42.1
Washington	14,991.3	8.1	1,010,550	35.0	2,304,262	34.3
West Virginia	17,557.2	28.0	697,069	79.0	1,445,261	78.0
Wisconsin	14,349.4	8.5	512,339	19.5	859,533	15.1
Wyoming	2,411.9	1.0	212,789	81.3	458,639	81.4

Across the 51 U.S. States and territories considered here, we found that Puerto Rico and the U.S. Virgin Islands ranked high (i.e., 1st to 9th) in terms of the percentage of the area in WUI, percentage of all houses in the WUI, and the percentage of the population that lives in the WUI (table 3-5). However, Puerto Rico and the U.S. Virgin Islands ranked middle to low (i.e., 13th to 50th) in terms of the total area (km²) of WUI, and the total number of houses and people in the WUI (table 3-5).

For example, in terms of the percentage of area occupied by WUI, Puerto Rico ranked 1st (with 65.3 percent of the area in WUI), followed by Connecticut (59.3 percent), U.S. Virgin Islands (52.3 percent), Massachusetts (41.9 percent), and New Hampshire (41.2 percent). The States and territories with the smallest percentage area in WUI are Nevada, South Dakota, Nebraska, and North Dakota, with less than 1 percent of their area in WUI (table 3-4).

Similarly, in terms of the percentage of housing units in the WUI, the U.S. Virgin Islands ranked 1st (with 93.4 percent of all houses occurring in the WUI), followed by Wyoming (81.3 percent), Maine (79.9 percent), and New Hampshire (79.8 percent; table 3-4). Puerto Rico ranked 9th, with 61.5 percent of the housing units occurring in the WUI, below Montana (63.9 percent) and above South Carolina (60.9 percent). Because houses and population are highly correlated, the ranking in terms of percentage of population in the WUI followed a similar trend to that observed based on percentage of houses. This resulted in the U.S. Virgin Islands ranking 1st and Puerto Rico 8th for percentage of population in the WUI (table 3-5).

When evaluating the WUI in km² and total number of housing units and people, Puerto Rico ranked in the middle (13th to 36th positions depending on the variable), and the U.S. Virgin Islands ranked at the very bottom (49th and 50th position depending on the variable; table 3-5). For example, the States and territories with the largest WUI area in km² are North Carolina, Texas, Georgia, and Pennsylvania, with 41,720 km² to 54,956 km² of WUI. Puerto Rico ranked 36th, with 5,553.6 km² of WUI, between New Mexico

(6,859.2 km²) and Montana (5,303.6 km²). The U.S. Virgin Islands (181.2 km² of WUI) ranked 50th, only above the District of Columbia (8.0 km² of WUI; table 3-4).

In terms of the total number of housing units in the WUI, California, Texas, and Florida lead the ranking with 2.6 to 4.4 million houses in the WUI (table 3-4). Puerto Rico, with just over a million houses in the WUI, ranked 16th and had very similar numbers to Michigan, Tennessee, Washington, and Colorado. The U.S. Virgin Islands, with over 52,000 houses in the WUI, ranked 49th, only above Delaware and the District of Columbia. The ranking based on the total number of people in the WUI followed a similar trend to that based on houses, with California, Texas, and Florida leading the rank with 5.5 to 11.2 million people in the WUI. Puerto Rico, with 2,369,995 people in the WUI, ranked 13th and had very similar numbers to Washington, Tennessee, and New Jersey (table 3-4). The U.S. Virgin Islands (97,038 people in the WUI) ranked 50th (table 3-5), only above the District of Columbia.

3.4. The WUI Across Municipalities and Districts

Puerto Rico encompasses 78 municipalities—each with its own urban center in the form of a city or town—and the U.S. Virgin Islands encompasses 3 districts. In this section, we first describe the spatial patterns, contents, and amounts of WUI across municipalities of Puerto Rico and districts of the U.S. Virgin Islands, and then provide municipality- and district-level WUI maps for the entire combined study areas (81 maps in total).

3.4.1. WUI area across Puerto Rico's municipalities

Across the 78 municipalities of Puerto Rico, the area of WUI ranged from 0.3 km² in Cataño, in the San Juan Metropolitan Area, to 222.9 km² in Utuado, in the central mountains, with a median WUI area of 67 km². The municipalities with the largest area of WUI are located in the center and western

Table 3-5. Ranking of Puerto Rico and U.S. Virgin Islands among 51 U.S. States and territories in terms of the wildland-urban interface (WUI).

State/Territory	WUI area		WUI housing units		WUI population	
	km ²	%	Number	%	Count	%
Puerto Rico	36th	1st	16th	9th	13th	8th
U.S. Virgin Islands	50th	3rd	49th	1st	50th	1st

3. Results

part of the island (e.g., Arecibo, Ponce, San Sebastián, Utuado), where municipalities are also typically large in size (fig. 3-4). In contrast, the municipalities with the smallest WUI area are in the eastern and coastal parts of the island, where municipalities are more developed and tend to be smaller in size (fig. 3-4).

On the other hand, the percentage of area occupied by WUI ranged between 2.8 percent in Cataño to 98.0 percent in Naranjito, with a median of 69.5 percent (fig. 3-4B; table 3-6). Evaluating the WUI area as a percentage highlights the abundance of WUI in the center of the island, as municipalities along the central mountains have typically >70 percent of their area in WUI, while those in the coastal and more developed areas (e.g., San Juan, Loiza, and Cataño in the north) have lower values (<60 percent). Notably, a large cluster of municipalities with very high percentages (>90 percent) of their area in WUI occur just outside the San Juan Metropolitan Area, including the municipalities of Aguas Buenas, Barranquitas, Comerío, Corozal, and Naranjito, among others. The likely reason for this is the abundance of both forest cover and sprawled developments, along with few public lands. In most municipalities (85 percent), the area of the intermix WUI was larger than that of the interface WUI (table 3-6).

3.4.2. WUI houses and population across Puerto Rico's municipalities

Across the 78 municipalities of Puerto Rico, the number of housing units in the WUI ranged between 177 in Cataño to 51,144 in Ponce (fig. 3-5, table 3-7). The municipalities with the largest numbers of houses in the WUI are also home to some of the largest urban centers, like Caguas, Carolina, Mayagüez, and Ponce (fig. 3-5A). In these municipalities, the large numbers of houses in the WUI can be explained by the fact that the urban centers are not only large in terms of population, but they are also surrounded by large patches of natural vegetation, which results in large proportions of those urban centers classified as part of the interface WUI.

The map depicting WUI houses in relative terms (i.e., percentage of housing units in the WUI) reinforces the high abundance of WUI in the central mountains (fig. 3-5B). Specifically, the municipality-level map shows that most municipalities along the central mountains have the vast majority (>95 percent) of their houses in WUI (fig. 3-6). The likely reasons are both that these municipalities are highly forested and that the urban centers in the central mountains are typically small in geographic area and narrow in shape (i.e., within the 2.4-km WUI buffer), and as a

Figure 3-4. Area of wildland-urban interface (WUI) across municipalities of Puerto Rico and districts of the U.S. Virgin Islands. (A) depicts WUI area expressed in km². (B) depicts WUI area expressed as a percentage of the total area in a municipality or district.

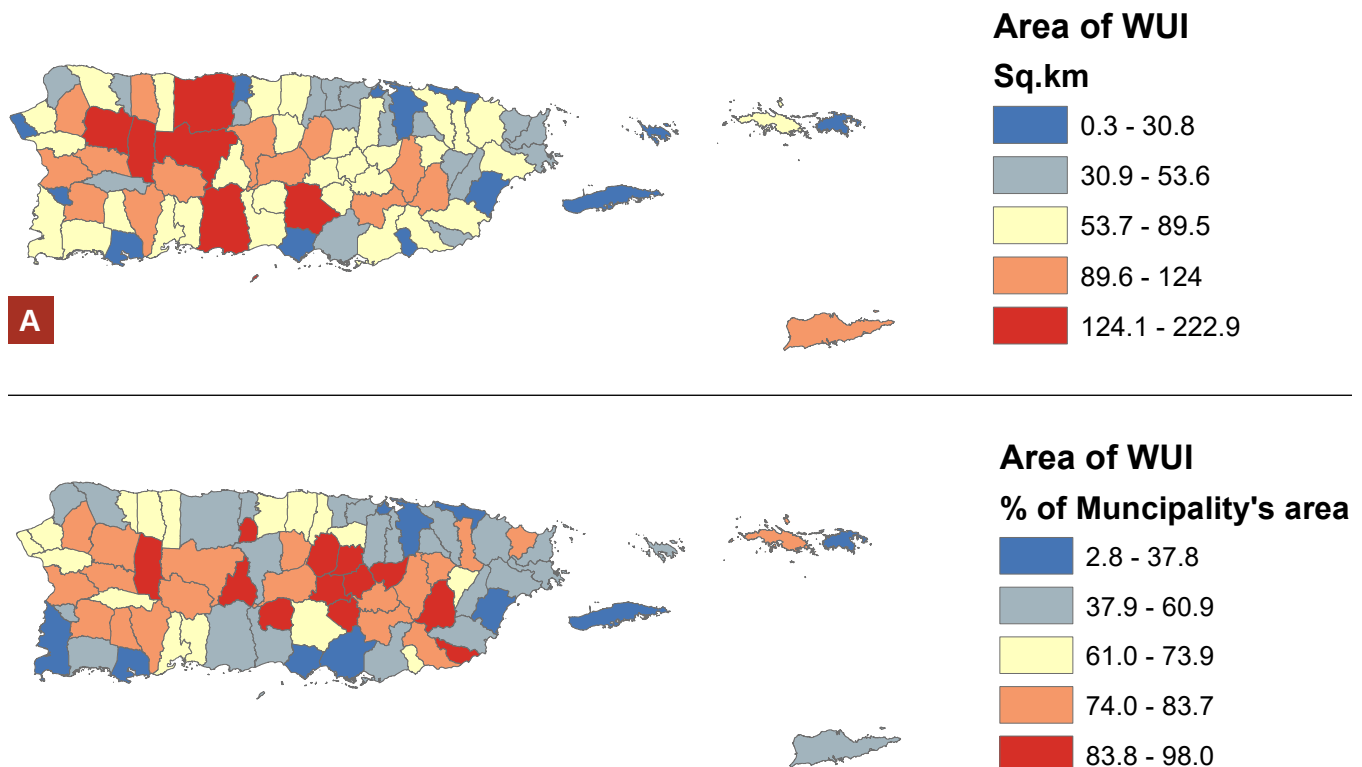


Table 3-6. Area of wildland-urban interface (WUI) across Puerto Rico's municipalities.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
Adjuntas	108.0	73.5	2.1	1.5	110.2	74.9	36.8	25.1	147.0	100.0
Aguada	42.1	48.4	17.8	20.5	59.9	68.9	27.0	31.1	86.9	100.0
Aguadilla	20.4	19.6	32.1	31.0	52.5	50.6	51.2	49.4	103.7	100.0
Aguas Buenas	62.5	83.8	6.5	8.7	69.0	92.6	5.5	7.4	74.5	100.0
Aibonito	60.5	74.5	12.2	15.1	72.7	89.6	8.5	10.4	81.2	100.0
Añasco	61.3	57.7	15.7	14.8	77.0	72.5	29.2	27.5	106.2	100.0
Arecibo	119.2	44.2	44.8	16.6	164.1	60.8	105.8	39.2	269.9	100.0
Arroyo	18.6	46.4	6.8	16.8	25.4	63.2	14.8	36.8	40.2	100.0
Barceloneta	9.3	20.1	9.3	20.1	18.7	40.2	27.8	59.8	46.4	100.0
Barranquitas	75.3	85.3	10.6	12.1	85.9	97.4	2.3	2.6	88.2	100.0
Bayamón	44.5	37.1	17.0	14.1	61.5	51.2	58.6	48.8	120.0	100.0
Cabo Rojo	31.4	17.2	35.2	19.3	66.6	36.6	115.4	63.4	182.0	100.0
Caguas	80.4	54.3	43.6	29.4	124.0	83.7	24.1	16.3	148.2	100.0
Camuy	52.5	38.9	43.7	32.5	96.2	71.4	38.5	28.6	134.7	100.0
Canóvanas	43.8	57.2	15.9	20.8	59.7	78.0	16.8	22.0	76.5	100.0
Carolina	39.6	31.0	20.9	16.4	60.5	47.3	67.4	52.7	127.9	100.0
Cataño	0.2	2.1	0.1	0.6	0.3	2.8	9.8	97.2	10.1	100.0
Cayey	78.5	66.0	20.0	16.8	98.4	82.8	20.5	17.2	118.9	100.0
Ceiba	27.3	42.5	8.6	13.3	35.9	55.8	28.4	44.2	64.3	100.0
Ciales	91.7	58.7	3.4	2.2	95.1	60.9	61.2	39.1	156.3	100.0
Cidra	51.4	48.2	29.7	27.8	81.1	76.0	25.7	24.0	106.8	100.0
Coamo	113.5	54.1	26.9	12.8	140.4	66.9	69.5	33.1	209.9	100.0
Comerio	60.5	81.8	7.1	9.5	67.5	91.4	6.4	8.6	73.9	100.0
Corozal	86.8	80.4	15.0	13.9	101.8	94.3	6.1	5.7	107.9	100.0
Culebra	9.0	46.5	1.4	7.2	10.4	53.7	8.9	46.3	19.3	100.0
Dorado	15.9	23.0	17.3	25.1	33.2	48.1	35.9	51.9	69.0	100.0
Fajardo	17.7	23.5	18.8	24.9	36.5	48.4	38.8	51.6	75.4	100.0
Florida	34.8	88.9	2.9	7.3	37.7	96.2	1.5	3.8	39.2	100.0
Guánica	17.7	21.8	10.6	13.1	28.3	34.8	52.9	65.2	81.2	100.0
Guayama	55.7	36.5	22.4	14.6	78.1	51.1	74.7	48.9	152.7	100.0
Guayanilla	58.6	58.7	8.5	8.5	67.1	67.2	32.7	32.8	99.8	100.0
Guaynabo	31.7	43.2	12.7	17.3	44.4	60.5	29.1	39.5	73.5	100.0
Gurabo	37.2	47.1	25.4	32.2	62.6	79.3	16.3	20.7	78.9	100.0

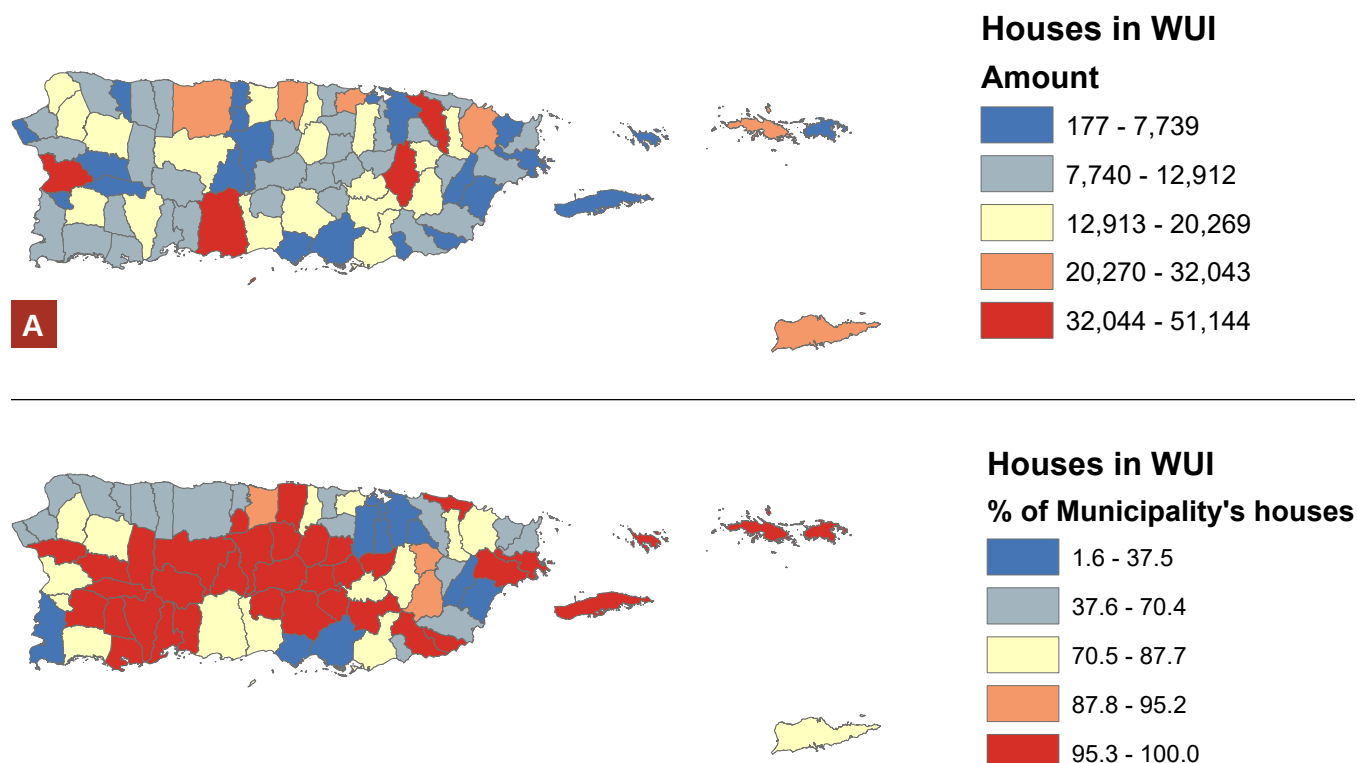
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Table 3-6. Area of wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
Hatillo	41.3	34.4	44.5	37.0	85.8	71.4	34.3	28.6	120.0	100.0
Hormigueros	11.0	36.2	7.0	23.3	18.0	59.4	12.3	40.6	30.3	100.0
Humacao	27.3	23.8	2.6	2.3	29.9	26.1	84.8	73.9	114.7	100.0
Isabela	38.2	27.2	39.9	28.4	78.1	55.6	62.3	44.4	140.4	100.0
Jayuya	68.9	84.8	1.8	2.2	70.7	87.0	10.5	13.0	81.2	100.0
Juana Díaz	71.0	43.8	18.5	11.4	89.5	55.3	72.5	44.7	162.0	100.0
Juncos	30.2	39.0	23.4	30.2	53.6	69.1	23.9	30.9	77.5	100.0
Lajas	34.8	21.6	36.5	22.7	71.3	44.2	90.0	55.8	161.3	100.0
Lares	135.9	85.3	4.3	2.7	140.3	88.0	19.0	12.0	159.3	100.0
Las Marías	95.3	79.1	0.5	0.4	95.7	79.5	24.7	20.5	120.4	100.0
Las Piedras	21.6	23.8	20.5	22.6	42.1	46.4	48.7	53.6	90.8	100.0
Loíza	4.8	11.9	10.3	25.8	15.1	37.8	25.0	62.2	40.1	100.0
Luquillo	21.5	45.6	15.0	31.9	36.6	77.5	10.6	22.5	47.2	100.0
Manatí	57.5	47.4	27.6	22.8	85.1	70.2	36.2	29.8	121.3	100.0
Maricao	52.6	69.5	0.2	0.3	52.8	69.8	22.8	30.2	75.6	100.0
Maunabo	33.7	62.3	13.7	25.4	47.4	87.6	6.7	12.4	54.1	100.0
Mayagüez	98.1	70.0	16.5	11.8	114.6	81.8	25.5	18.2	140.1	100.0
Moca	78.7	56.7	37.4	26.9	116.1	83.6	22.7	16.4	138.8	100.0
Morovis	67.9	67.3	15.7	15.6	83.6	83.0	17.2	17.0	100.8	100.0
Naguabo	25.6	23.5	40.5	37.2	66.1	60.7	42.8	39.3	108.9	100.0
Naranjito	65.2	90.7	5.3	7.3	70.5	98.0	1.4	2.0	71.9	100.0
Orocovis	113.8	77.5	7.3	5.0	121.0	82.5	25.7	17.5	146.7	100.0
Patillas	73.9	72.0	11.1	10.8	85.0	82.8	17.6	17.2	102.6	100.0
Peñuelas	66.5	62.5	5.6	5.3	72.1	67.7	34.3	32.3	106.4	100.0
Ponce	131.1	45.2	36.6	12.6	167.7	57.8	122.5	42.2	290.2	100.0
Quebradillas	27.4	41.5	20.1	30.5	47.5	71.9	18.5	28.1	66.0	100.0
Rincón	19.4	44.5	11.4	26.1	30.8	70.6	12.8	29.4	43.6	100.0
Río Grande	33.2	28.9	27.8	24.2	61.0	53.1	53.9	46.9	114.9	100.0
Sabana Grande	45.3	60.1	14.7	19.5	60.0	79.6	15.4	20.4	75.4	100.0
Salinas	25.5	14.2	14.9	8.3	40.4	22.5	139.6	77.5	180.0	100.0
San Germán	75.6	66.4	17.8	15.6	93.4	82.0	20.5	18.0	113.9	100.0
San Juan	17.7	14.4	5.0	4.1	22.7	18.5	99.7	81.5	122.4	100.0
San Lorenzo	94.6	70.5	24.9	18.6	119.5	89.1	14.6	10.9	134.1	100.0

Table 3-6. Area of wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
San Sebastián	118.0	58.5	38.5	19.0	156.5	77.5	45.4	22.5	201.9	100.0
Santa Isabel	14.3	16.1	5.2	5.9	19.5	22.0	69.3	78.0	88.8	100.0
Toa Alta	34.9	46.5	14.1	18.7	49.0	65.2	26.1	34.8	75.2	100.0
Toa Baja	10.9	16.5	24.8	37.6	35.7	54.1	30.3	45.9	66.0	100.0
Trujillo Alto	23.9	41.1	10.5	18.1	34.4	59.3	23.6	40.7	58.0	100.0
Utua	217.6	74.8	5.3	1.8	222.9	76.6	68.1	23.4	291.0	100.0
Vega Alta	29.1	50.1	13.3	22.9	42.4	73.0	15.6	27.0	58.0	100.0
Vega Baja	50.8	44.9	32.8	29.0	83.7	73.9	29.5	26.1	113.2	100.0
Vieques	13.3	10.0	10.4	7.9	23.7	17.9	108.6	82.1	132.2	100.0
Villalba	79.3	84.2	4.2	4.4	83.5	88.6	10.7	11.4	94.2	100.0
Yabucoa	61.0	40.2	18.4	12.2	79.4	52.3	72.3	47.7	151.7	100.0
Yauco	95.5	62.7	21.0	13.8	116.6	76.5	35.8	23.5	152.4	100.0
Total	4,210.9	49.5	1,342.7	15.8	5,553.6	65.3	2,952.7	34.7	8,506.3	100.0

Figure 3-5. Housing units in the wildland-urban interface (WUI) across municipalities of Puerto Rico and districts of the U.S. Virgin Islands. Map (A) depicts WUI houses in absolute terms. Map (B) depicts WUI houses expressed as a percentage of the municipality's or district's total houses.

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Figure 3-6. Houses in St. Thomas, VI, December 2023. This photo captures the abundance of woody vegetation commonly found around houses in the hilly areas of St. Thomas and typically observed in the central mountains of Puerto Rico. USDA Forest Service photo by Maya Quiñones.



result they are entirely classified as interface WUI (fig. 3-7). Indeed, two-thirds of all municipalities had more housing units in the interface than in the intermix WUI (table 3-7).

Finally, the patterns based on WUI population (not shown) were very similar to those based on houses, as population and houses are highly correlated. Information on WUI population for each municipality of Puerto Rico is provided in table 3-8.

3.4.3. WUI area, houses, and population across U.S. Virgin Islands districts

The U.S. Virgin Islands include three districts: St. Croix, St. John, and St. Thomas. St. Croix has the largest WUI area (105 km²), but St. Thomas had the highest percentage of WUI area (75 percent) because it is highly developed (fig. 3-4, table 3-9). On the other hand, St. John had the smallest WUI area (36 percent), due to the presence of large protected areas (fig. 3-4). At the same time, the three districts had >82 percent of their houses and population in the WUI (fig. 3-5).

In terms of comparing intermix and interface WUI, the three U.S. Virgin Islands districts had more area (km²) of intermix than interface WUI but had more housing units in the interface WUI (figs. 3-8, 3-9). The WUI statistics for the three U.S. Virgin Islands districts are provided in table 3-9 (WUI area), table 3-10 (WUI houses), and table 3-11 (WUI population).

Figure 3-7. In the central mountains, many urban centers are classified as interface WUI. The reason is that these urban centers are typically small and narrow in shape (i.e., <2.4 km wide) and are surrounded by large patches of forest, which makes them part of the interface WUI. The example in the aerial imagery is Comerío, PR. Image source: Google Earth. The area depicted covers about 800 by 800 m.



Table 3-7. Housing units in the wildland-urban interface (WUI) across Puerto Rico's municipalities.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Housing units	%	Housing units	%	Housing units	%	Housing units	%	Housing units	%
Adjuntas	5,755	70.8	2,300	28.3	8,055	99.1	70	0.9	8,125	100.0
Aguada	6,871	37.6	4,370	23.9	11,241	61.6	7,017	38.4	18,258	100.0
Aguadilla	1,967	6.9	13,568	47.7	15,535	54.6	12,895	45.4	28,430	100.0
Aguas Buenas	7,611	66.2	3,878	33.8	11,489	100.0	1	0.0	11,490	100.0
Aibonito	4,520	43.4	5,883	56.5	10,403	99.9	6	0.1	10,409	100.0
Añasco	4,898	38.4	7,539	59.1	12,437	97.5	318	2.5	12,755	100.0
Arecibo	9,416	21.8	14,943	34.5	24,359	56.3	18,894	43.7	43,253	100.0
Arroyo	1,680	18.9	4,564	51.4	6,244	70.4	2,631	29.6	8,875	100.0
Barceloneta	1,868	17.5	4,917	46.0	6,785	63.5	3,908	36.5	10,693	100.0
Barranquitas	7,984	70.0	3,150	27.6	11,134	97.6	270	2.4	11,404	100.0
Bayamón	7,098	8.2	11,633	13.5	18,731	21.8	67,329	78.2	86,060	100.0
Cabo Rojo	3,993	13.2	7,341	24.3	11,334	37.5	18,872	62.5	30,206	100.0
Caguas	11,796	19.5	39,046	64.7	50,842	84.2	9,529	15.8	60,371	100.0
Camuy	2,183	15.1	7,231	50.1	9,414	65.2	5,017	34.8	14,431	100.0
Canóvanas	4,926	25.3	11,131	57.2	16,057	82.5	3,417	17.5	19,474	100.0
Carolina	5,781	7.2	31,588	39.6	37,369	46.8	42,473	53.2	79,842	100.0
Cataño	130	1.2	47	0.4	177	1.6	11,026	98.4	11,203	100.0
Cayey	6,720	32.1	13,549	64.7	20,269	96.8	666	3.2	20,935	100.0
Ceiba	1,828	23.6	5,911	76.2	7,739	99.8	16	0.2	7,755	100.0
Ciales	5,497	71.1	2,123	27.4	7,620	98.5	116	1.5	7,736	100.0
Cidra	5,459	31.9	8,187	47.9	13,646	79.8	3,457	20.2	17,103	100.0
Coamo	6,084	36.4	10,224	61.2	16,308	97.6	408	2.4	16,716	100.0
Comerio	4,568	56.5	3,509	43.4	8,077	99.8	14	0.2	8,091	100.0
Corozal	7,995	57.1	5,998	42.8	13,993	100.0	6	0.0	13,999	100.0
Culebra	699	43.6	891	55.6	1,590	99.2	13	0.8	1,603	100.0
Dorado	3,211	19.2	5,786	34.7	8,997	53.9	7,690	46.1	16,687	100.0
Fajardo	1,548	8.0	11,045	57.0	12,593	64.9	6,798	35.1	19,391	100.0
Florida	2,906	56.6	2,225	43.3	5,131	99.9	6	0.1	5,137	100.0
Guánica	1,805	18.7	7,843	81.1	9,648	99.8	18	0.2	9,666	100.0
Guayama	3,341	16.9	13,347	67.7	16,688	84.7	3,023	15.3	19,711	100.0
Guayanilla	3,840	44.0	4,870	55.8	8,710	99.8	15	0.2	8,725	100.0
Guaynabo	5,823	13.9	6,593	15.7	12,416	29.6	29,596	70.4	42,012	100.0

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Table 3-7. Housing units in the wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Housing units	%	Housing units	%	Housing units	%	Housing units	%	Housing units	%
Gurabo	4,111	22.7	13,132	72.5	17,243	95.2	865	4.8	18,108	100.0
Hatillo	2,543	14.6	9,478	54.6	12,021	69.2	5,344	30.8	17,365	100.0
Hormigueros	2,708	34.8	4,050	52.0	6,758	86.8	1,025	13.2	7,783	100.0
Humacao	4,033	14.4	2,171	7.7	6,204	22.1	21,896	77.9	28,100	100.0
Isabela	2,404	11.3	6,528	30.7	8,932	42.0	12,335	58.0	21,267	100.0
Jayuya	4,659	71.2	1,842	28.2	6,501	99.4	40	0.6	6,541	100.0
Juana Díaz	4,332	21.6	12,600	62.9	16,932	84.6	3,087	15.4	20,019	100.0
Juncos	3,803	22.7	6,176	36.9	9,979	59.7	6,739	40.3	16,718	100.0
Lajas	2,787	22.5	7,299	58.9	10,086	81.4	2,311	18.6	12,397	100.0
Lares	11,291	87.1	1,621	12.5	12,912	99.7	44	0.3	12,956	100.0
Las Marías	3,545	88.9	396	9.9	3,941	98.8	46	1.2	3,987	100.0
Las Piedras	2,800	17.2	2,567	15.8	5,367	33.0	10,881	67.0	16,248	100.0
Loíza	503	4.0	11,808	93.1	12,311	97.0	378	3.0	12,689	100.0
Luquillo	1,851	16.9	4,751	43.3	6,602	60.2	4,366	39.8	10,968	100.0
Manatí	4,231	22.0	13,829	71.8	18,060	93.8	1,200	6.2	19,260	100.0
Maricao	2,462	89.9	253	9.2	2,715	99.1	25	0.9	2,740	100.0
Maunabo	1,592	28.7	3,897	70.3	5,489	99.0	57	1.0	5,546	100.0
Mayagüez	12,426	29.0	23,899	55.8	36,325	84.8	6,497	15.2	42,822	100.0
Moca	5,794	34.5	8,929	53.1	14,723	87.6	2,077	12.4	16,800	100.0
Morovis	5,343	43.2	7,006	56.6	12,349	99.7	32	0.3	12,381	100.0
Naguabo	1,709	14.2	10,259	85.3	11,968	99.5	60	0.5	12,028	100.0
Naranjito	8,964	79.5	2,318	20.5	11,282	100.0	0	0.0	11,282	100.0
Orocovis	7,162	77.4	2,044	22.1	9,206	99.5	49	0.5	9,255	100.0
Patillas	4,030	43.1	5,323	56.9	9,353	99.9	7	0.1	9,360	100.0
Peñuelas	3,980	43.2	5,177	56.1	9,157	99.3	63	0.7	9,220	100.0
Ponce	8,551	12.3	42,593	61.2	51,144	73.5	18,486	26.5	69,630	100.0
Quebradillas	1,977	18.4	3,729	34.7	5,706	53.1	5,048	46.9	10,754	100.0
Rincón	3,286	33.9	2,534	26.1	5,820	60.0	3,874	40.0	9,694	100.0
Río Grande	4,148	17.1	17,081	70.3	21,229	87.4	3,070	12.6	24,299	100.0
Sabana Grande	4,260	38.9	6,659	60.8	10,919	99.6	39	0.4	10,958	100.0
Salinas	1,847	12.8	3,205	22.3	5,052	35.1	9,328	64.9	14,380	100.0
San Germán	7,830	49.2	8,084	50.8	15,914	100.0	6	0.0	15,920	100.0

Table 3-7. Housing units in the wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Housing units	%	Housing units	%	Housing units	%	Housing units	%	Housing units	%
San Juan	5,332	2.7	1,440	0.7	6,772	3.4	193,143	96.6	199,915	100.0
San Lorenzo	7,908	45.9	7,758	45.0	15,666	90.9	1,560	9.1	17,226	100.0
San Sebastián	8,873	47.5	7,300	39.0	16,173	86.5	2,522	13.5	18,695	100.0
Santa Isabel	865	9.0	1,535	16.0	2,400	25.1	7,175	74.9	9,575	100.0
Toa Alta	5,479	20.3	6,073	22.5	11,552	42.8	15,454	57.2	27,006	100.0
Toa Baja	2,377	6.5	29,666	81.2	32,043	87.7	4,503	12.3	36,546	100.0
Trujillo Alto	4,509	14.9	3,600	11.9	8,109	26.8	22,186	73.2	30,295	100.0
Utua	10,233	72.1	3,818	26.9	14,051	99.0	141	1.0	14,192	100.0
Vega Alta	4,997	29.4	9,783	57.5	14,780	86.9	2,222	13.1	17,002	100.0
Vega Baja	4,462	17.6	20,930	82.4	25,392	100.0	9	0.0	25,401	100.0
Vieques	1,069	19.3	4,396	79.3	5,465	98.6	76	1.4	5,541	100.0
Villalba	6,288	64.8	3,410	35.1	9,698	99.9	12	0.1	9,710	100.0
Yabucoa	4,764	30.2	4,524	28.6	9,288	58.8	6,510	41.2	15,798	100.0
Yauco	5,938	33.0	12,035	66.8	17,973	99.7	47	0.3	18,020	100.0
Total	363,857	22.2	642,736	39.3	1,006,593	61.5	630,350	38.5	1,636,943	100.0

Table 3-8. Population in the wildland-urban interface (WUI) across Puerto Rico's municipalities.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Population	%	Population	%	Population	%	Population	%	Population	%
Adjuntas	14,011	71.9	5,285	27.1	19,296	99.0	187	1.0	19,483	100.0
Aguada	16,086	38.3	10,495	25.0	26,581	63.3	15,378	36.7	41,959	100.0
Aguadilla	4,261	7.0	27,460	45.1	31,721	52.0	29,228	48.0	60,949	100.0
Aguas Buenas	19,170	66.9	9,486	33.1	28,656	100.0	3	0.0	28,659	100.0
Aibonito	11,376	43.9	14,518	56.1	25,894	100.0	6	0.0	25,900	100.0
Añasco	11,554	39.5	16,939	57.9	28,493	97.4	768	2.6	29,261	100.0
Arecibo	21,724	22.5	33,976	35.2	55,700	57.8	40,740	42.2	96,440	100.0
Arroyo	2,964	15.1	10,808	55.2	13,772	70.4	5,803	29.6	19,575	100.0
Barceloneta	4,356	17.6	11,341	45.7	15,697	63.3	9,119	36.7	24,816	100.0
Barranquitas	21,370	70.5	8,202	27.1	29,572	97.5	746	2.5	30,318	100.0
Bayamón	18,263	8.8	30,017	14.4	48,280	23.2	159,836	76.8	208,116	100.0
Cabo Rojo	6,653	13.1	14,519	28.5	21,172	41.6	29,745	58.4	50,917	100.0
Caguas	29,184	20.4	93,142	65.2	122,326	85.6	20,567	14.4	142,893	100.0

3. Results

Table 3-8. Population in the wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Population	%	Population	%	Population	%	Population	%	Population	%
Camuy	5,504	15.7	17,444	49.6	22,948	65.3	12,211	34.7	35,159	100.0
Canóvanas	11,539	24.2	27,477	57.7	39,016	81.9	8,632	18.1	47,648	100.0
Carolina	14,481	8.2	74,261	42.0	88,742	50.2	88,020	49.8	176,762	100.0
Cataño	349	1.2	139	0.5	488	1.7	27,652	98.3	28,140	100.0
Cayey	15,339	31.9	30,979	64.4	46,318	96.3	1,801	3.7	48,119	100.0
Ceiba	2,904	21.3	10,709	78.6	13,613	99.9	18	0.1	13,631	100.0
Ciales	13,550	72.1	4,973	26.5	18,523	98.6	259	1.4	18,782	100.0
Cidra	14,000	32.2	20,488	47.1	34,488	79.3	8,992	20.7	43,480	100.0
Coamo	15,100	37.3	24,400	60.2	39,500	97.5	1,012	2.5	40,512	100.0
Comerio	11,693	56.3	9,054	43.6	20,747	99.9	31	0.1	20,778	100.0
Corozal	21,408	57.6	15,710	42.3	37,118	99.9	24	0.1	37,142	100.0
Culebra	565	31.1	1,249	68.7	1,814	99.8	4	0.2	1,818	100.0
Dorado	7,748	20.3	13,953	36.6	21,701	56.9	16,464	43.1	38,165	100.0
Fajardo	2,580	7.0	23,473	63.5	26,053	70.4	10,940	29.6	36,993	100.0
Florida	7,131	56.2	5,531	43.6	12,662	99.9	18	0.1	12,680	100.0
Guánica	3,869	19.9	15,502	79.8	19,371	99.7	56	0.3	19,427	100.0
Guayama	7,419	16.4	29,256	64.5	36,675	80.8	8,687	19.2	45,362	100.0
Guayanilla	9,447	43.8	12,105	56.1	21,552	99.9	29	0.1	21,581	100.0
Guaynabo	14,430	14.7	15,825	16.2	30,255	30.9	67,669	69.1	97,924	100.0
Gurabo	9,888	21.8	33,305	73.4	43,193	95.2	2,176	4.8	45,369	100.0
Hatillo	6,161	14.7	22,610	53.9	28,771	68.6	13,182	31.4	41,953	100.0
Hormigueros	5,724	33.2	9,066	52.6	14,790	85.7	2,460	14.3	17,250	100.0
Humacao	9,403	16.1	5,012	8.6	14,415	24.7	44,051	75.3	58,466	100.0
Isabela	5,182	11.4	15,243	33.4	20,425	44.8	25,206	55.2	45,631	100.0
Jayuya	12,212	73.4	4,343	26.1	16,555	99.5	87	0.5	16,642	100.0
Juana Díaz	10,965	21.6	32,246	63.5	43,211	85.1	7,536	14.9	50,747	100.0
Juncos	9,123	22.6	15,678	38.9	24,801	61.6	15,489	38.4	40,290	100.0
Lajas	5,587	21.7	16,442	63.8	22,029	85.5	3,724	14.5	25,753	100.0
Lares	27,161	88.3	3,477	11.3	30,638	99.6	115	0.4	30,753	100.0
Las Marías	8,861	89.7	915	9.3	9,776	98.9	105	1.1	9,881	100.0
Las Piedras	6,636	17.2	6,274	16.2	12,910	33.4	25,765	66.6	38,675	100.0
Loíza	1,288	4.3	27,740	92.3	29,028	96.6	1,032	3.4	30,060	100.0
Luquillo	4,061	20.2	10,897	54.3	14,958	74.5	5,110	25.5	20,068	100.0

Table 3-8. Population in the wildland-urban interface (WUI) across Puerto Rico's municipalities, continued.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Population	%	Population	%	Population	%	Population	%	Population	%
Manatí	10,018	22.7	31,279	70.9	41,297	93.6	2,816	6.4	44,113	100.0
Maricao	5,720	91.1	497	7.9	6,217	99.1	59	0.9	6,276	100.0
Maunabo	3,447	28.2	8,643	70.7	12,090	98.9	135	1.1	12,225	100.0
Mayagüez	26,818	30.1	47,853	53.7	74,671	83.8	14,400	16.2	89,071	100.0
Moca	14,228	35.5	20,567	51.3	34,795	86.8	5,314	13.2	40,109	100.0
Morovis	14,072	43.2	18,437	56.5	32,509	99.7	101	0.3	32,610	100.0
Naguabo	3,744	14.0	22,859	85.6	26,603	99.6	117	0.4	26,720	100.0
Naranjito	24,437	80.4	5,965	19.6	30,402	100.0	0	0.0	30,402	100.0
Orocovis	18,208	77.7	5,099	21.8	23,307	99.5	116	0.5	23,423	100.0
Patillas	8,446	43.8	10,822	56.1	19,268	100.0	9	0.0	19,277	100.0
Peñuelas	10,202	42.0	13,946	57.4	24,148	99.4	134	0.6	24,282	100.0
Ponce	22,397	13.5	100,932	60.7	123,329	74.1	42,998	25.9	166,327	100.0
Quebradillas	4,839	18.7	9,356	36.1	14,195	54.8	11,724	45.2	25,919	100.0
Rincón	5,310	34.9	4,793	31.5	10,103	66.5	5,097	33.5	15,200	100.0
Río Grande	9,588	17.7	39,180	72.1	48,768	89.8	5,536	10.2	54,304	100.0
Sabana Grande	9,861	39.0	15,236	60.3	25,097	99.3	168	0.7	25,265	100.0
Salinas	3,998	12.9	6,565	21.1	10,563	34.0	20,515	66.0	31,078	100.0
San Germán	18,429	51.9	17,092	48.1	35,521	100.0	6	0.0	35,527	100.0
San Juan	12,108	3.1	3,554	0.9	15,662	4.0	379,664	96.0	395,326	100.0
San Lorenzo	18,536	45.1	18,647	45.4	37,183	90.6	3,875	9.4	41,058	100.0
San Sebastián	20,356	48.0	16,247	38.3	36,603	86.3	5,827	13.7	42,430	100.0
Santa Isabel	1,893	8.1	4,172	17.9	6,065	26.1	17,209	73.9	23,274	100.0
Toa Alta	14,343	19.4	16,192	21.9	30,535	41.2	43,531	58.8	74,066	100.0
Toa Baja	6,203	6.9	71,900	80.2	78,103	87.2	11,506	12.8	89,609	100.0
Trujillo Alto	11,370	15.2	9,281	12.4	20,651	27.6	54,191	72.4	74,842	100.0
Utua	24,269	73.2	8,580	25.9	32,849	99.1	300	0.9	33,149	100.0
Vega Alta	12,396	31.0	23,887	59.8	36,283	90.8	3,668	9.2	39,951	100.0
Vega Baja	11,081	18.6	48,549	81.4	59,630	99.9	32	0.1	59,662	100.0
Vieques	1,735	18.7	7,462	80.2	9,197	98.9	104	1.1	9,301	100.0
Villalba	16,725	64.1	9,322	35.8	26,047	99.9	26	0.1	26,073	100.0
Yabucoa	11,784	31.1	10,322	27.2	22,106	58.3	15,835	41.7	37,941	100.0
Yauco	13,877	33.0	28,077	66.8	41,954	99.8	89	0.2	42,043	100.0
Total	872,718	23.4	1,497,277	40.2	2,369,995	63.6	1,355,785	36.4	3,725,780	100.0

3. Results

Figure 3-8. Neighborhood in the town of Charlotte Amalie, St. Thomas, VI, 2022. This photo captures the mix of houses and forests around the town. USDA Natural Resources Conservation Service photo by Julie Wright.



Table 3-9. Area of wildland-urban interface (WUI) across U.S. Virgin Islands districts.

District	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
St. Croix	58.3	26.4	46.5	21.1	104.7	47.5	115.7	52.5	220.4	100.0
St. John	12.8	27.9	3.7	8.1	16.5	36.0	29.3	64.0	45.7	100.0
St. Thomas	42.3	52.8	17.7	22.1	60.0	74.8	20.2	25.2	80.1	100.0
Total	113.3	32.7	67.8	19.6	181.2	52.3	165.1	47.7	346.3	100.0

Table 3-10. Housing units in the wildland-urban interface (WUI) across U.S. Virgin Islands districts.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Housing units	%	Housing units	%	Housing units	%	Housing units	%	Housing units	%
St. Croix	4,382	17.3	17,233	68.2	21,615	85.5	3,660	14.5	25,275	100.0
St. John	1,539	44.6	1,908	55.3	3,447	99.8	6	0.2	3,453	100.0
St. Thomas	8,641	31.8	18,503	68.1	27,144	99.9	29	0.1	27,173	100.0
Total	14,562	26.0	37,644	67.3	52,206	93.4	3,695	6.6	55,901	100.0

Table 3-11. Population in the wildland-urban interface (WUI) across U.S. Virgin Islands districts.

Municipality	Intermix WUI		Interface WUI		WUI (total)		Non-WUI		Grand total	
	Population	%	Population	%	Population	%	Population	%	Population	%
St. Croix	7,664	15.1	33,981	67.2	41,645	82.3	8,956	17.7	50,601	100.0
St. John	2,067	49.6	2,078	49.8	4,145	99.4	25	0.6	4,170	100.0
St. Thomas	16,150	31.3	35,098	68.0	51,248	99.3	386	0.7	51,634	100.0
Total	25,881	24.3	71,157	66.9	97,038	91.2	9,367	8.8	106,405	100.0

Figure 3-9. View of Charlotte Amalie, St. Thomas, VI, 2022. A large portion of the coastal town of Charlotte Amalie was classified as interface WUI. This is due to its narrow shape (i.e., within the 2.4-km WUI buffer) and the presence of large patches of forest nearby, which makes this area interface WUI. USDA Natural Resources Conservation Service photo by Julie Wright.



3. Results

3.5. WUI Maps for Puerto Rico's Municipalities

Puerto Rico encompasses 78 municipalities (fig. 3-10). In this section, figures 3-11 through 3-88 depict the wildland-urban interface in the 78 municipalities of Puerto Rico in 2010.

Figure 3-10. Puerto Rico municipalities.



Figure 3-11. Wildland-urban interface in Adjuntas, PR.

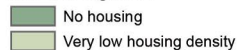
Adjuntas 2010



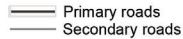
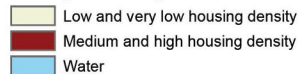
Wildland-Urban Interface (WUI)



Non-WUI Vegetated



Non-vegetated or Agriculture



Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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0 2.5 5 km

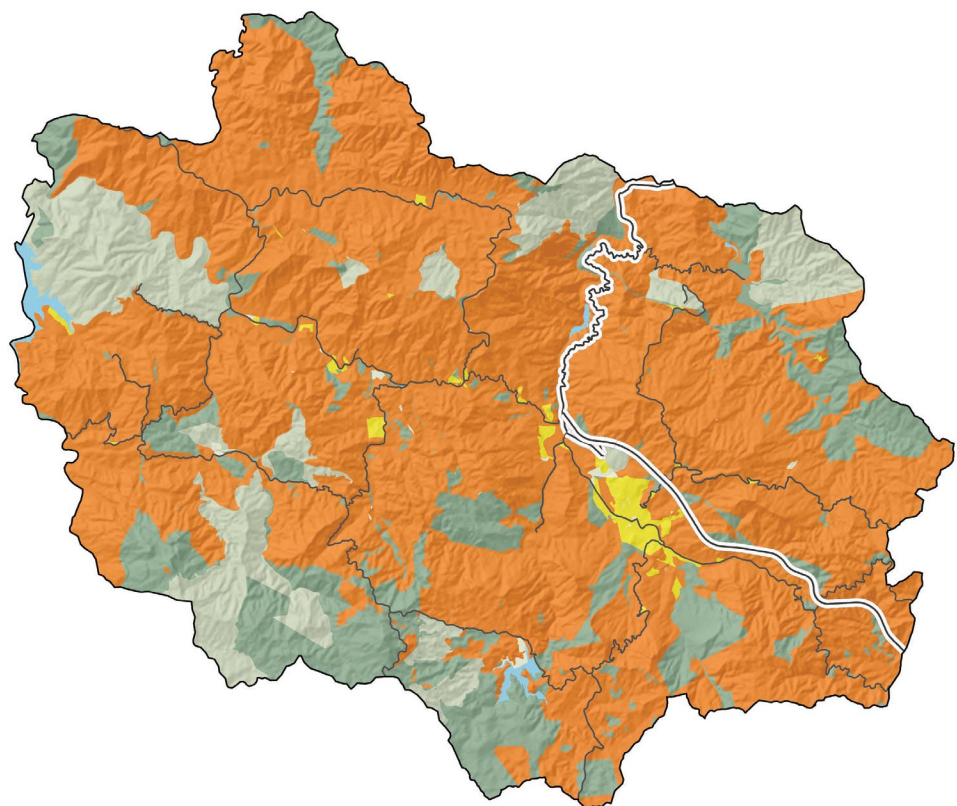


Figure 3-12. Wildland-urban interface in Aguada, PR.

Aguada

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

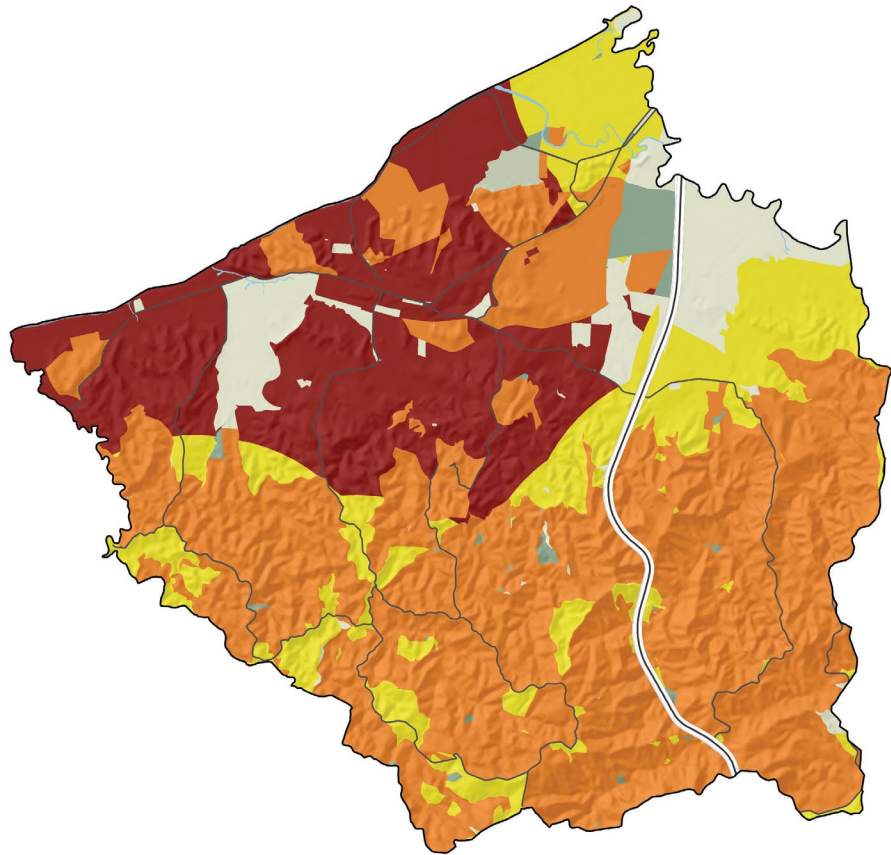
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 1.5 3 km



3. Results

Figure 3-13. Wildland-urban interface in Aguadilla, PR.

Aguadilla

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

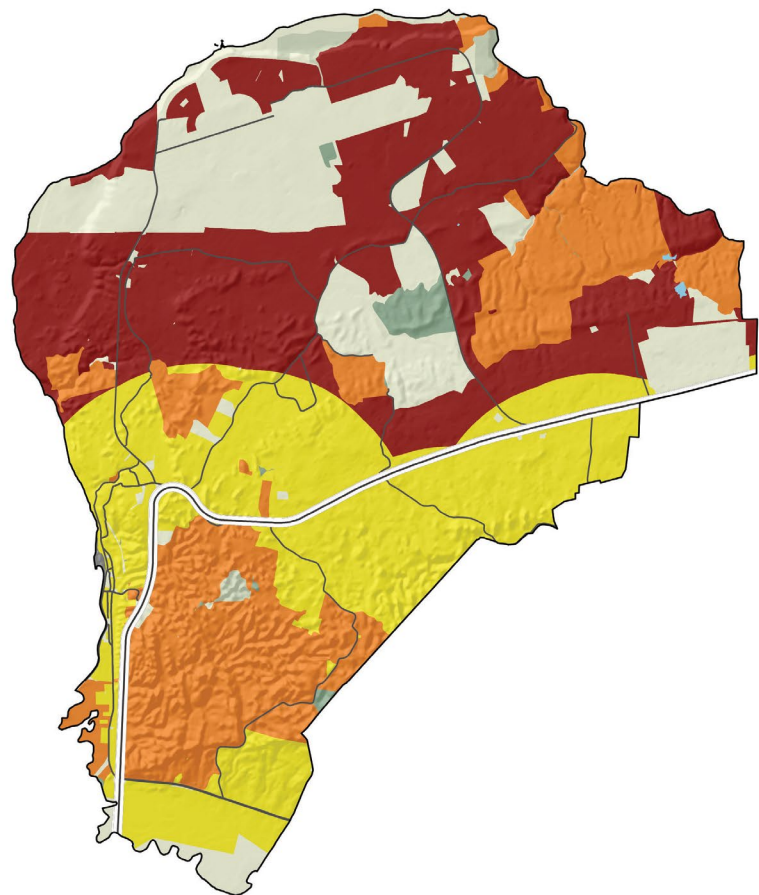
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2 4 km



Figure 3-14. Wildland-urban interface in Aguas Buenas, PR.

Aguas Buenas

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

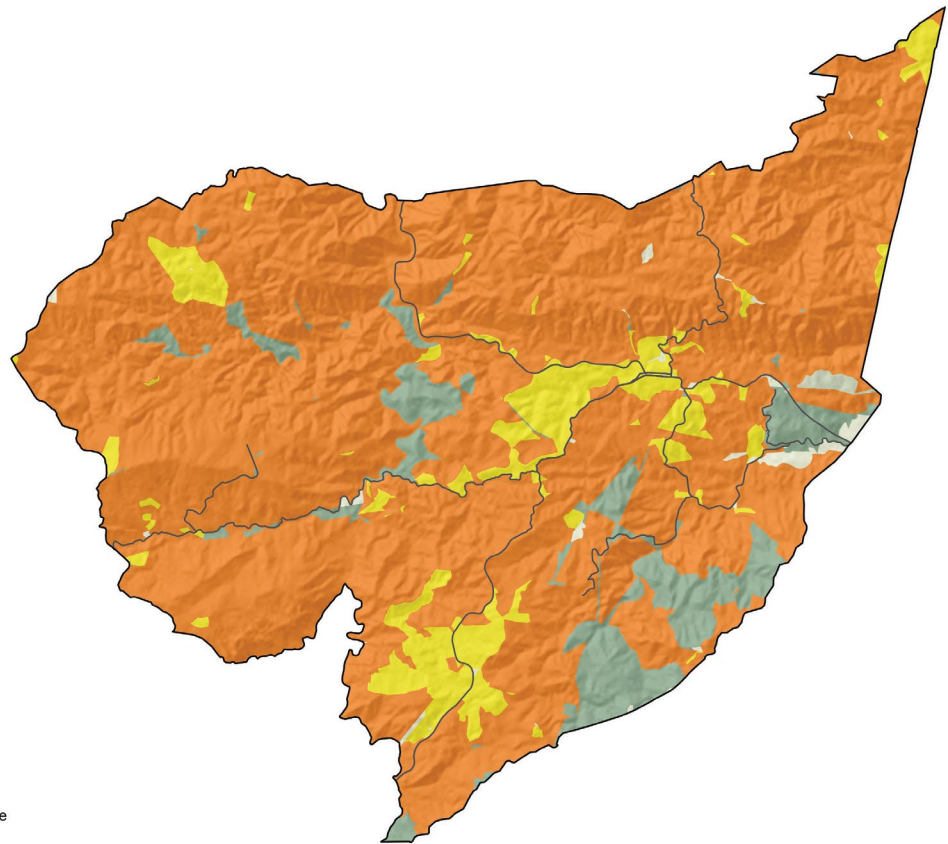
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-15. Wildland-urban interface in Aibonito, PR.

Aibonito

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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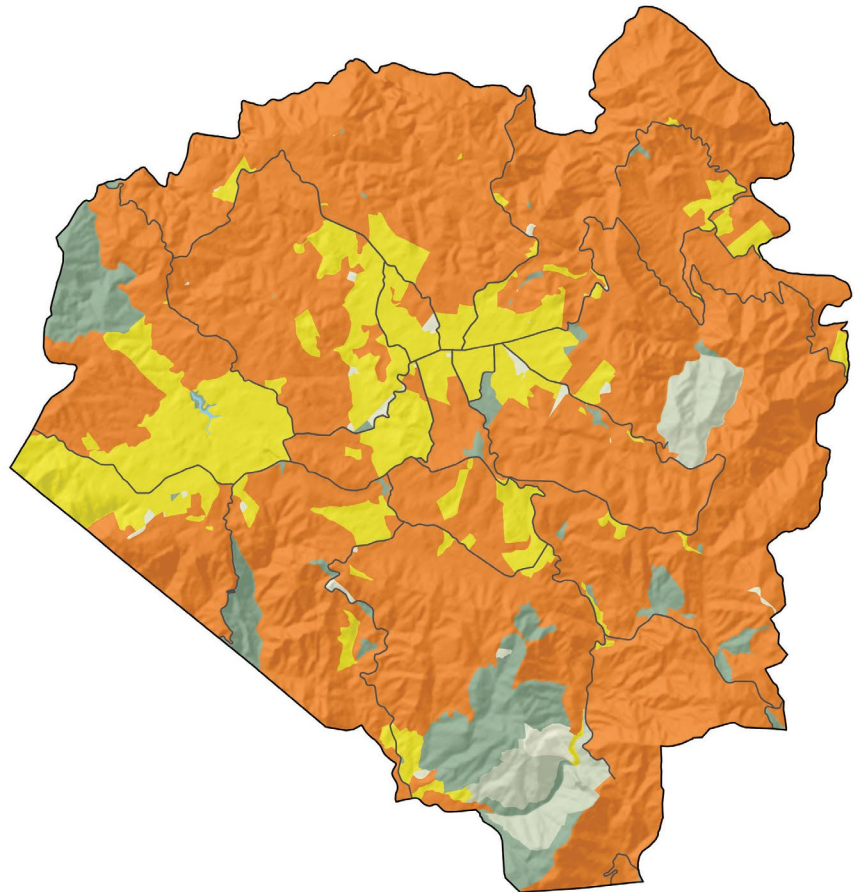


Figure 3-16. Wildland-urban interface in Añasco, PR.

Añasco

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

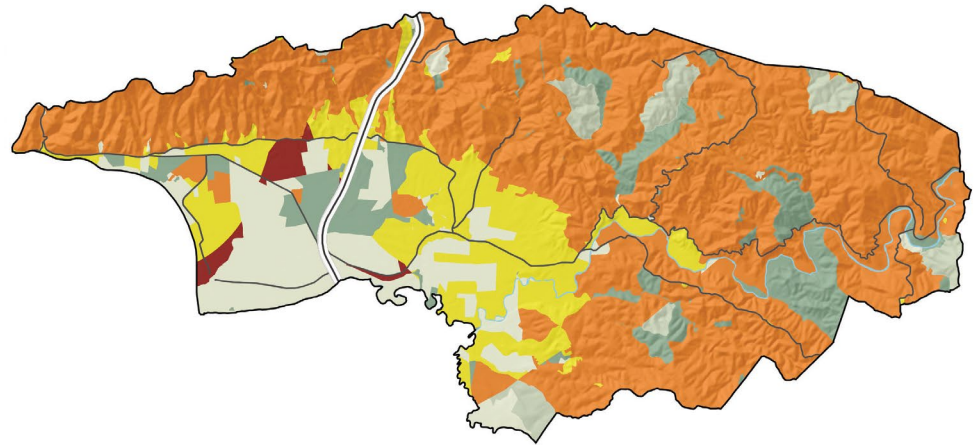
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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0 3 6 km



3. Results

Figure 3-17. Wildland-urban interface in Arecibo, PR.

Arecibo
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

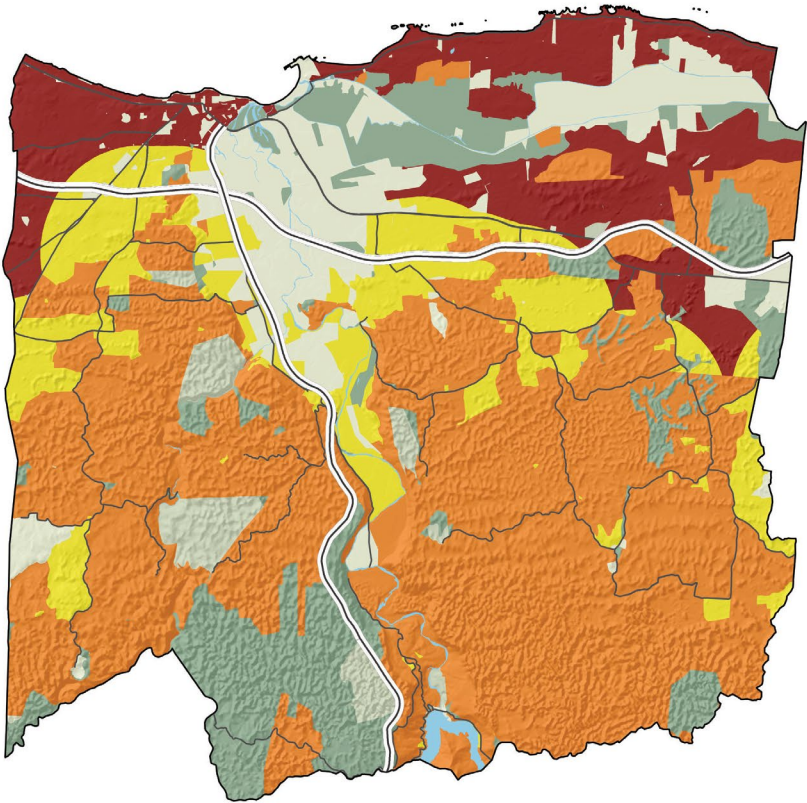
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3.5 7 km



Figure 3-18. Wildland-urban interface in Arroyo, PR.

Arroyo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

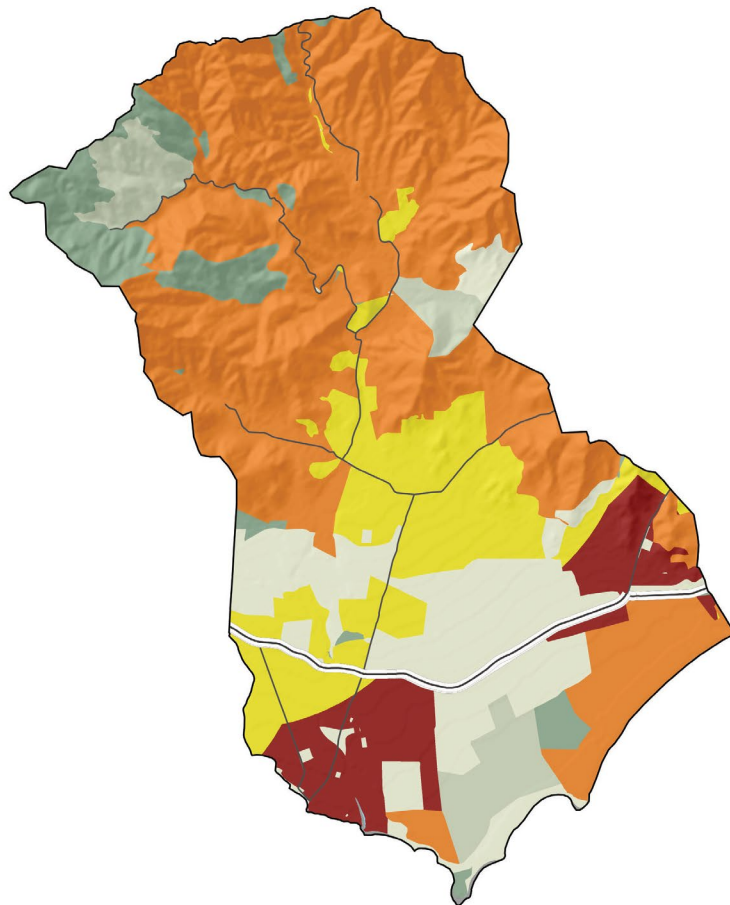
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 1.5 3 km



3. Results

Figure 3-19. Wildland-urban interface in Barceloneta, PR.

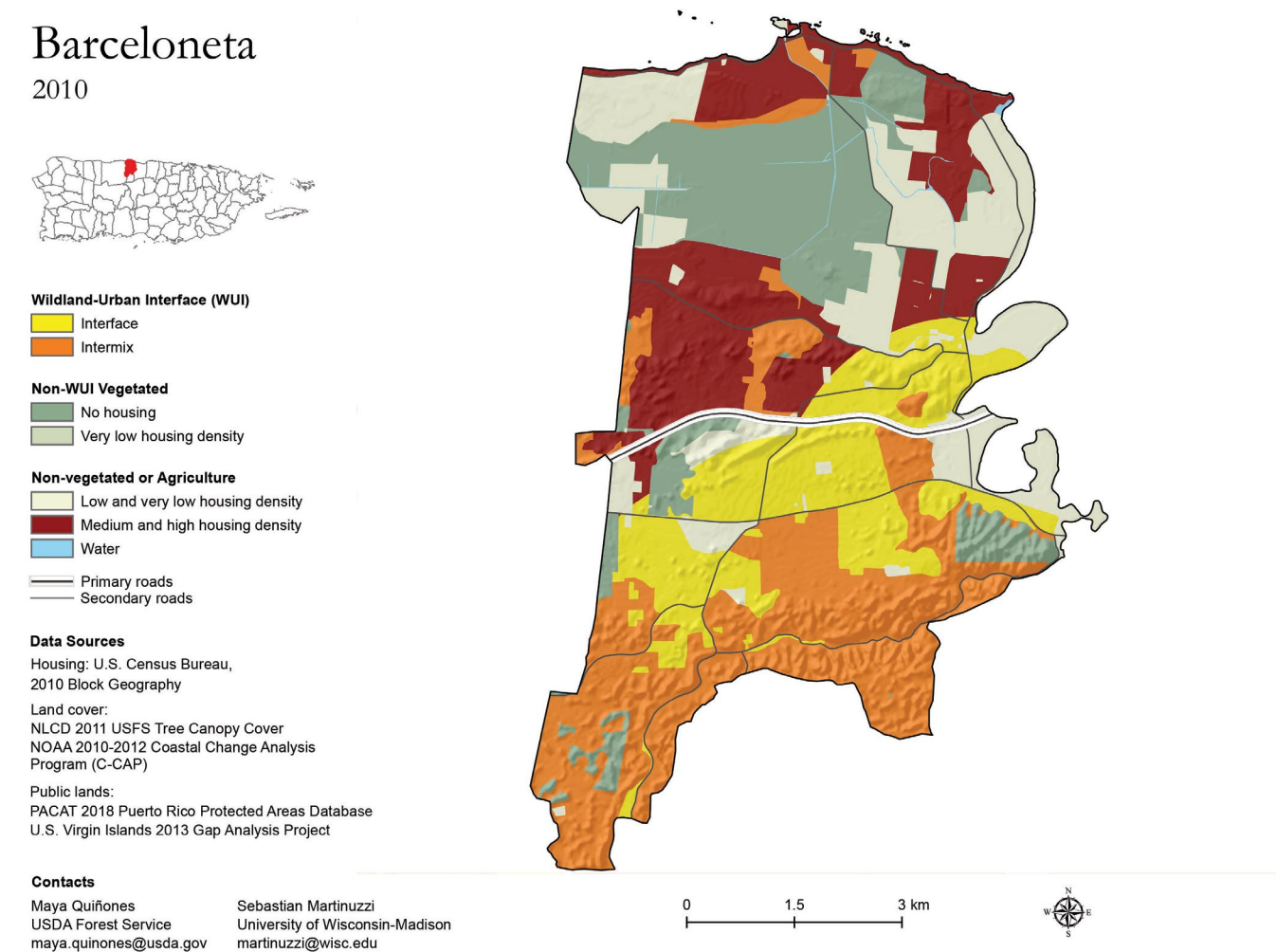
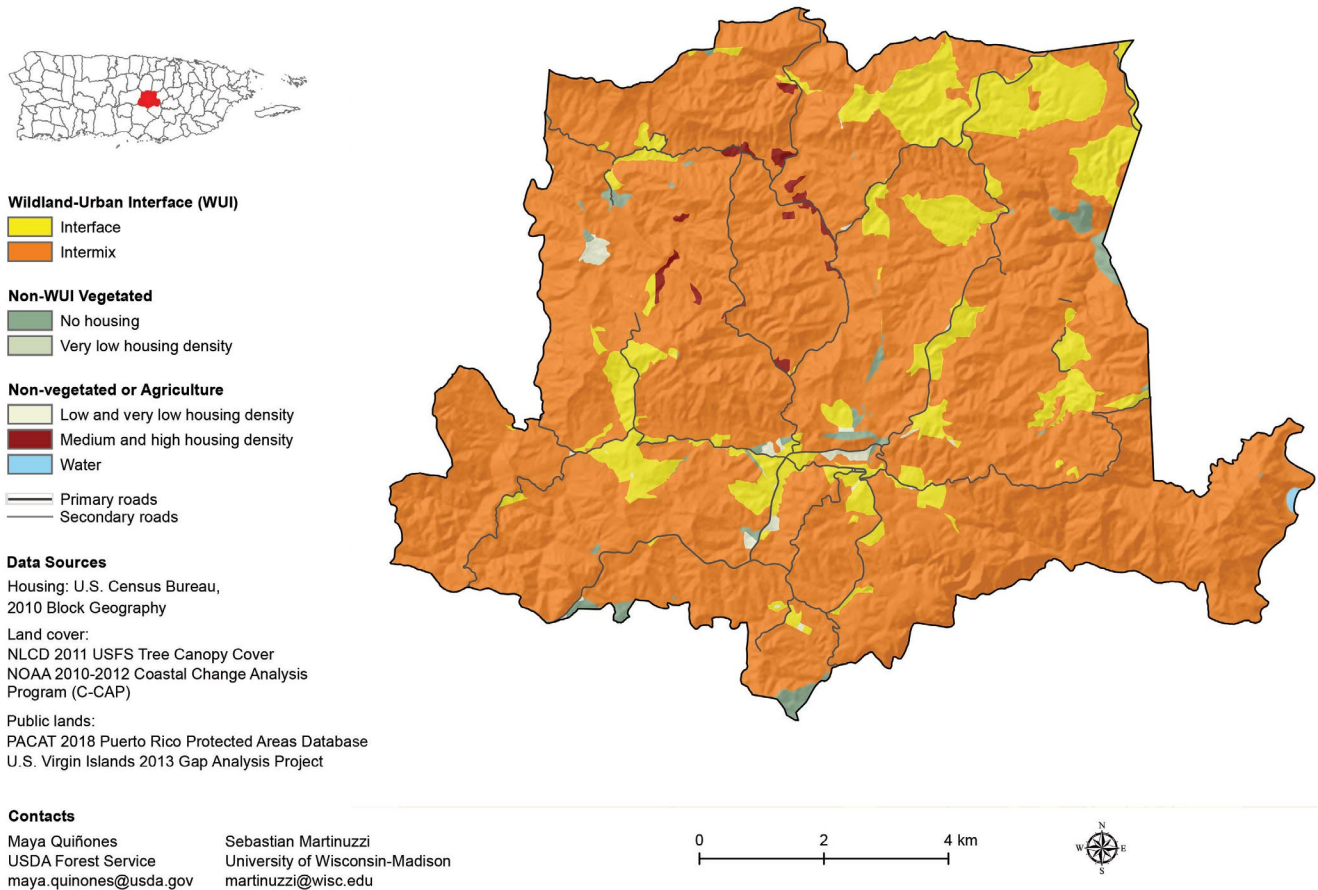


Figure 3-20. Wildland-urban interface in Barranquitas, PR.

Barranquitas

2010



3. Results

Figure 3-21. Wildland-urban interface in Bayamón, PR.

Bayamón

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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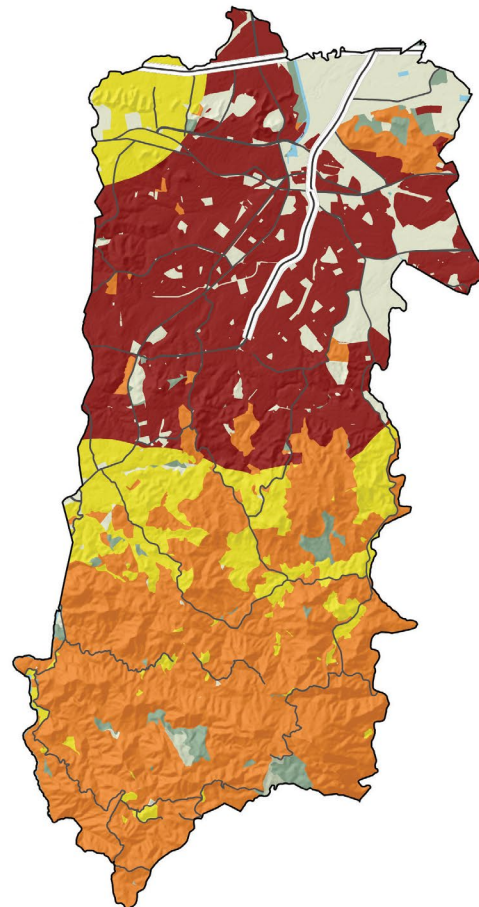


Figure 3-22. Wildland-urban interface in Cabo Rojo, PR.

Cabo Rojo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

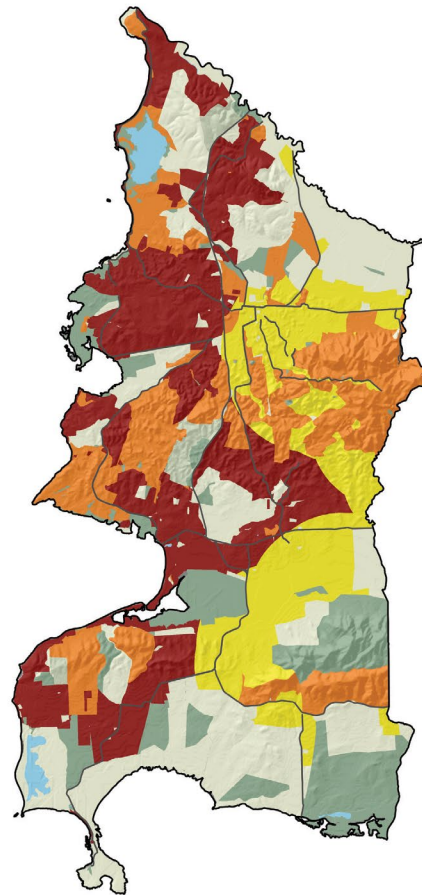
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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0 4 8 km



3. Results

Figure 3-23. Wildland-urban interface in Caguas, PR.

Caguas
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

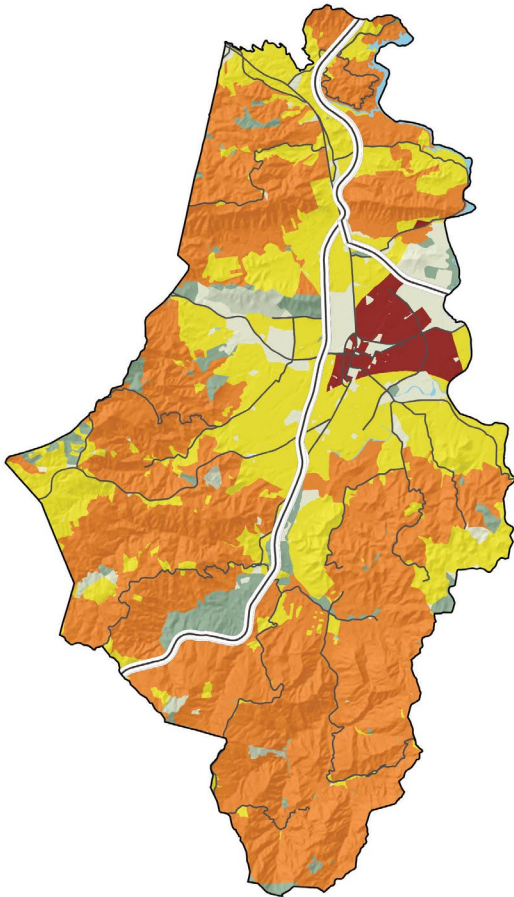
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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U.S. Virgin Islands 2013 Gap Analysis Project

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0 3.5 7 km



Figure 3-24. Wildland-urban interface in Camuy, PR.

Camuy

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

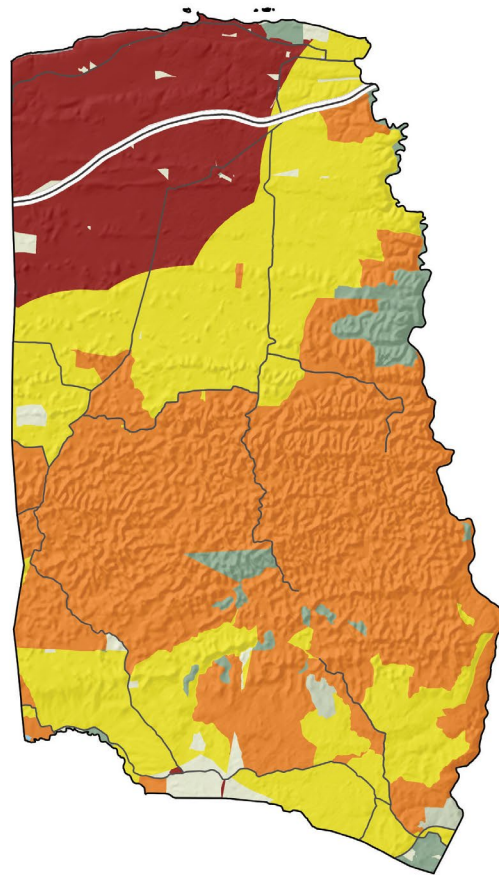
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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U.S. Virgin Islands 2013 Gap Analysis Project

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0 2.5 5 km



3. Results

Figure 3-25. Wildland-urban interface in Canóvanas, PR.

Canóvanas

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

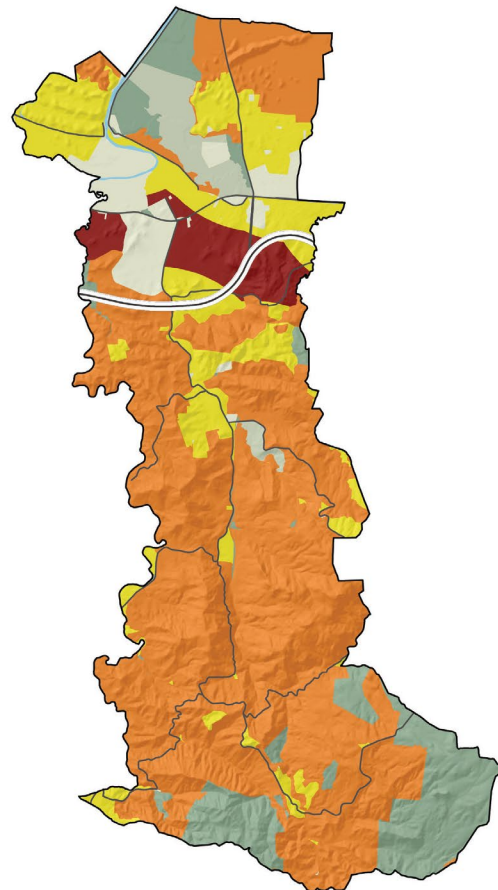
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



Figure 3-26. Wildland-urban interface in Carolina, PR.

Carolina

2010

**Wildland-Urban Interface (WUI)**

Interface

Intermix

Non-WUI Vegetated

No housing

Very low housing density

Non-vegetated or Agriculture

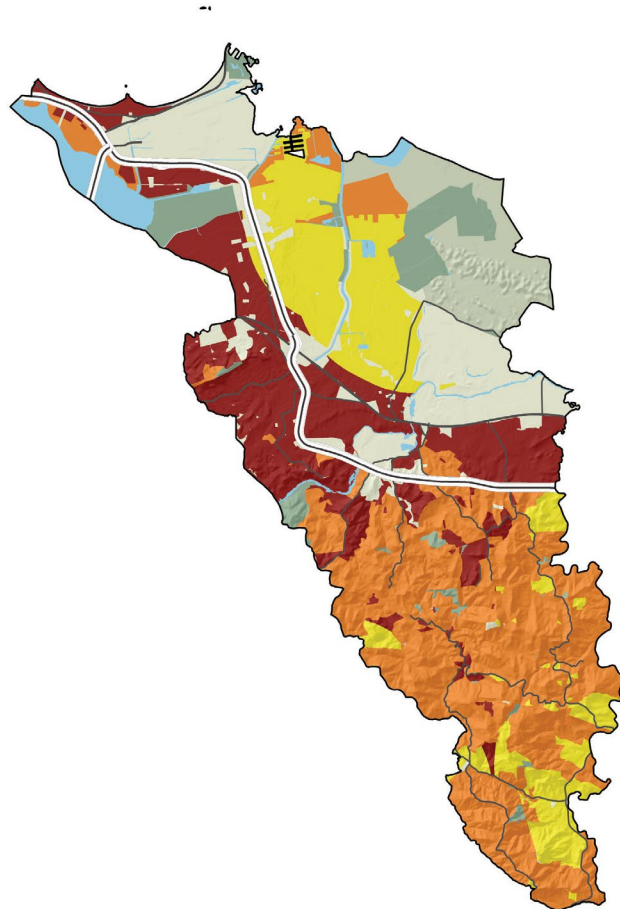
Low and very low housing density

Medium and high housing density

Water

Primary roads

Secondary roads

Data SourcesHousing: U.S. Census Bureau,
2010 Block GeographyLand cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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3. Results

Figure 3-27. Wildland-urban interface in Cataño, PR.

Cataño
2010

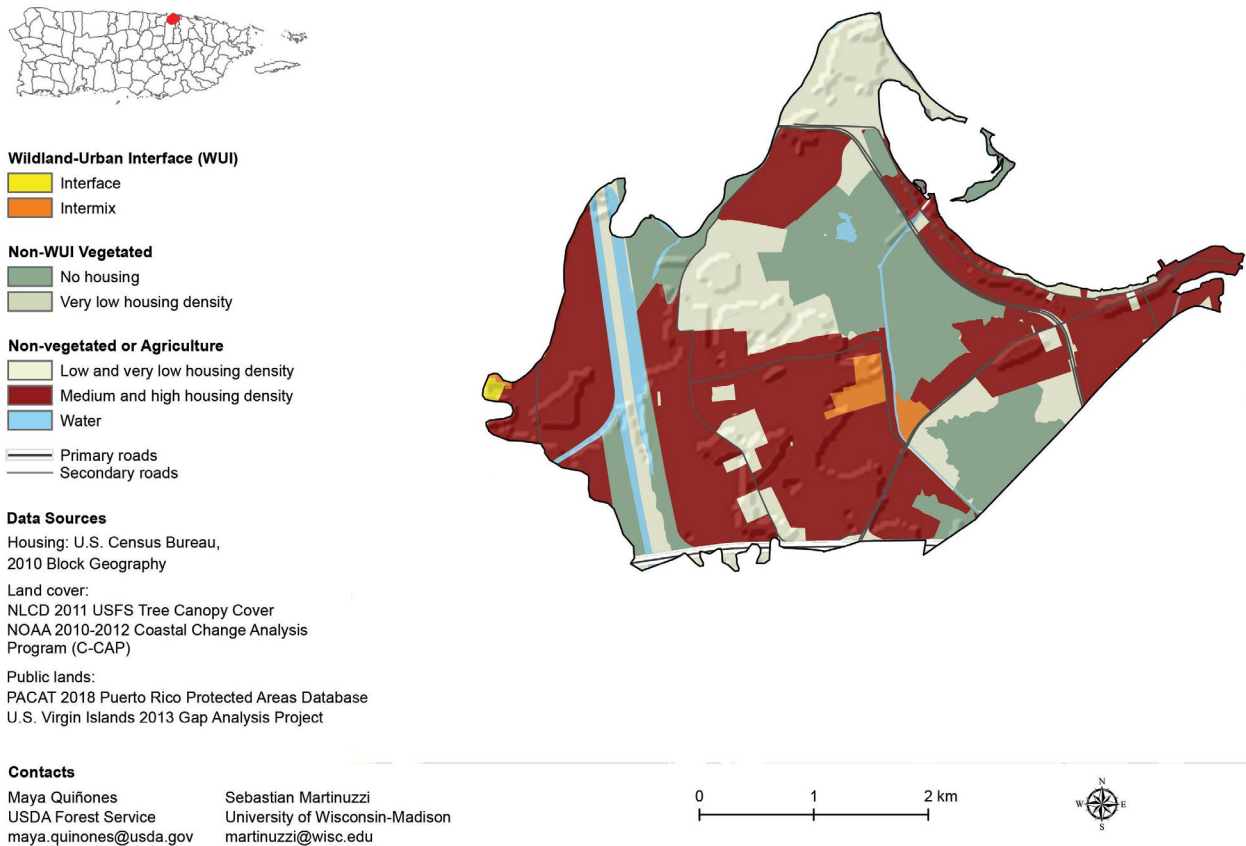


Figure 3-28. Wildland-urban interface in Cayey, PR.

Cayey

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

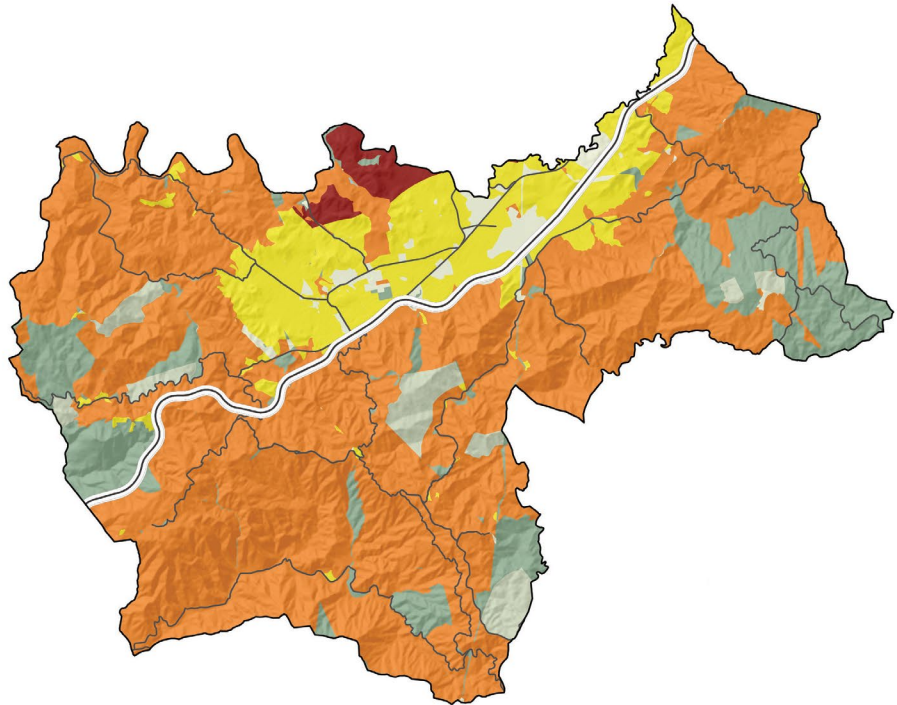
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-29. Wildland-urban interface in Ceiba, PR.

Ceiba
2010

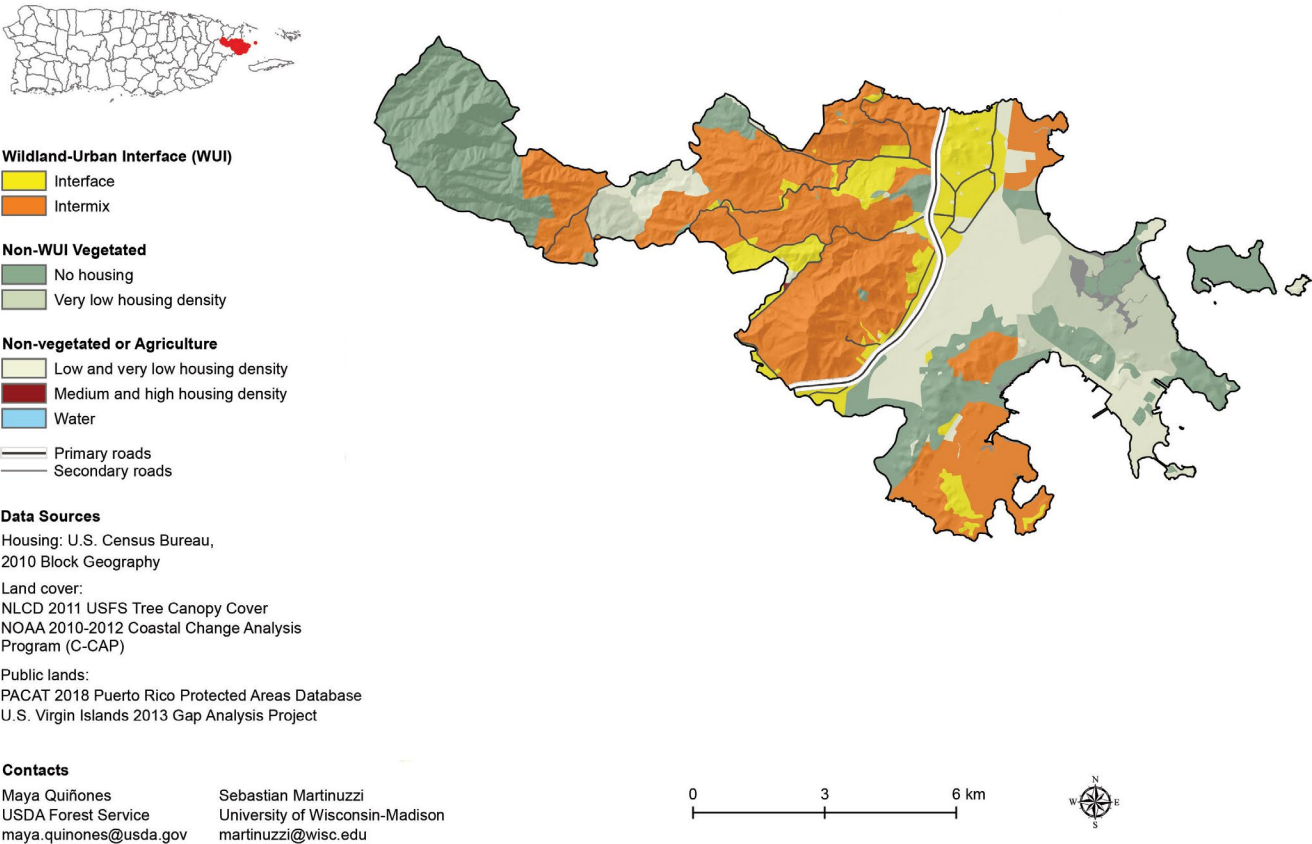


Figure 3-30. Wildland-urban interface in Ciales, PR.

Ciales

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

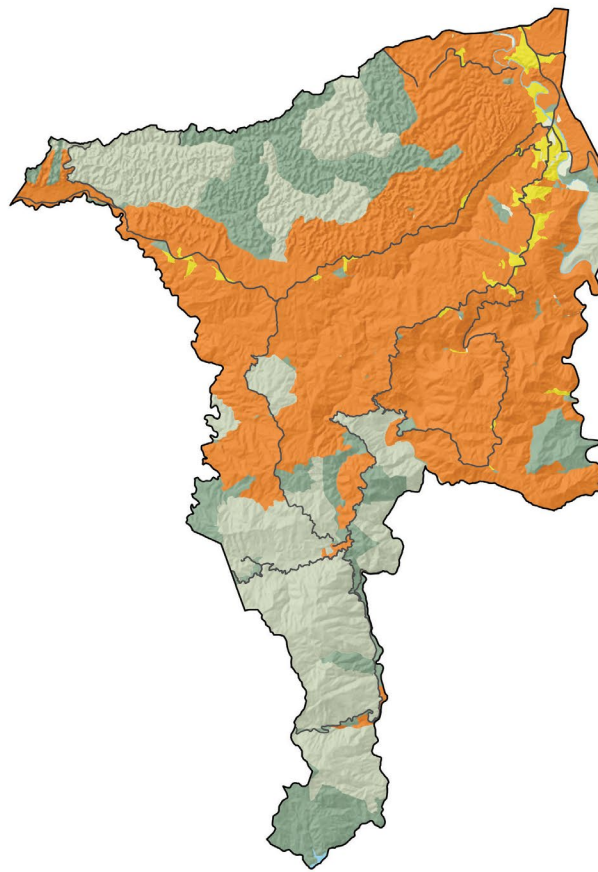
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-31. Wildland-urban interface in Cidra, PR.

Cidra

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

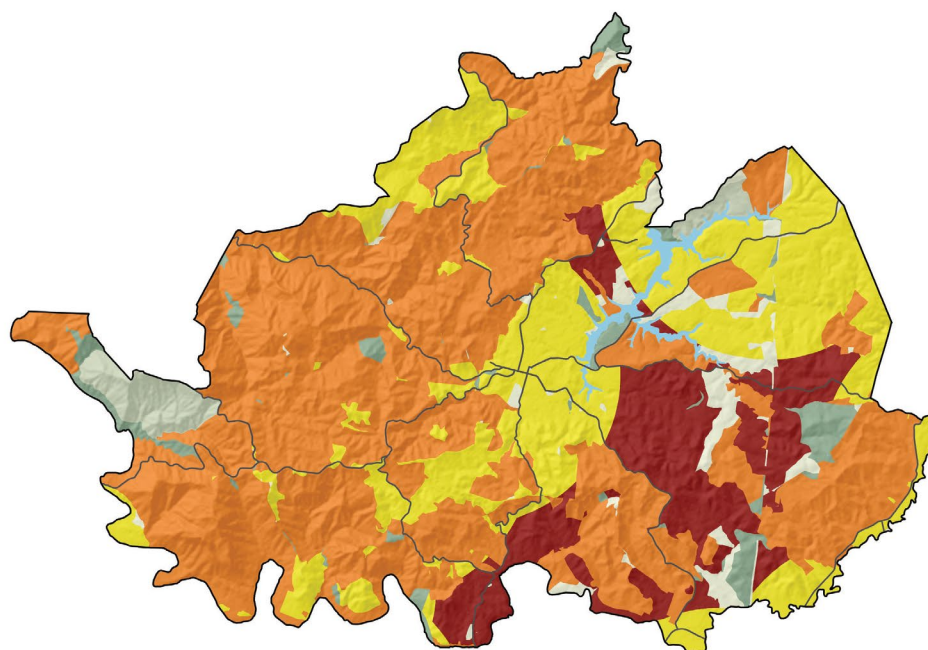
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2 4 km



Figure 3-32. Wildland-urban interface in Coamo, PR.

Coamo

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

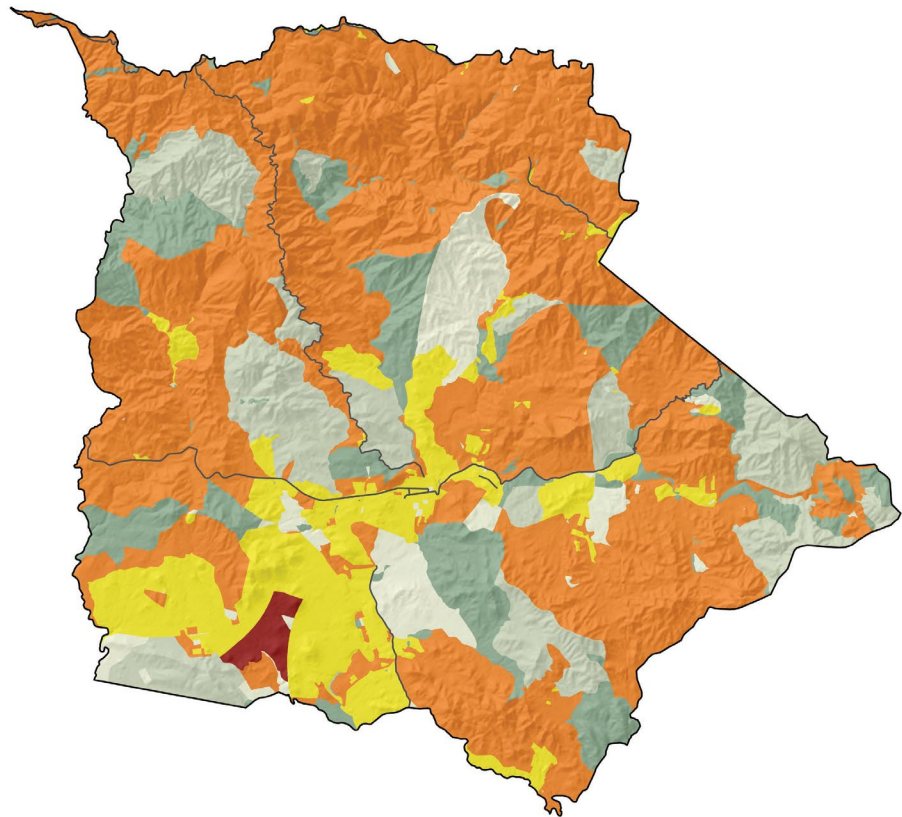
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3 6 km



3. Results

Figure 3-33. Wildland-urban interface in Comerío, PR.

Comerío
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

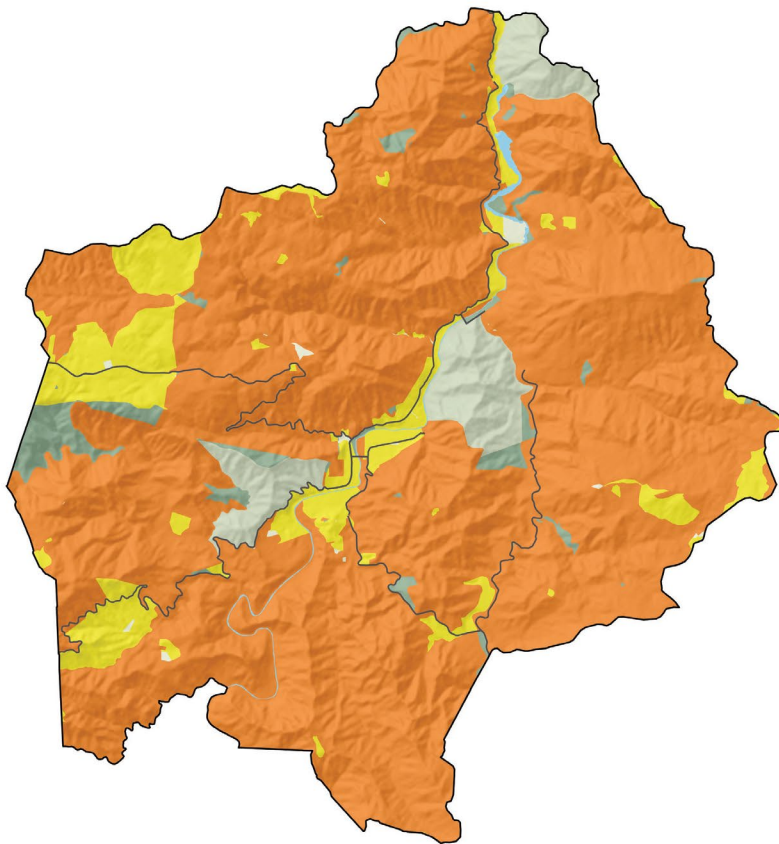
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2 4 km



Figure 3-34. Wildland-urban interface in Corozal, PR.

Corozal

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

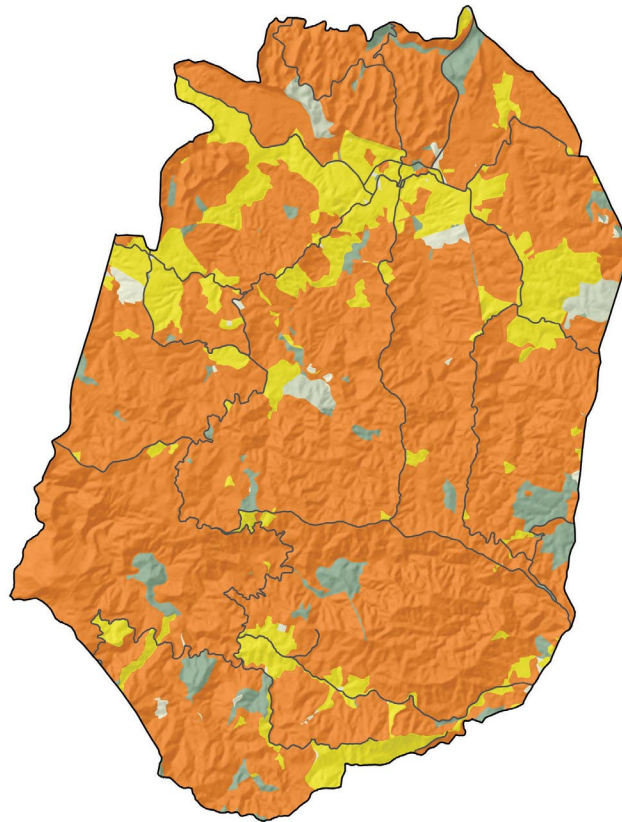
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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0 2.5 5 km



3. Results

Figure 3-35. Wildland-urban interface in Culebra, PR.

Culebra
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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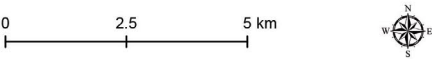
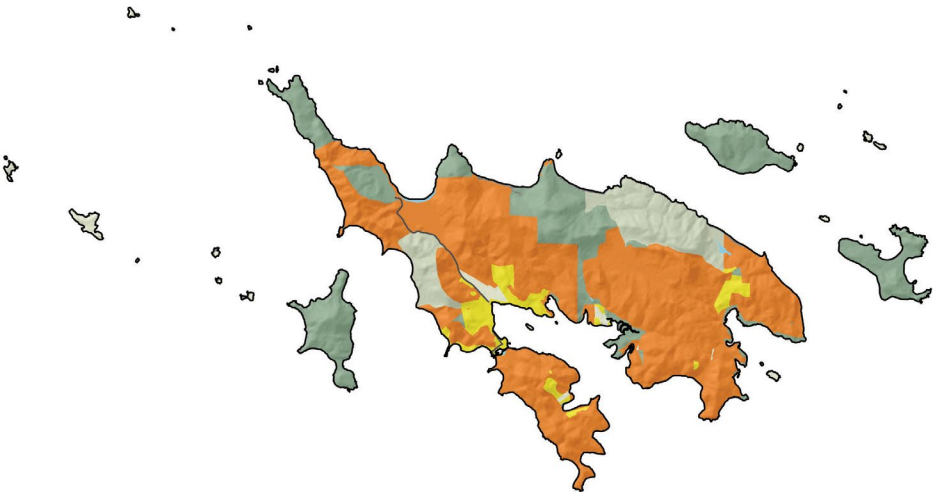


Figure 3-36. Wildland-urban interface in Dorado, PR.

Dorado

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

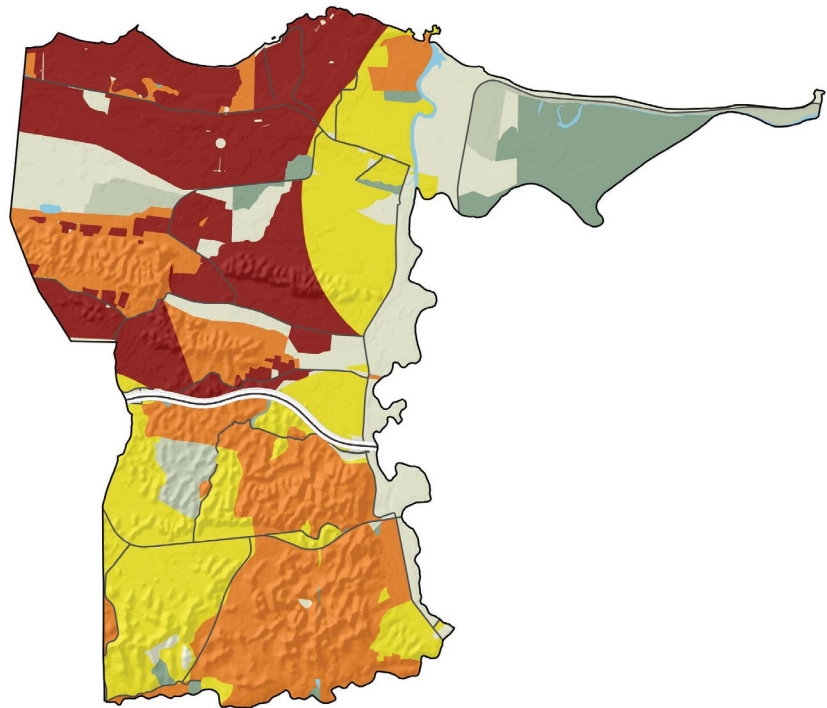
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2 4 km



3. Results

Figure 3-37. Wildland-urban interface in Fajardo, PR.

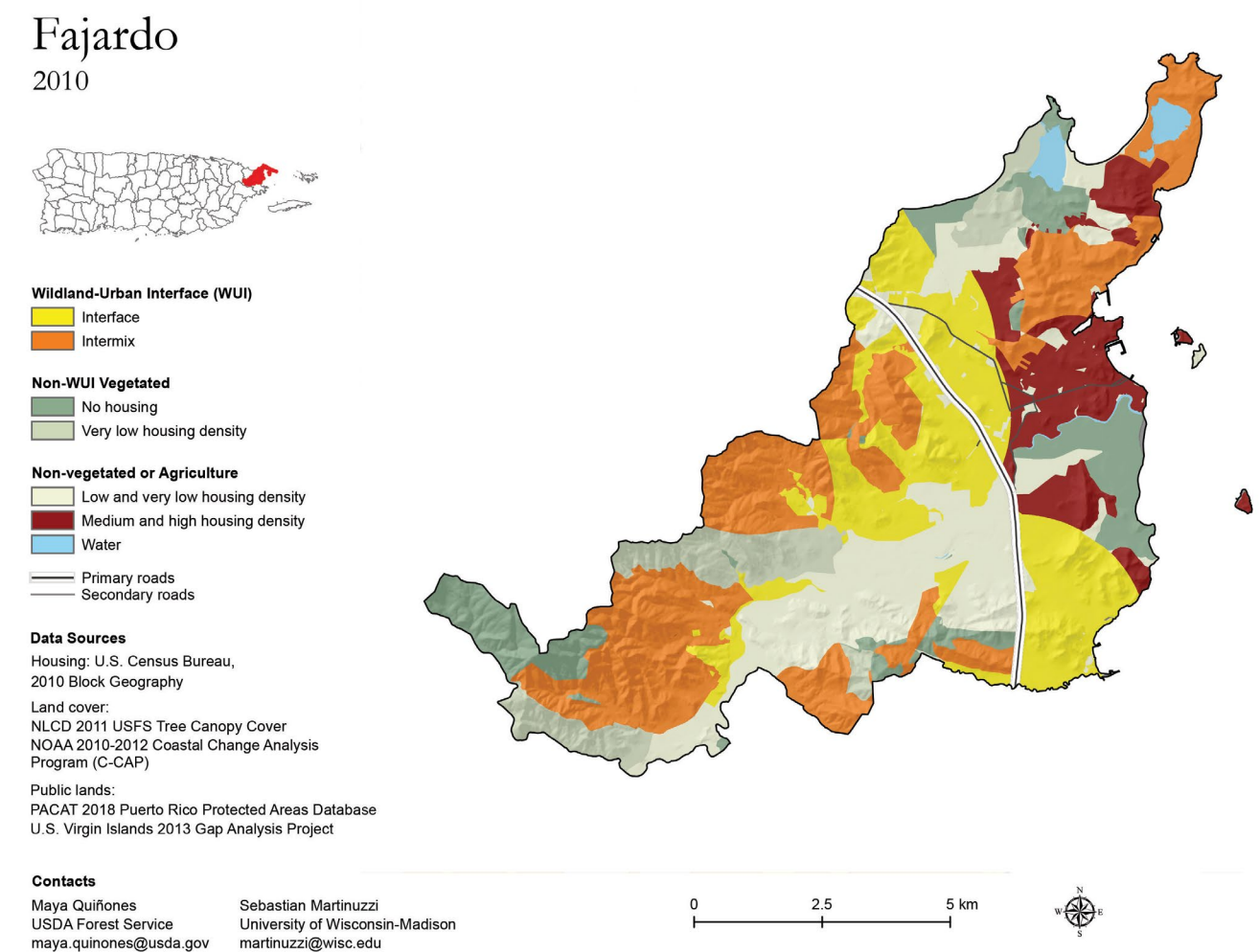


Figure 3-38. Wildland-urban interface in Florida, PR.

Florida

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

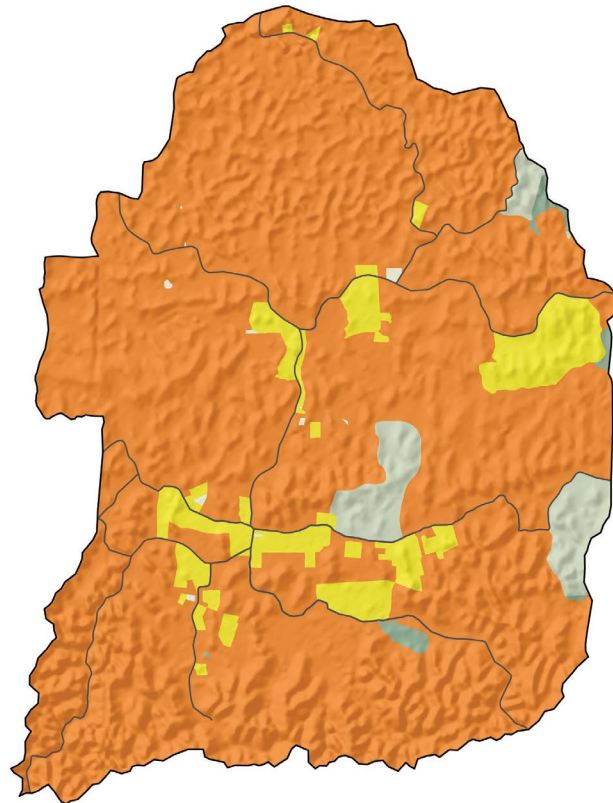
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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Public lands:
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0 1.5 3 km



3. Results

Figure 3-39. Wildland-urban interface in Guánica, PR.

Guánica

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

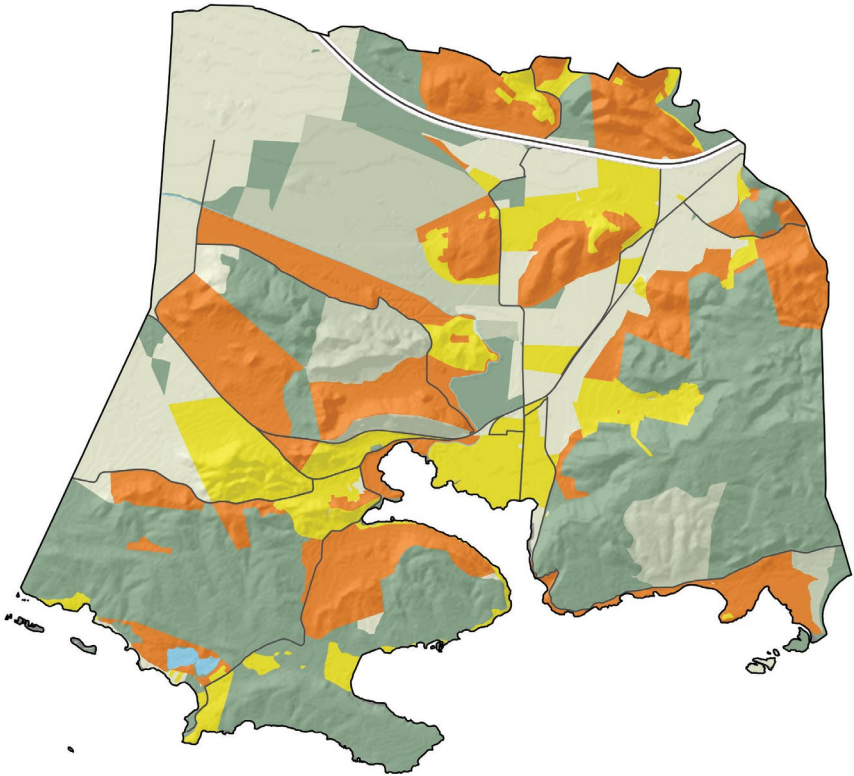
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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Public lands:
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0 2 4 km



Figure 3-40. Wildland-urban interface in Guayama, PR.

Guayama

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

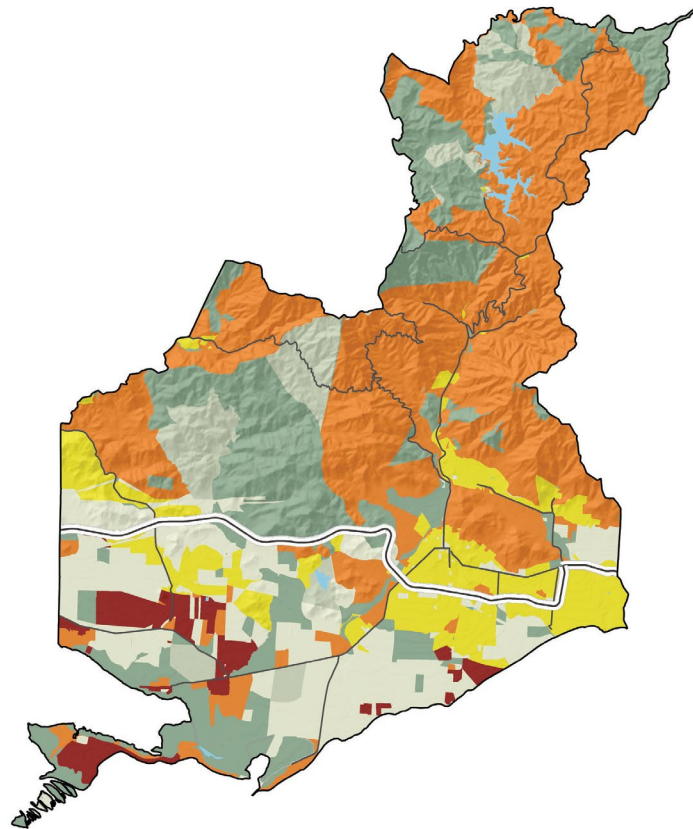
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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Public lands:
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3. Results

Figure 3-41. Wildland-urban interface in Guayanilla, PR.

Guayanilla

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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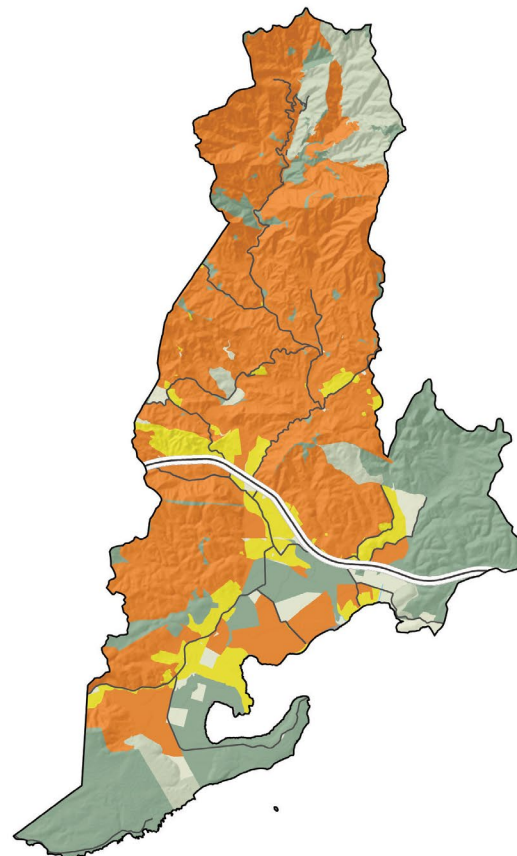


Figure 3-42. Wildland-urban interface in Guaynabo, PR.

Guaynabo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

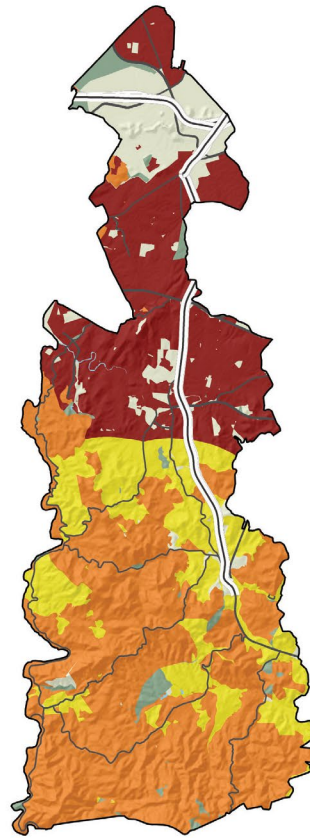
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3 6 km



3. Results

Figure 3-43. Wildland-urban interface in Gurabo, PR.

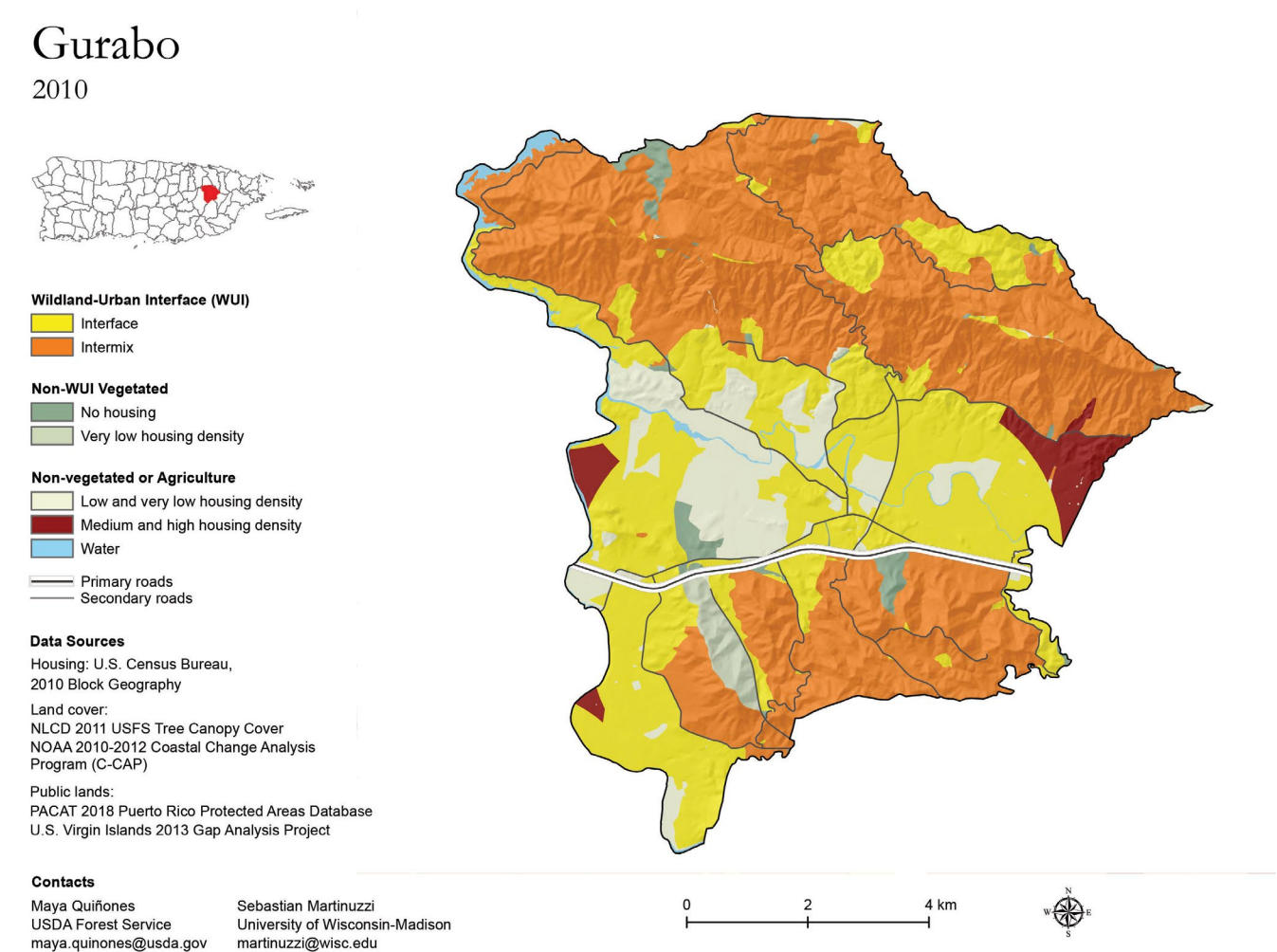


Figure 3-44. Wildland-urban interface in Hatillo, PR.

Hatillo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

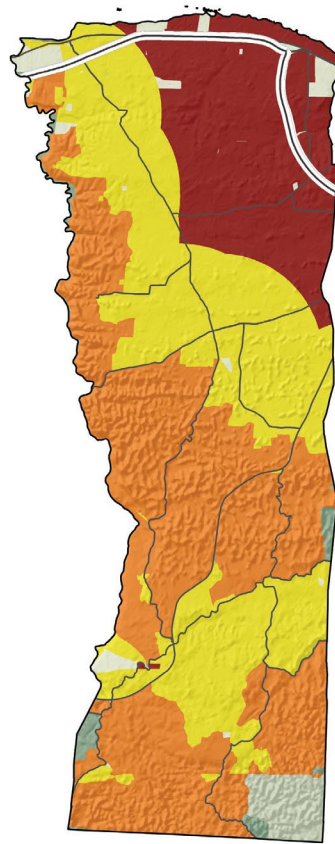
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3 6 km



3. Results

Figure 3-45. Wildland-urban interface in Hormigueros, PR.

Hormigueros

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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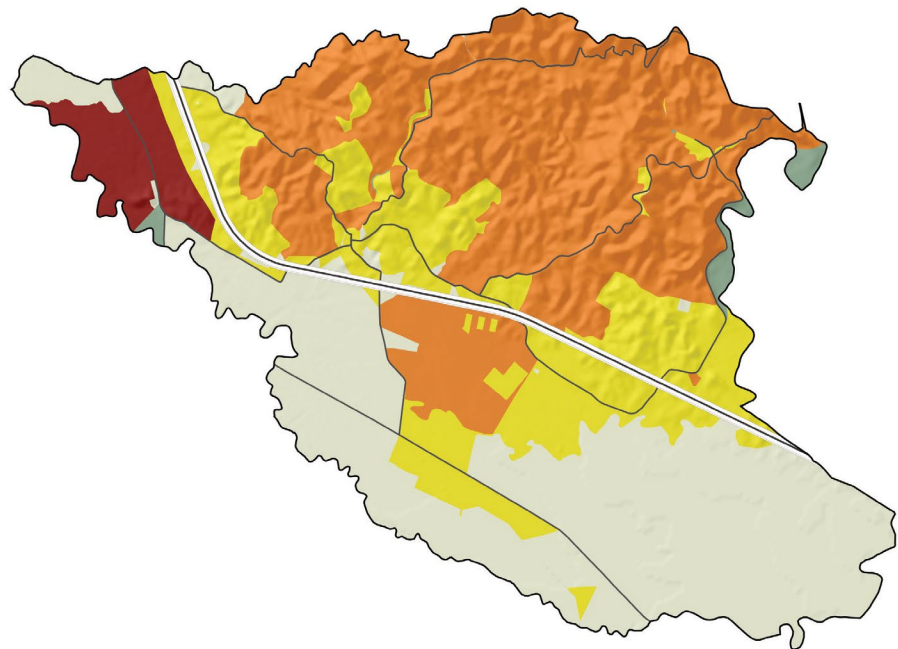


Figure 3-46. Wildland-urban interface in Humacao, PR.

Humacao

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

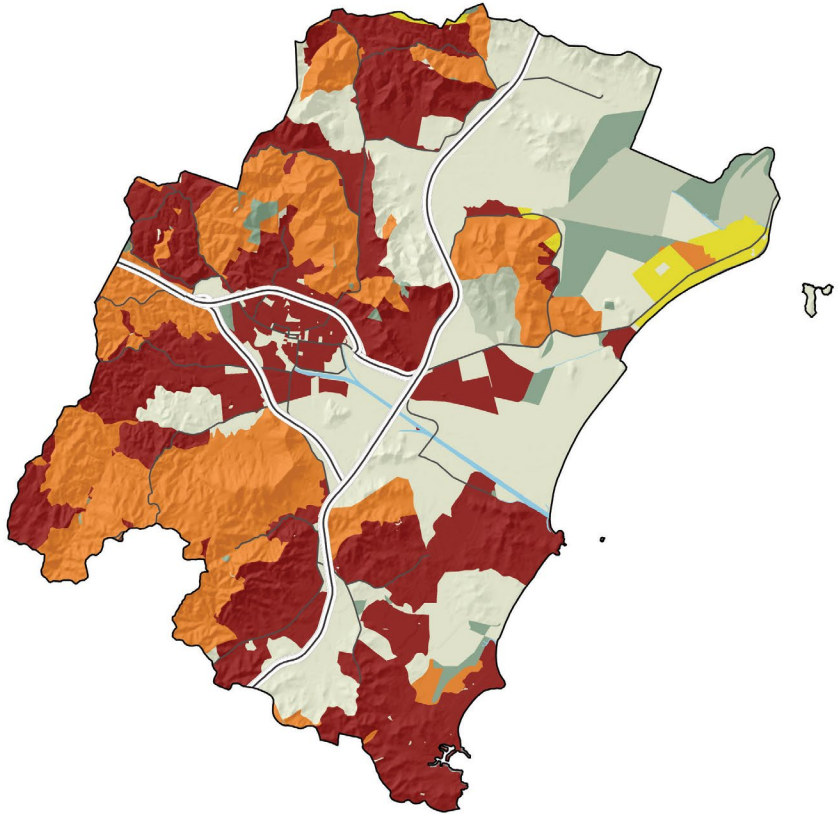
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



3. Results

Figure 3-47. Wildland-urban interface in Isabela, PR.

Isabela
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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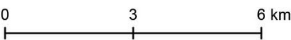
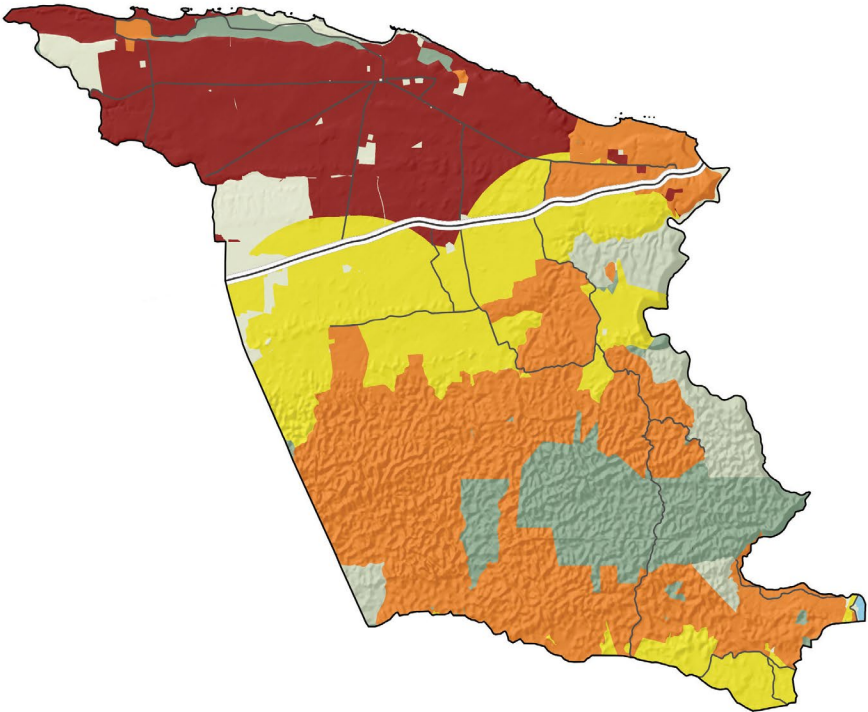


Figure 3-48. Wildland-urban interface in Jayuya, PR.

Jayuya

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

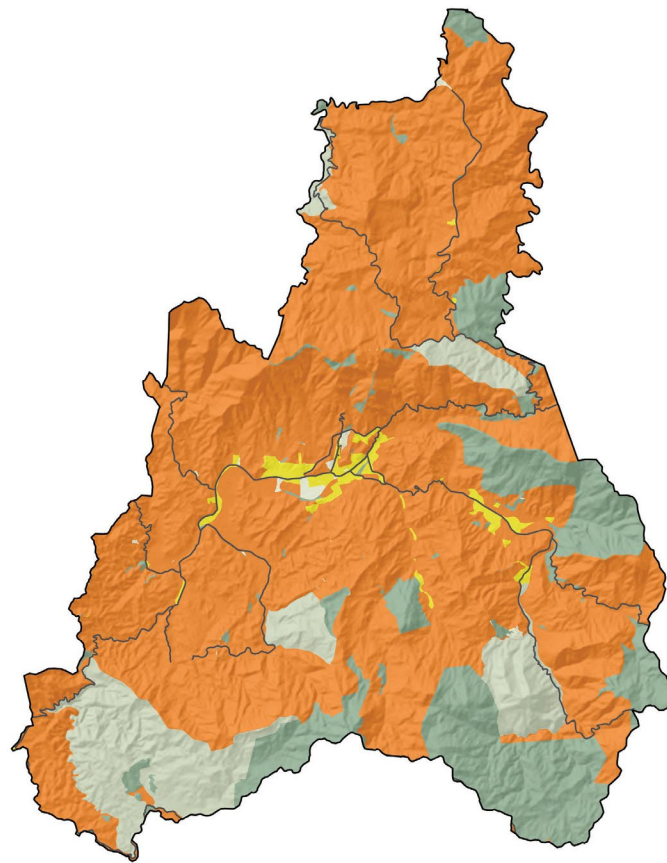
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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3. Results

Figure 3-49. Wildland-urban interface in Juana Díaz, PR.

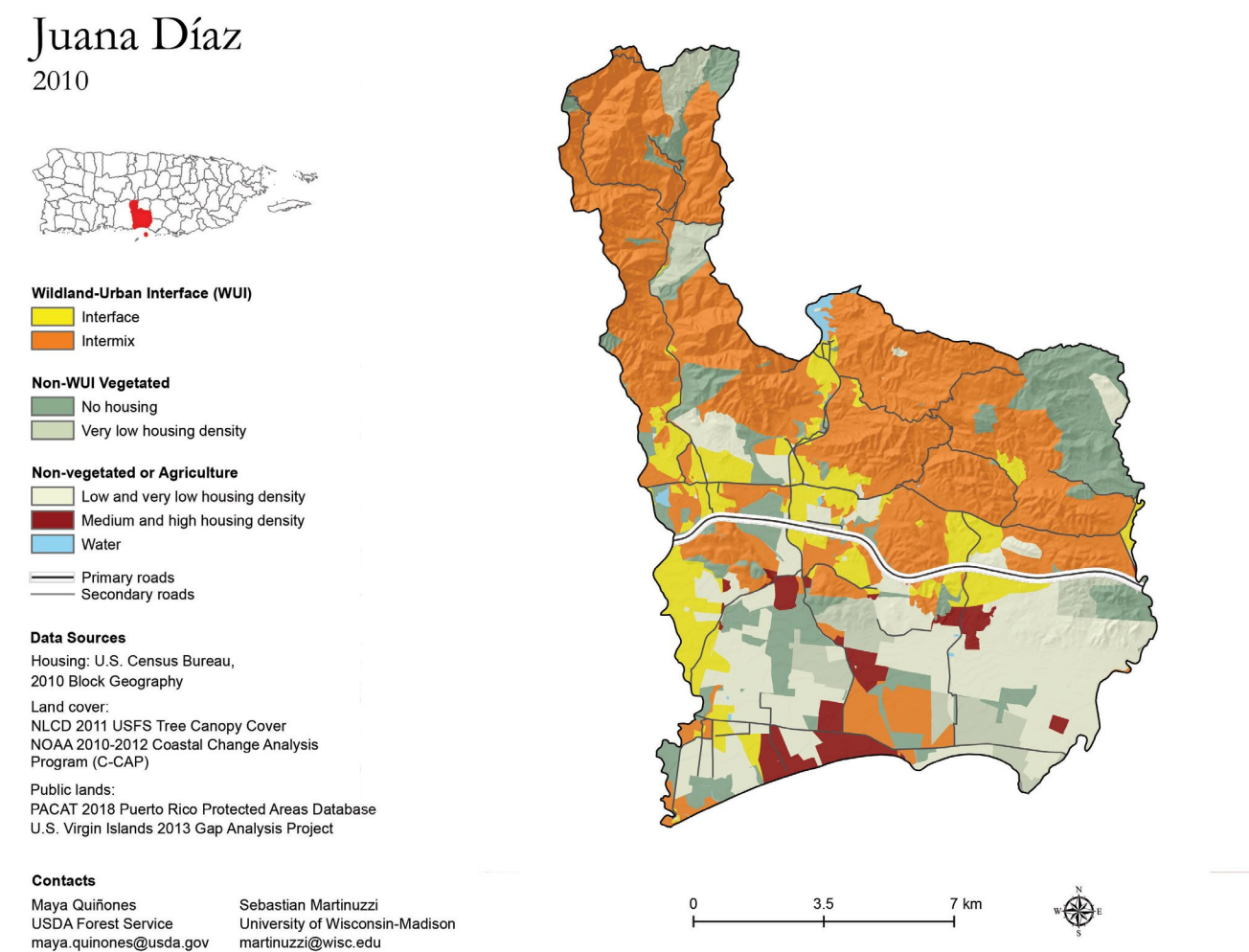


Figure 3-50. Wildland-urban interface in Juncos, PR.

Juncos

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

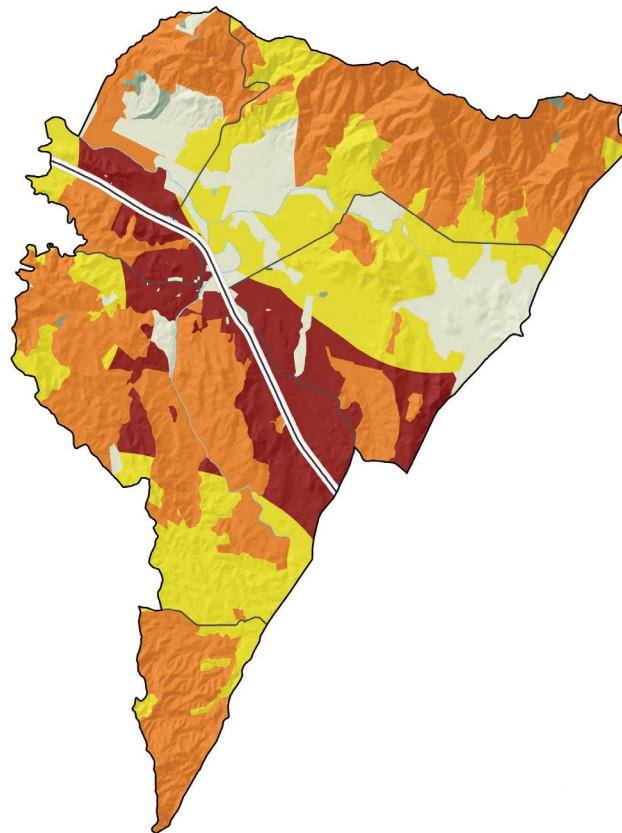
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-51. Wildland-urban interface in Lajas, PR.

Lajas

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

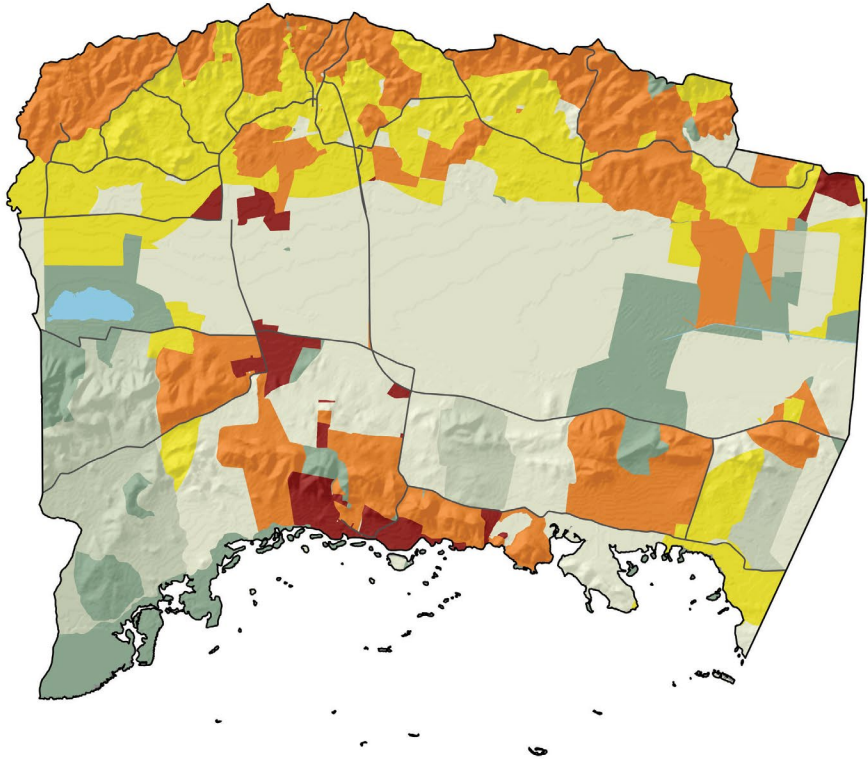
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



Figure 3-52. Wildland-urban interface in Lares, PR.

Lares

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

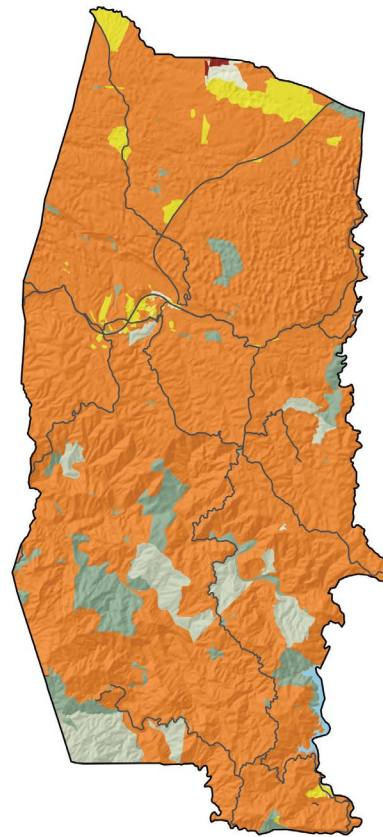
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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0 3.5 7 km



3. Results

Figure 3-53. Wildland-urban interface in Las Marías, PR.

Las Marías
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

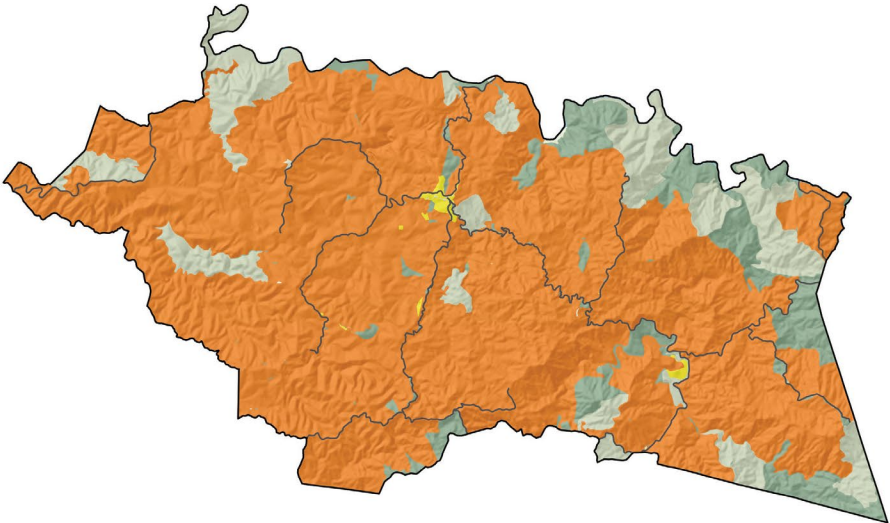
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3 6 km



Figure 3-54. Wildland-urban interface in Las Piedras, PR.

Las Piedras

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

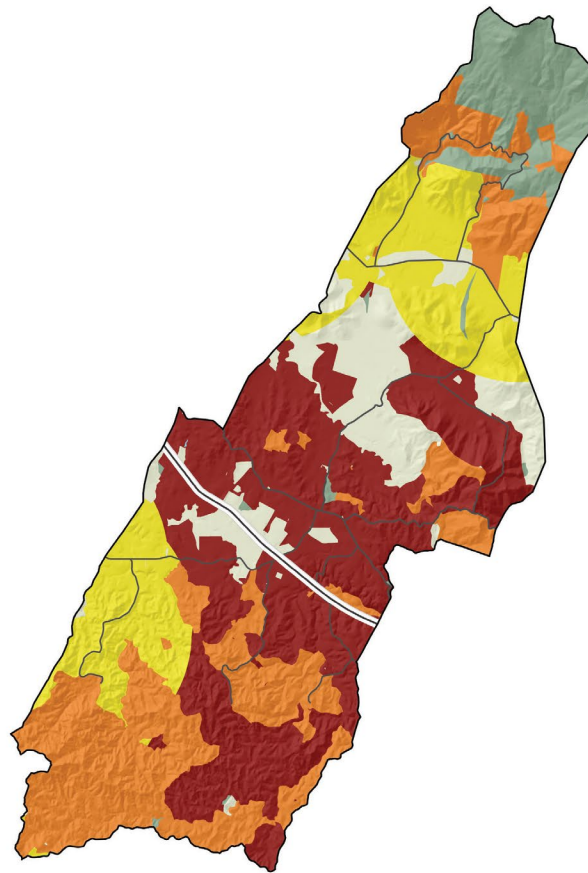
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-55. Wildland-urban interface in Loíza, PR.

Loíza

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

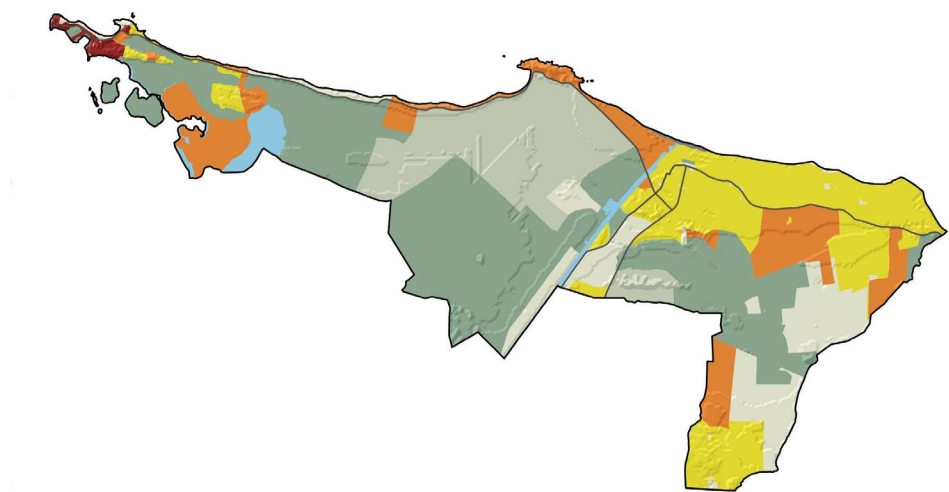
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



Figure 3-56. Wildland-urban interface in Luquillo, PR.

Luquillo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

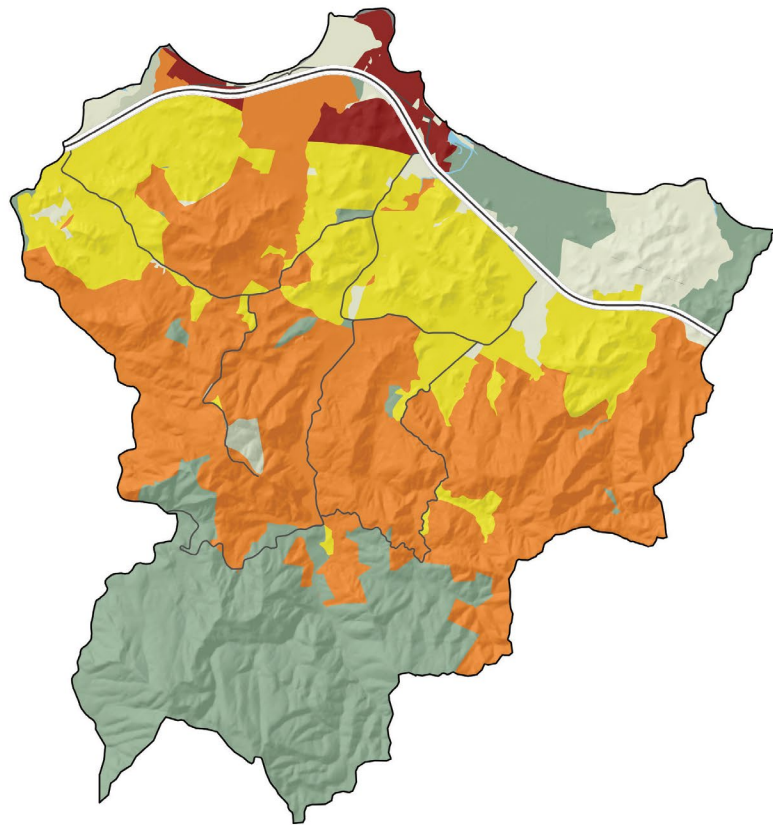
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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3. Results

Figure 3-57. Wildland-urban interface in Manatí, PR.

Manatí

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

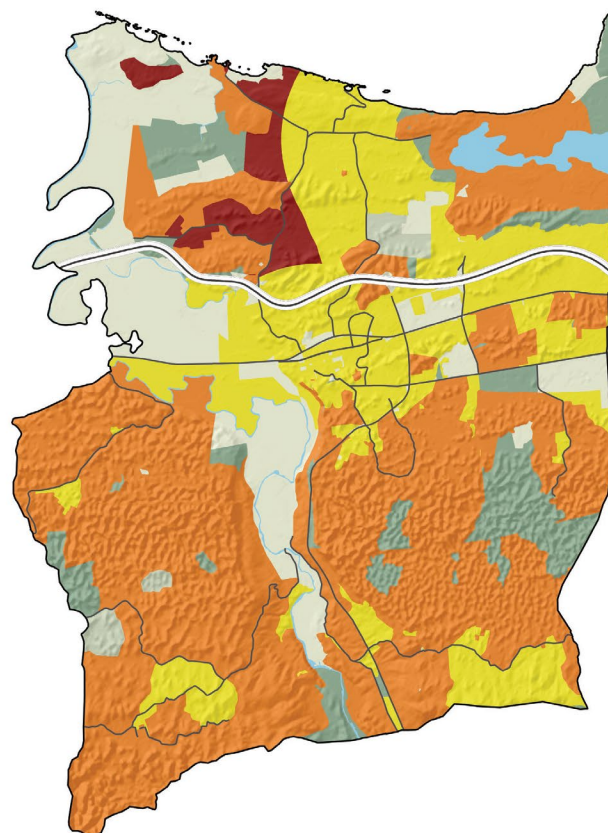
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



Figure 3-58. Wildland-urban interface in Maricao, PR.

Maricao

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

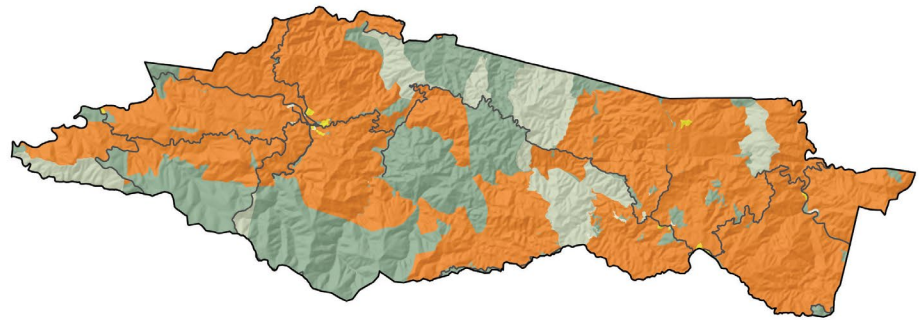
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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0 3.5 7 km



3. Results

Figure 3-59. Wildland-urban interface in Maunabo, PR.

Maunabo
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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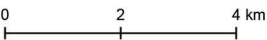
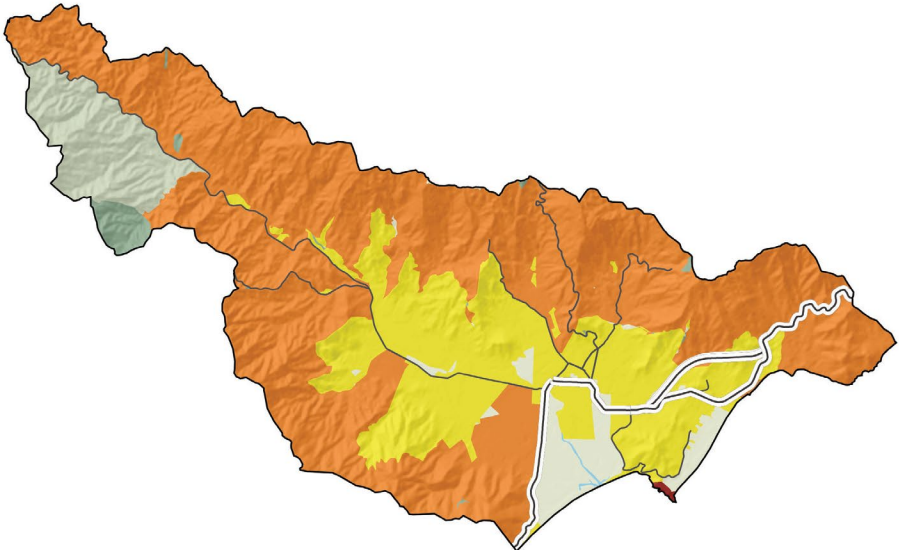


Figure 3-60. Wildland-urban interface in Mayagüez, PR.

Mayagüez

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

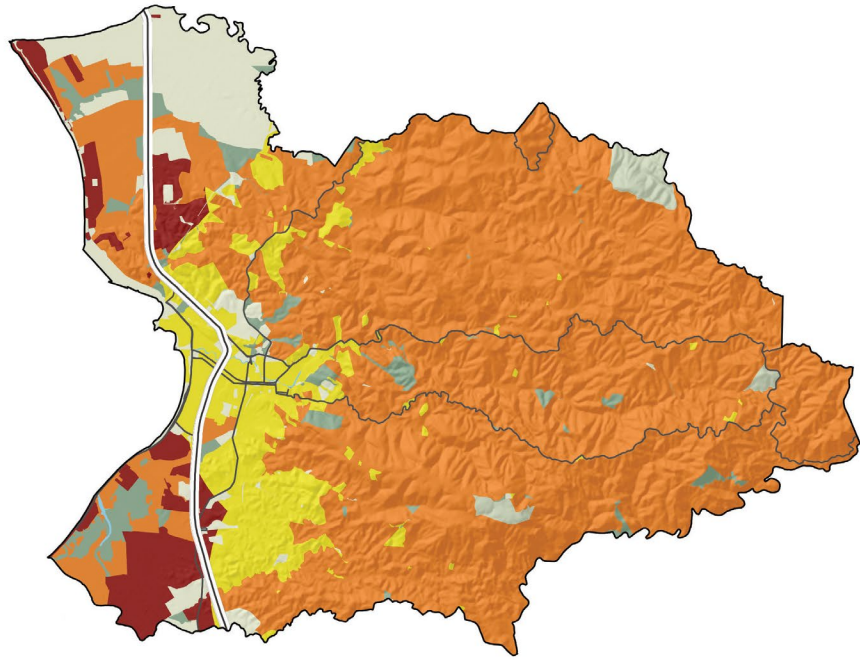
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3 6 km



3. Results

Figure 3-61. Wildland-urban interface in Moca, PR.

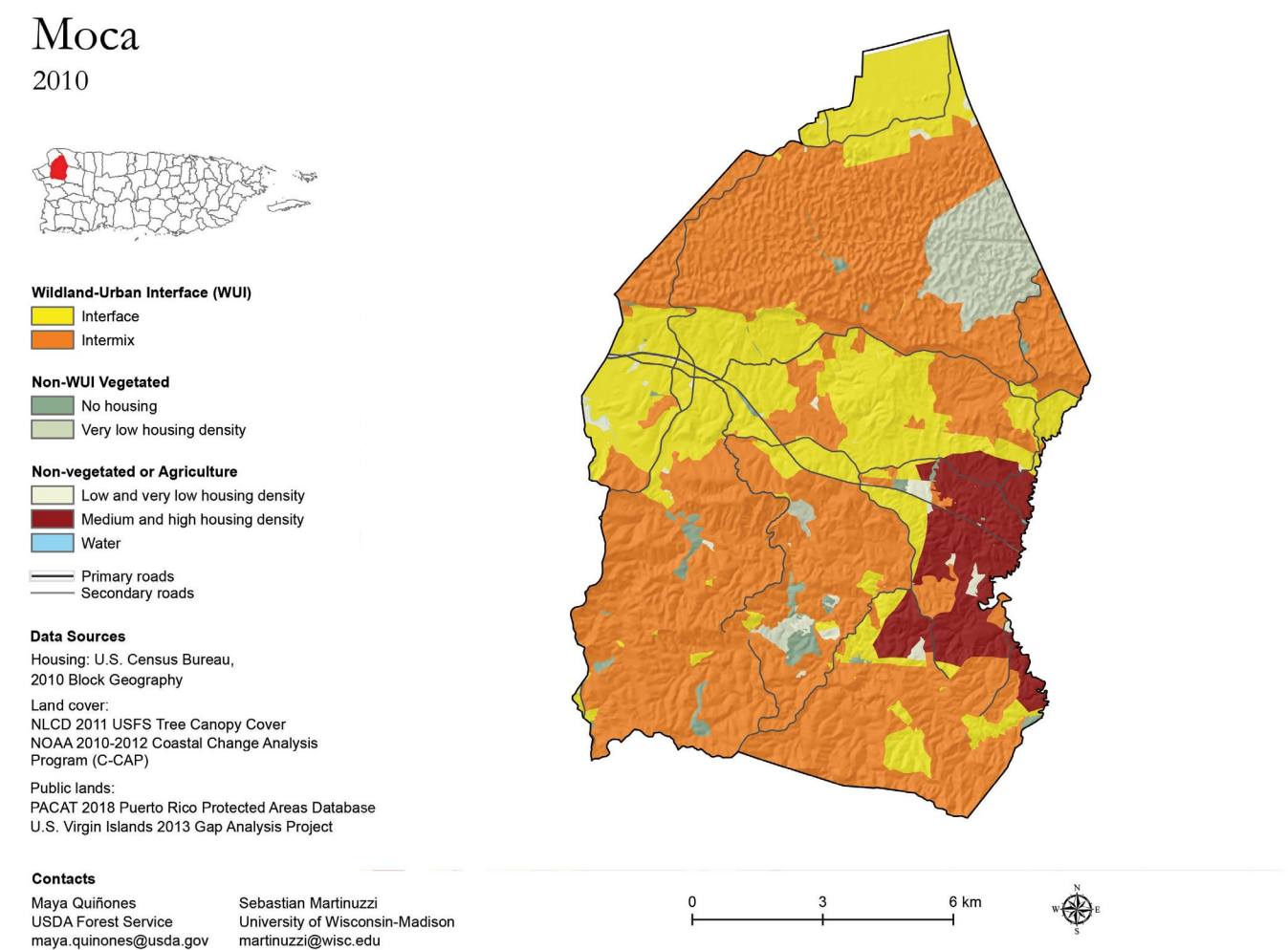


Figure 3-62. Wildland-urban interface in Morovis, PR.

Morovis

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

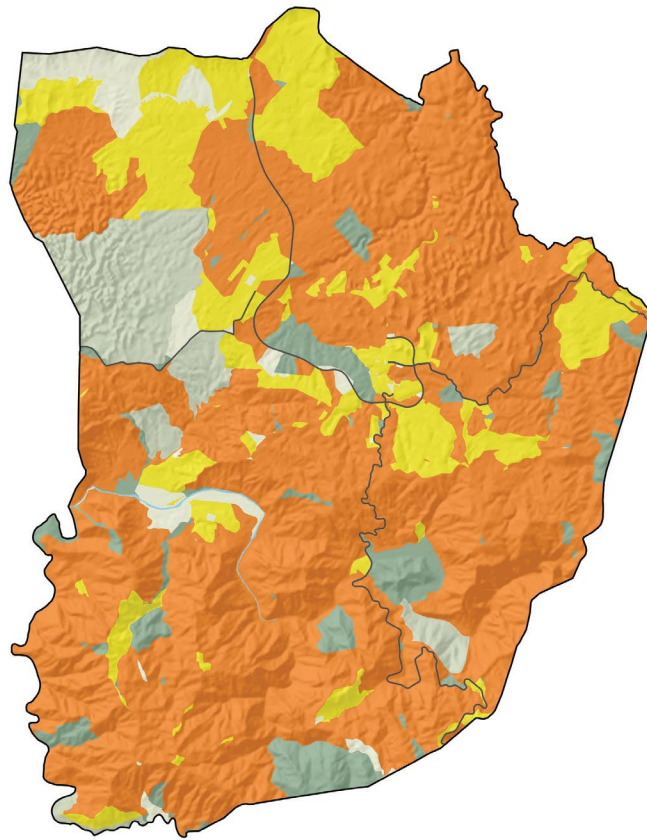
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-63. Wildland-urban interface in Naguabo, PR.

Naguabo
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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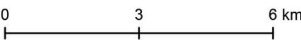
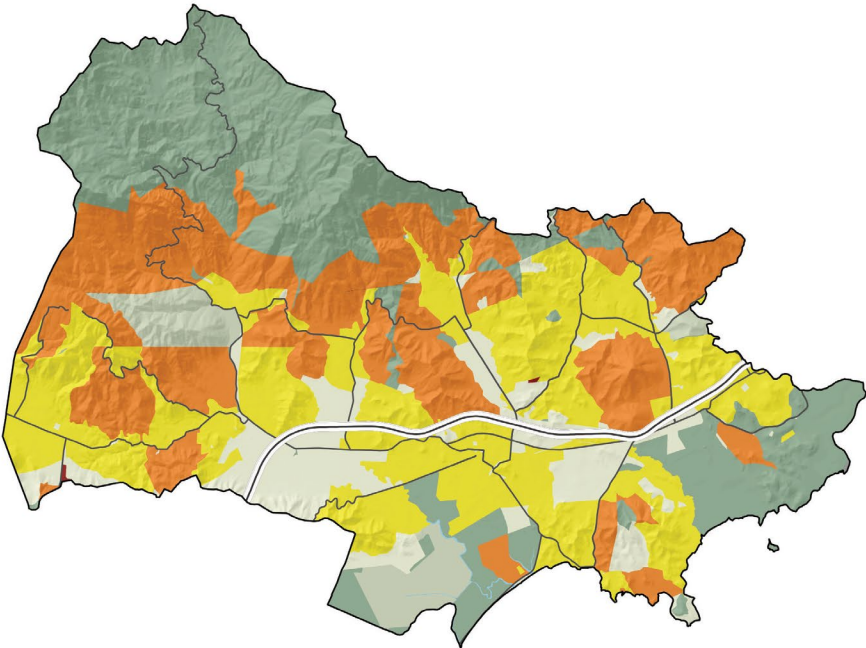


Figure 3-64. Wildland-urban interface in Naranjito, PR.

Naranjito

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

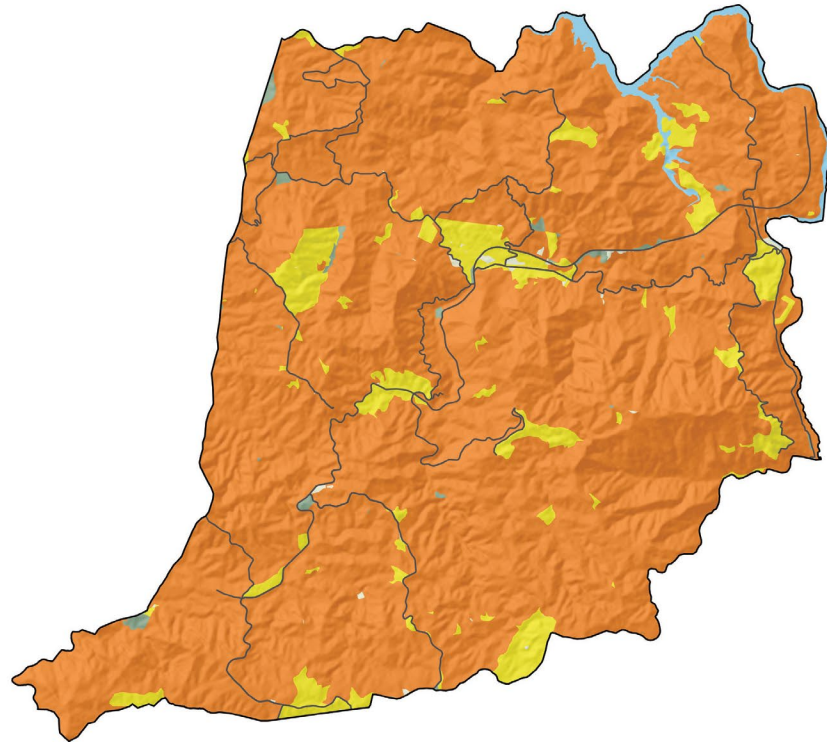
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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0 2 4 km



3. Results

Figure 3-65. Wildland-urban interface in Orocovis, PR.

Orocovis

2010

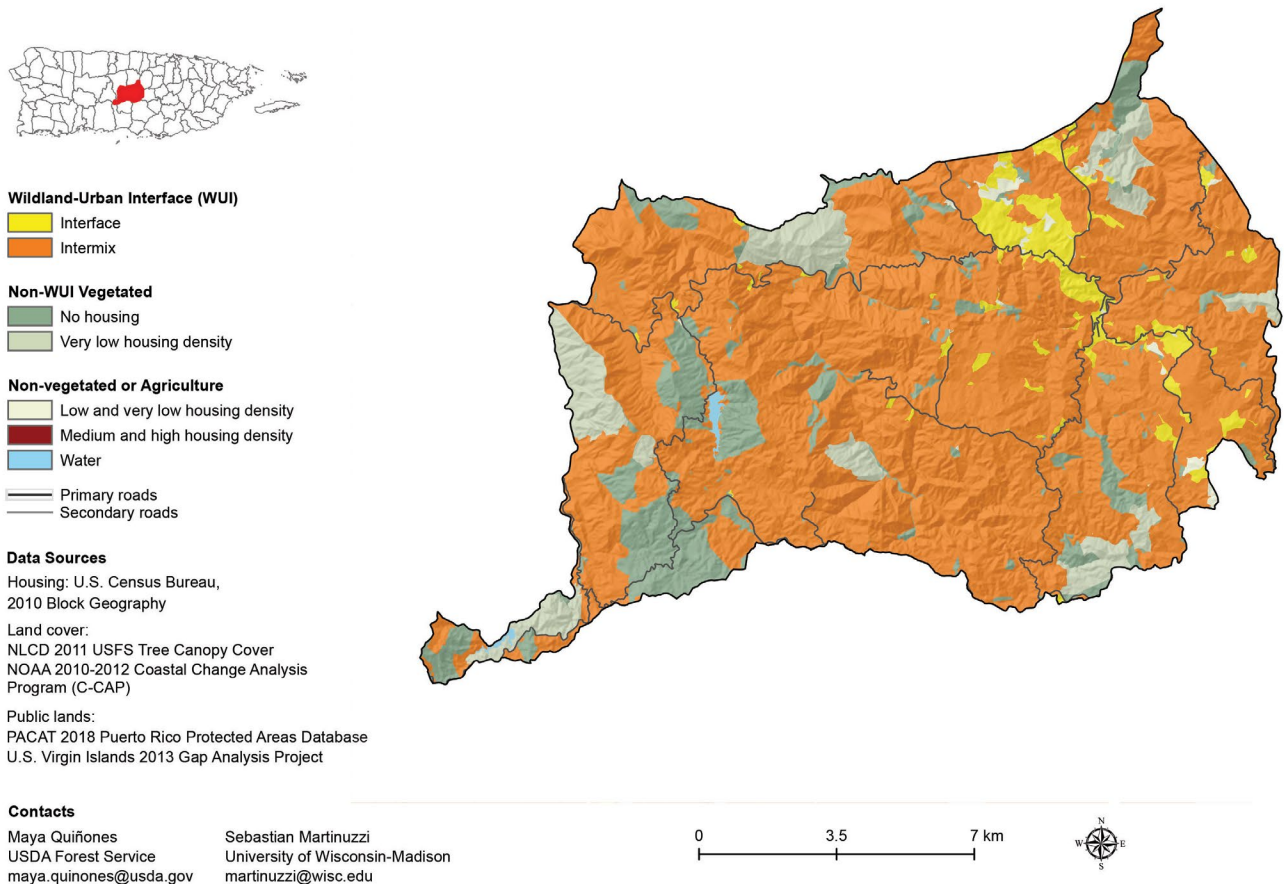
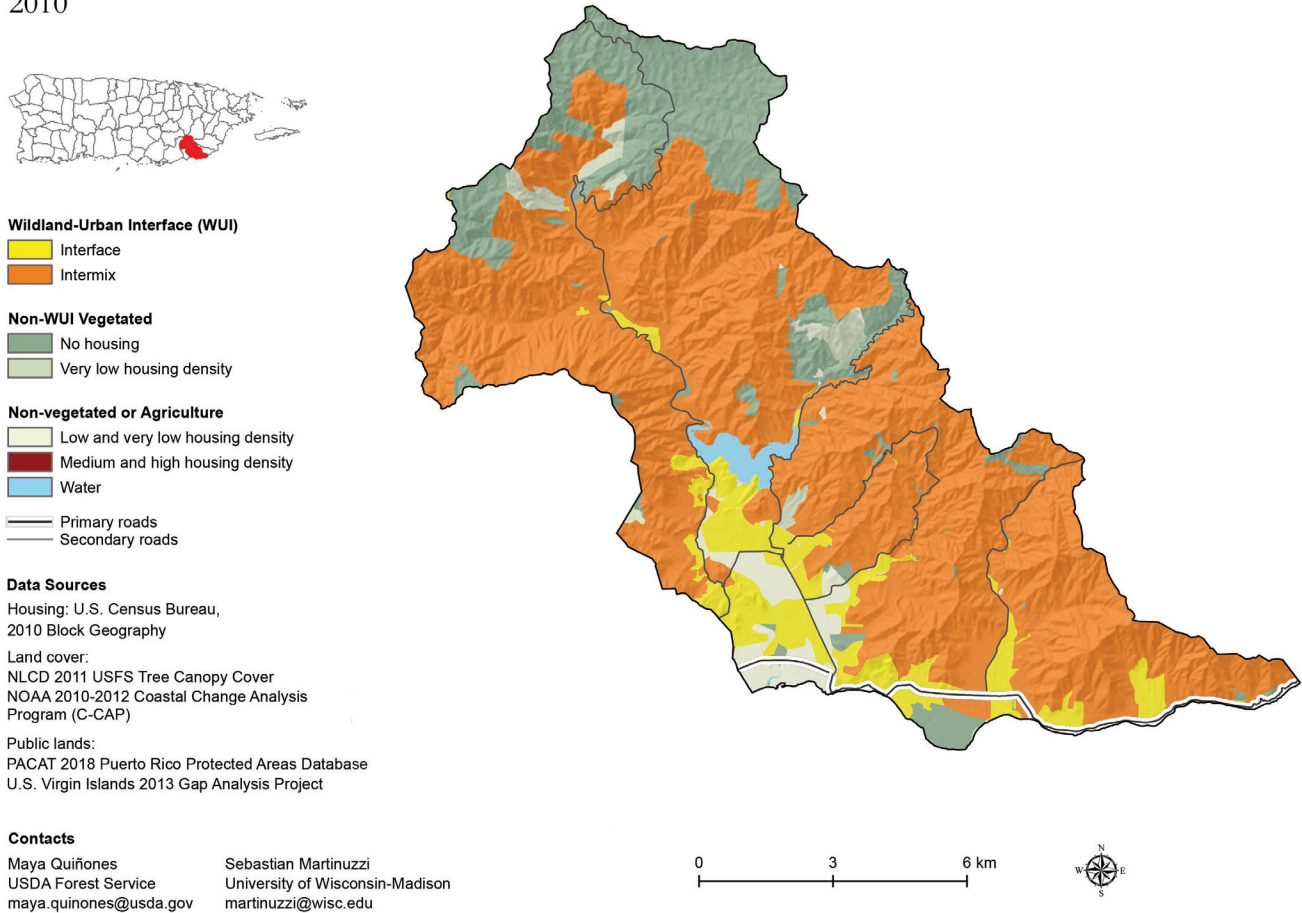


Figure 3-66. Wildland-urban interface in Patillas, PR.

Patillas

2010



3. Results

Figure 3-67. Wildland-urban interface in Peñuelas, PR.

Peñuelas
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
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Public lands:
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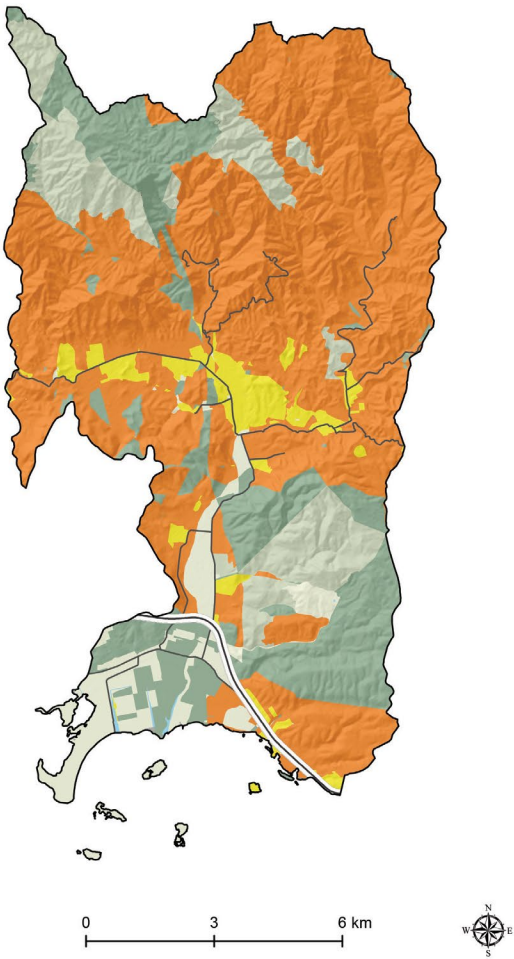


Figure 3-68. Wildland-urban interface in Ponce, PR.

Ponce

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

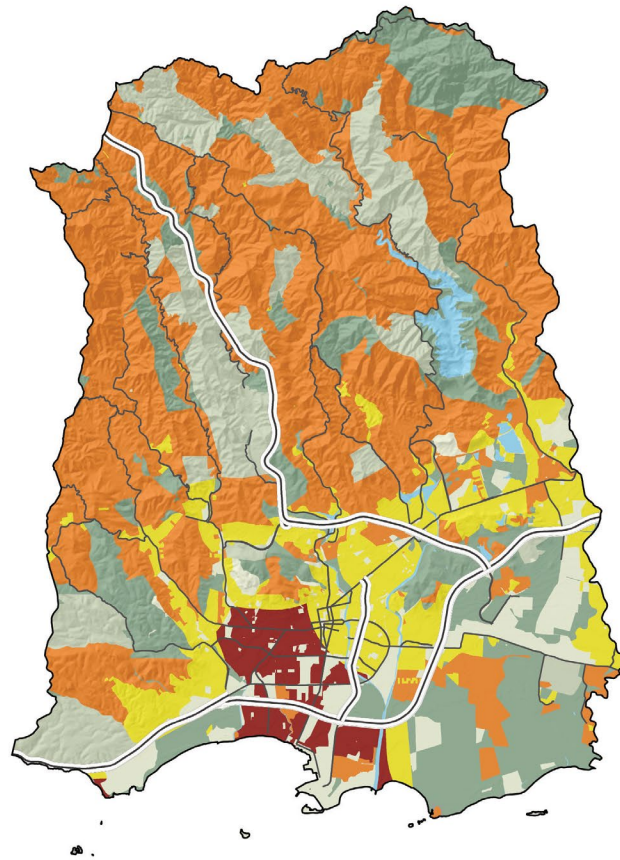
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

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3. Results

Figure 3-69. Wildland-urban interface in Quebradillas, PR.

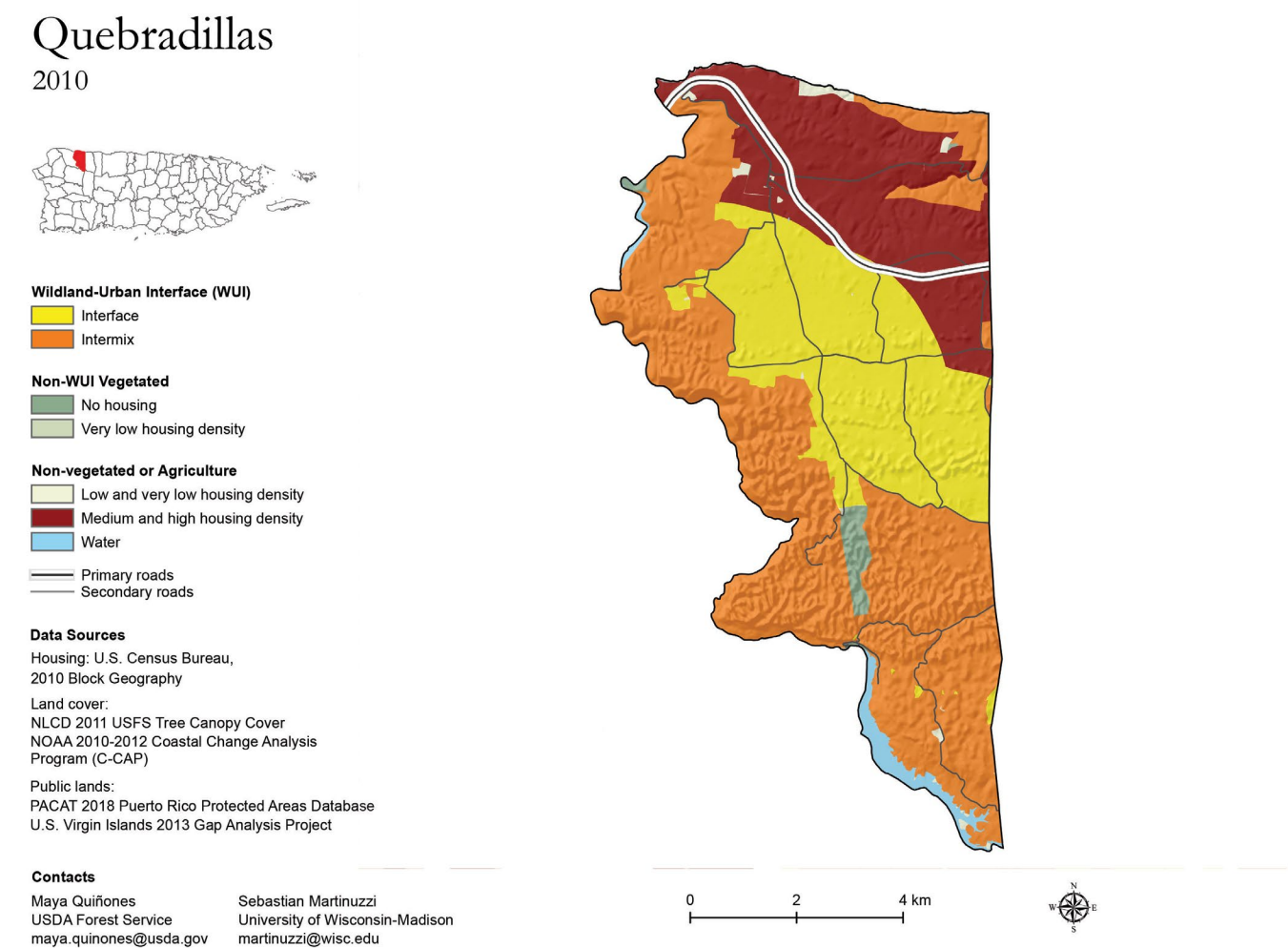


Figure 3-70. Wildland-urban interface in Rincón, PR.

Rincón

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

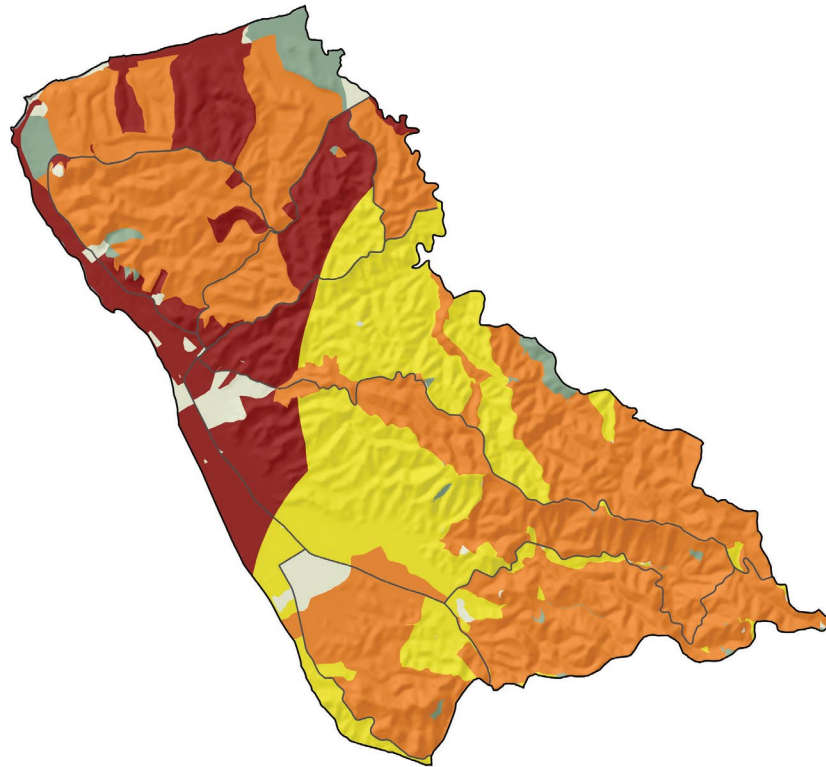
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

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0 1.5 3 km



3. Results

Figure 3-71. Wildland-urban interface in Río Grande, PR.

Río Grande

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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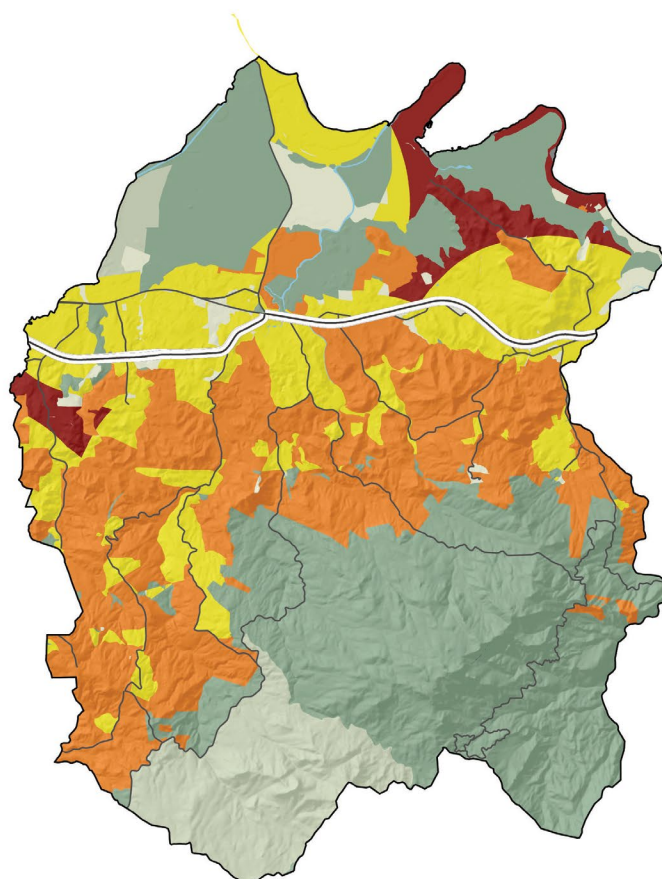


Figure 3-72. Wildland-urban interface in Sabana Grande, PR.

Sabana Grande

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

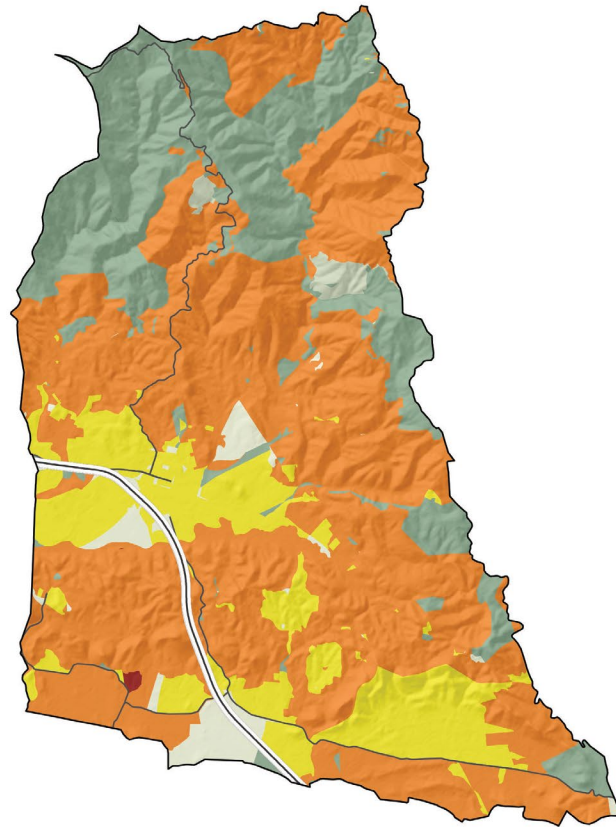
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



3. Results

Figure 3-73. Wildland-urban interface in Salinas, PR.

Salinas

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

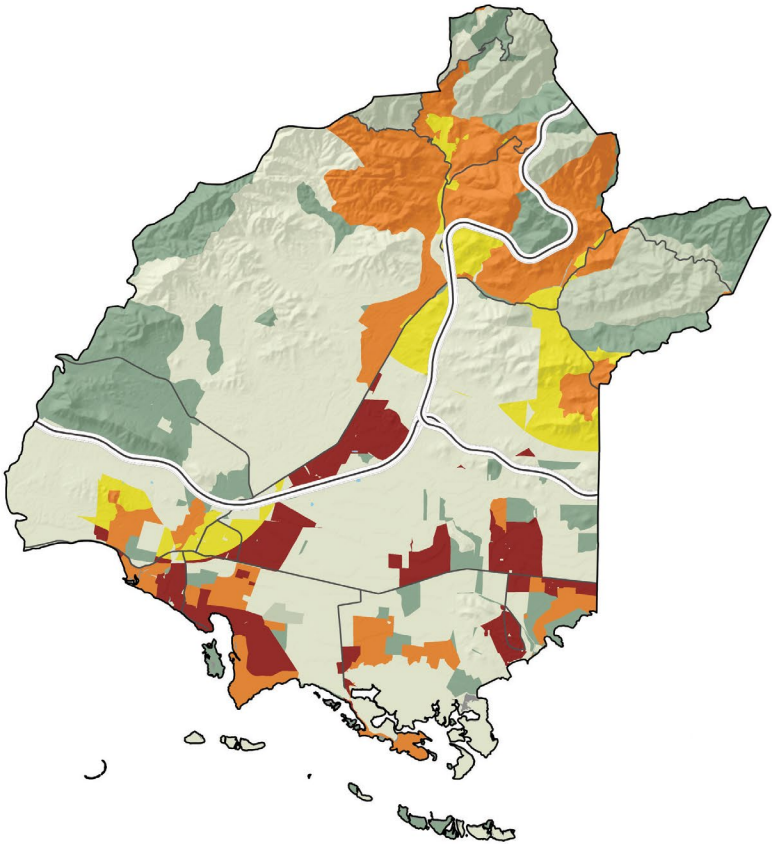
Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 3.5 7 km



Figure 3-74. Wildland-urban interface in San Germán, PR.

San Germán

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

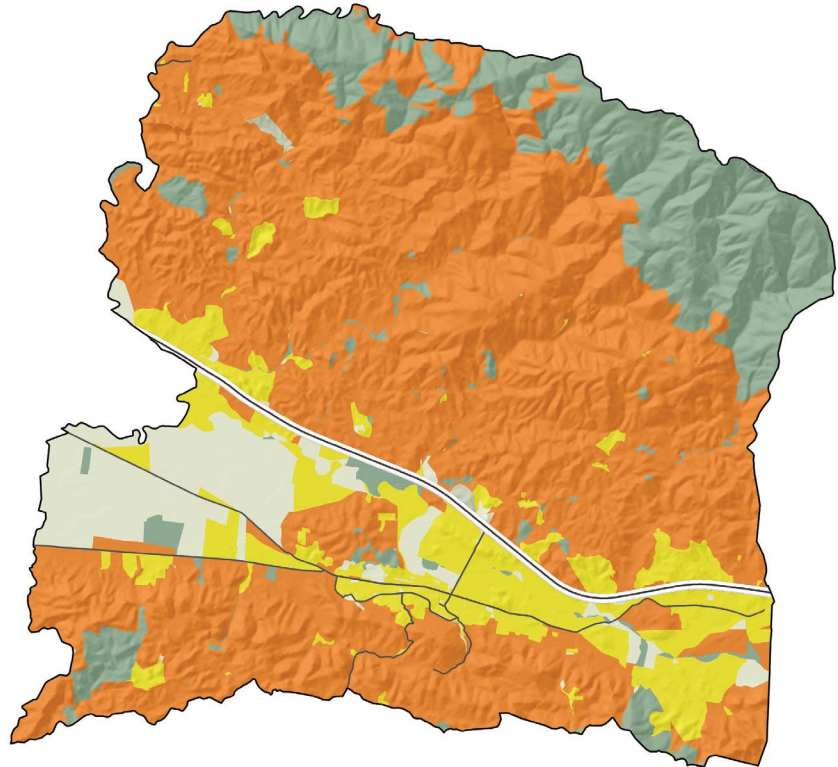
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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3. Results

Figure 3-75. Wildland-urban interface in San Juan, PR.

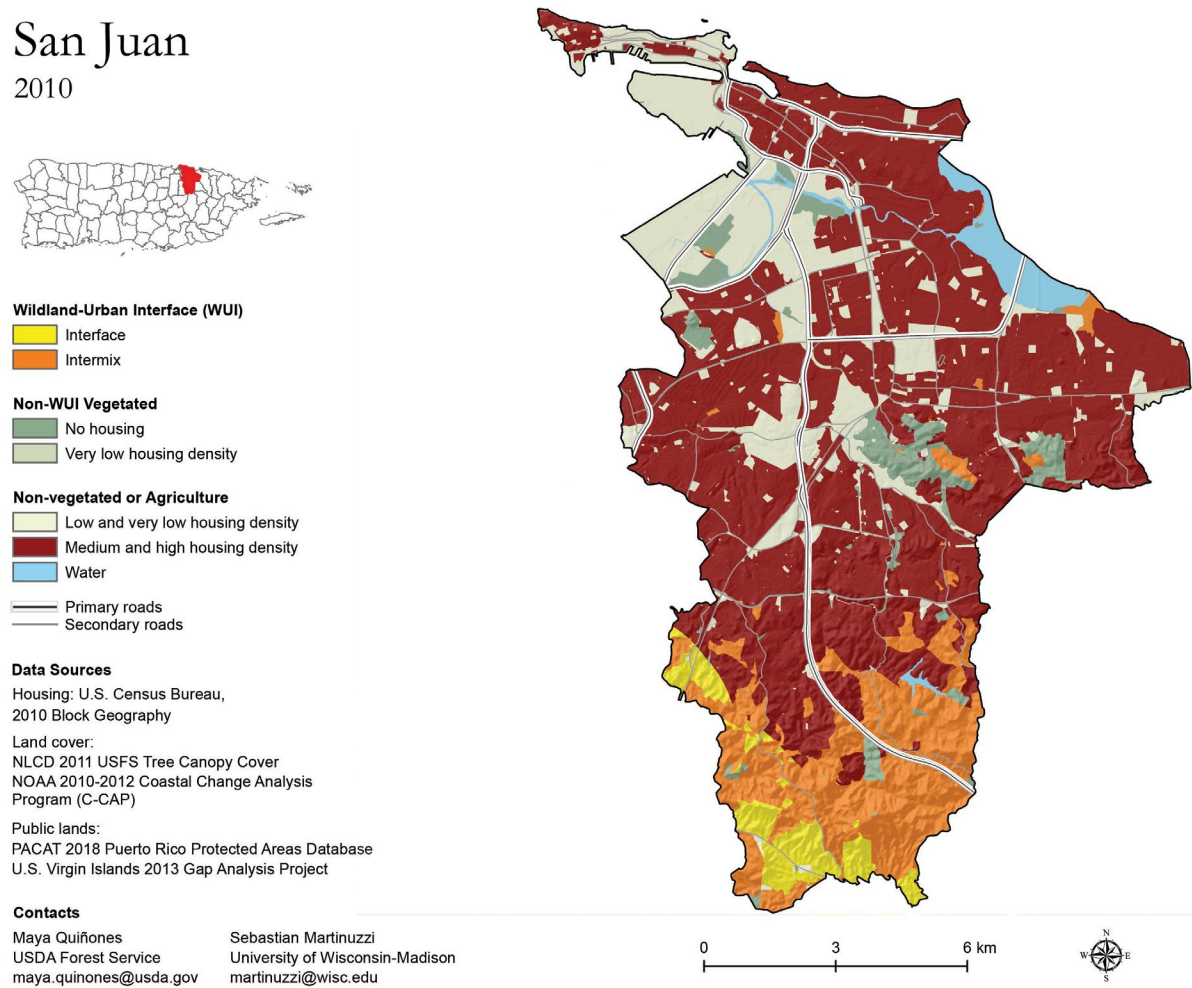


Figure 3-76. Wildland-urban interface in San Lorenzo, PR.

San Lorenzo

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

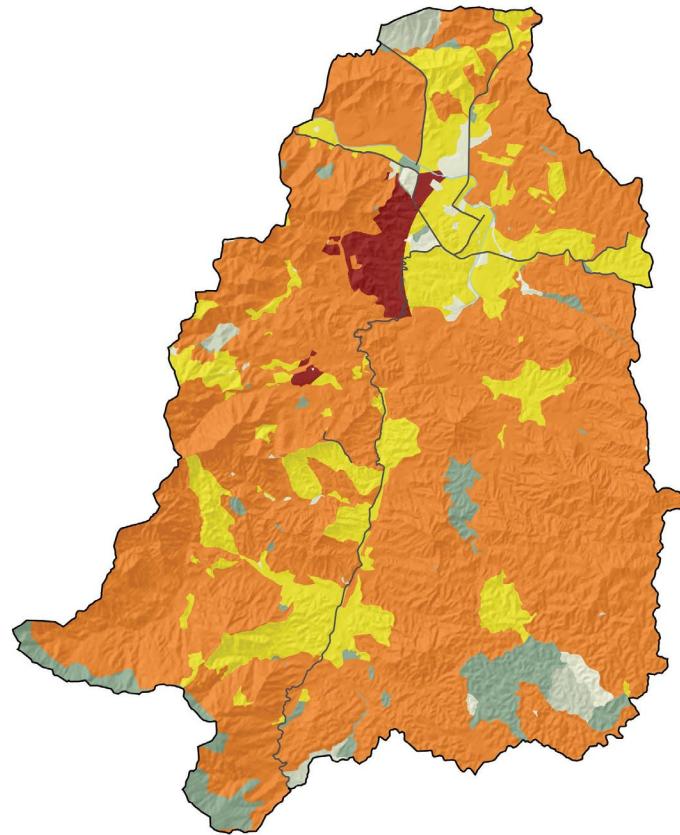
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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3. Results

Figure 3-77. Wildland-urban interface in San Sebastián, PR.

San Sebastián

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

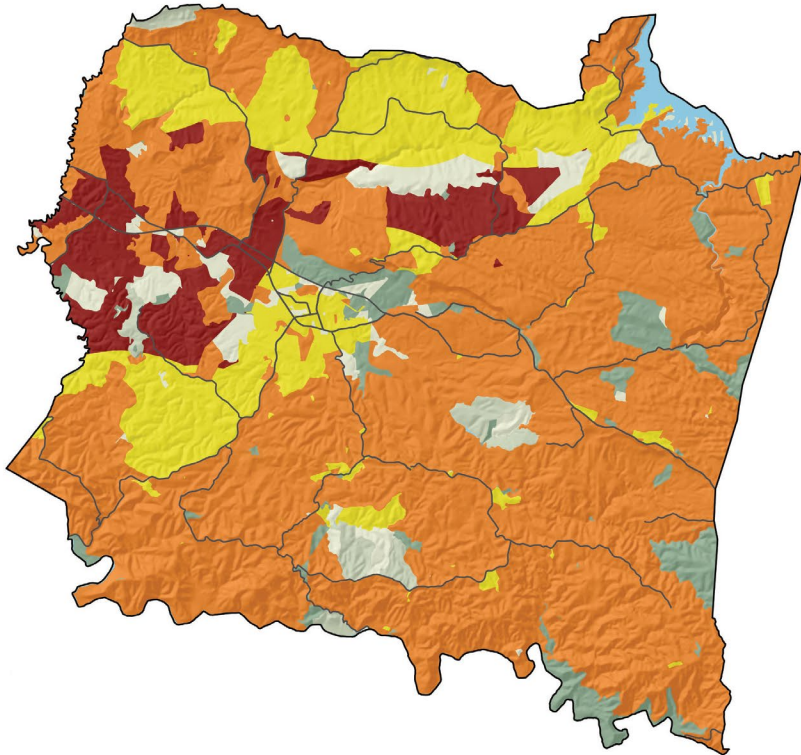
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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0 3 6 km



Figure 3-78. Wildland-urban interface in Santa Isabel, PR.

Santa Isabel

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

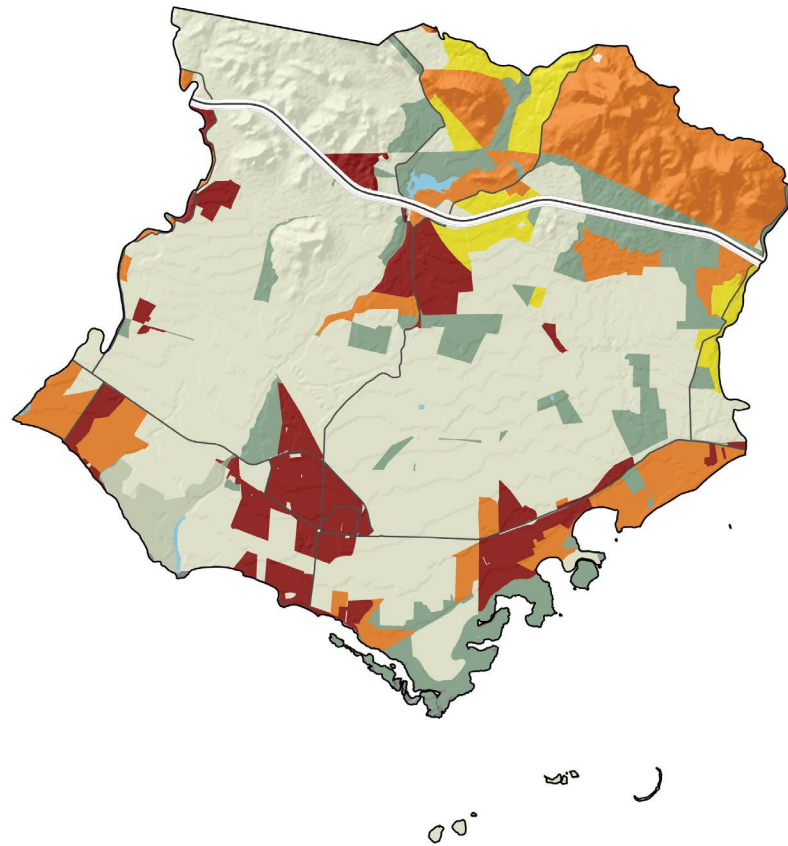
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2 4 km



3. Results

Figure 3-79. Wildland-urban interface in Toa Alta, PR.

Toa Alta

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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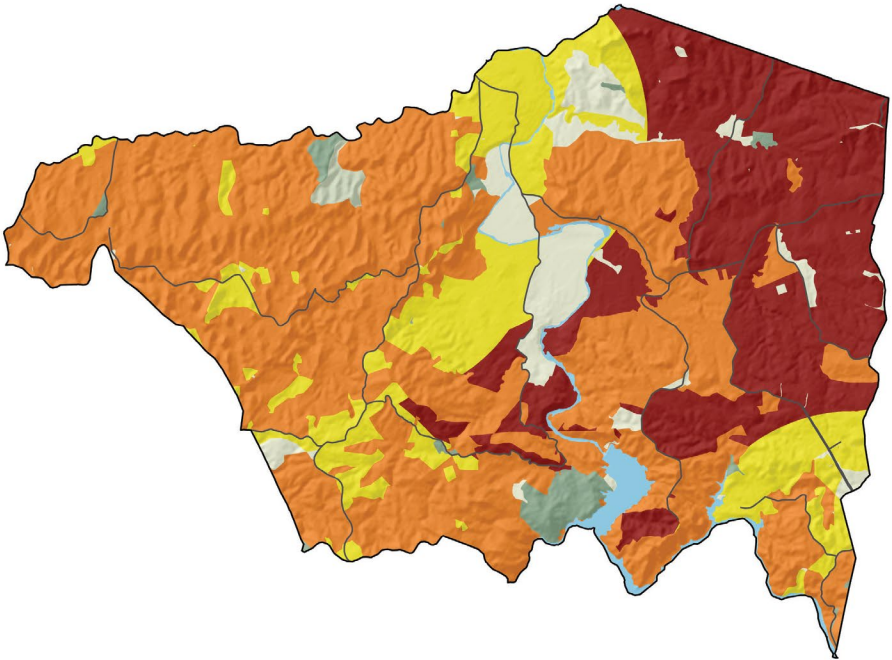


Figure 3-80. Wildland-urban interface in Toa Baja, PR.

Toa Baja

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

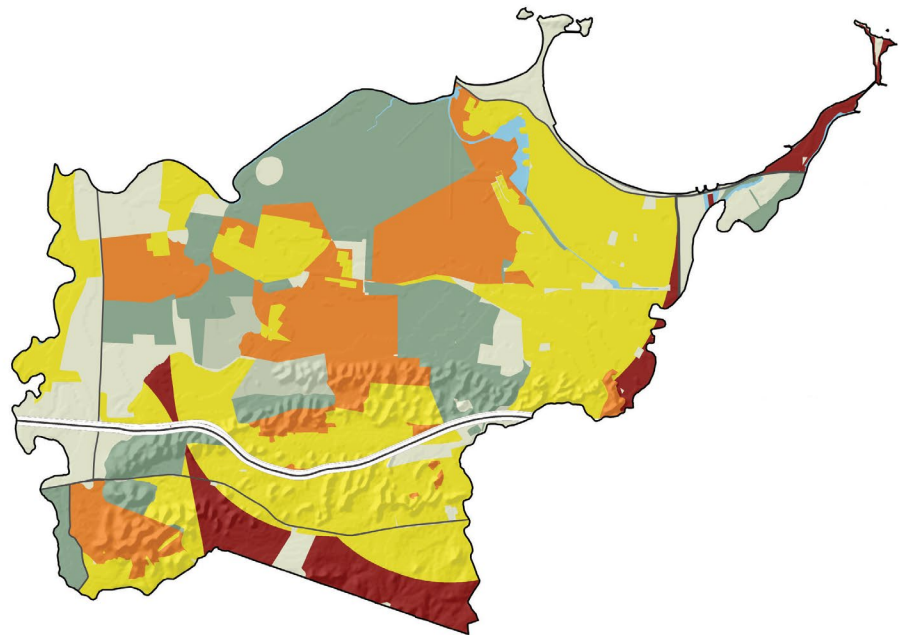
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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0 2 4 km



3. Results

Figure 3-81. Wildland-urban interface in Trujillo Alto, PR.

Trujillo Alto

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

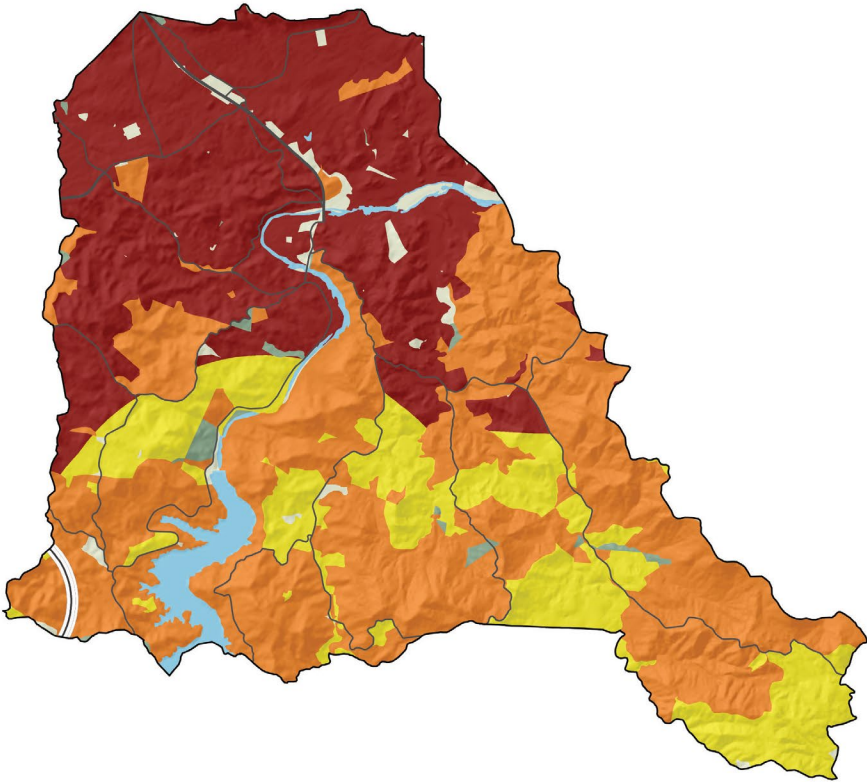
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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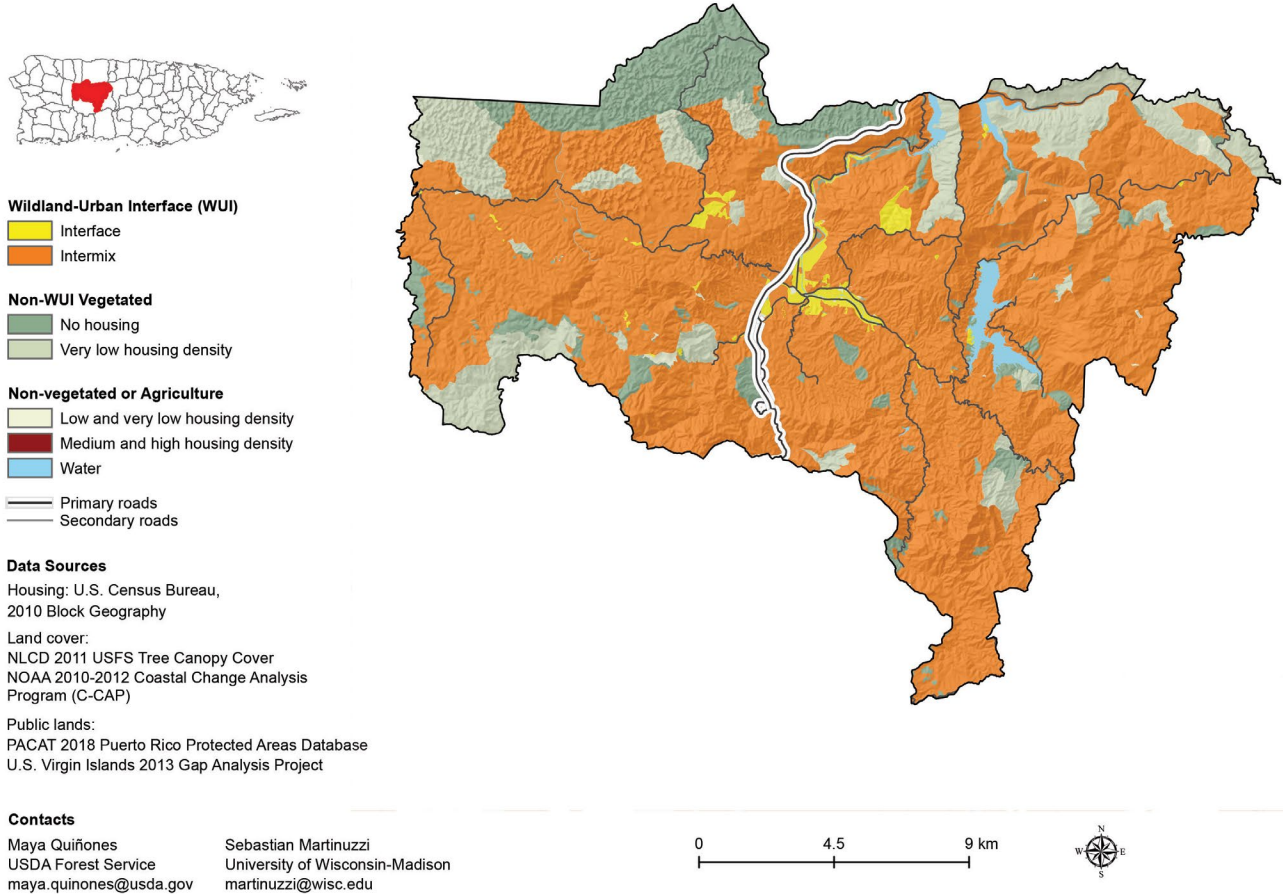
0 1.5 3 km



Figure 3-82. Wildland-urban interface in Utuado, PR.

Utuado

2010



3. Results

Figure 3-83. Wildland-urban interface in Vega Alta, PR.

Vega Alta 2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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martinuzzi@wisc.edu

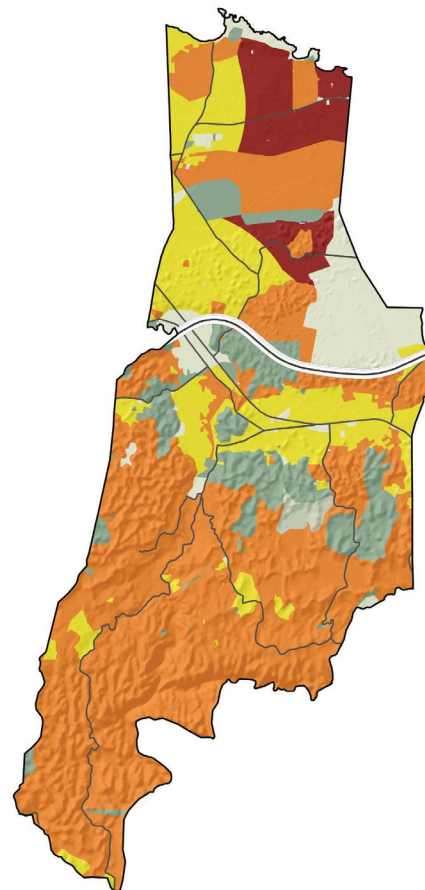


Figure 3-84. Wildland-urban interface in Vega Baja, PR.

Vega Baja

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

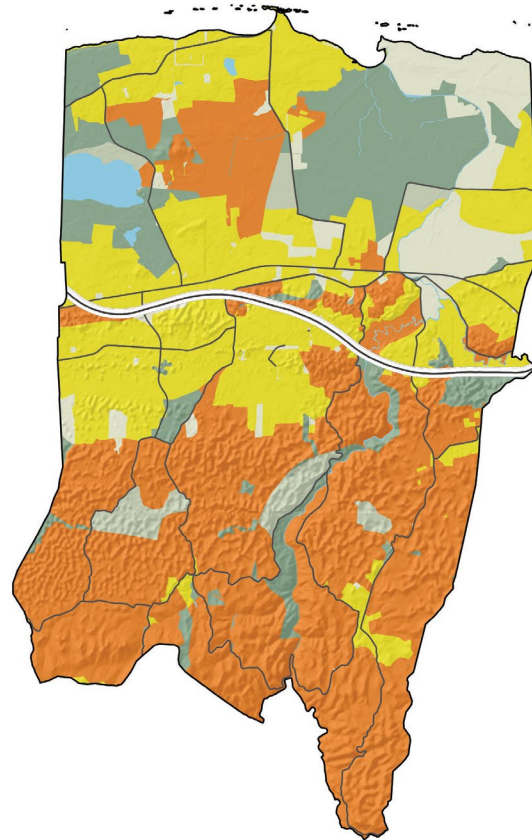
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 2.5 5 km



3. Results

Figure 3-85. Wildland-urban interface in Vieques, PR.

Vieques
2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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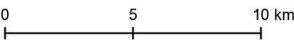
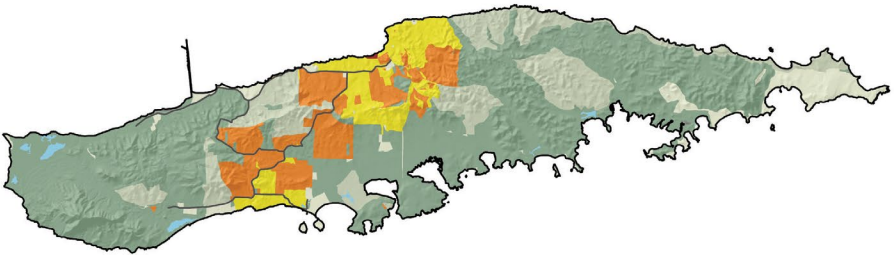


Figure 3-86. Wildland-urban interface in Villalba, PR.

Villalba

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

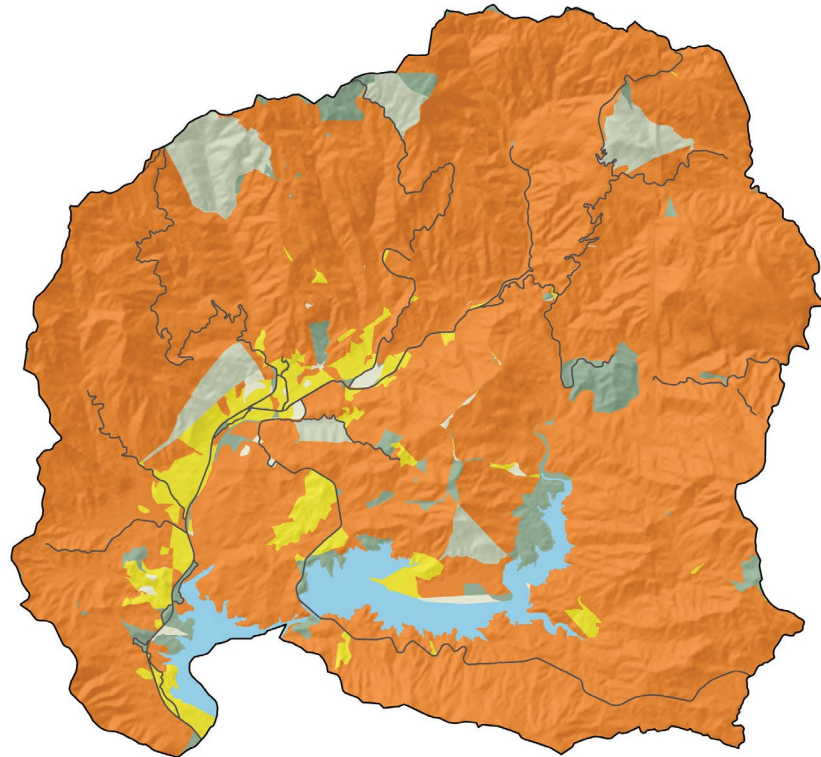
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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0 2 4 km



3. Results

Figure 3-87. Wildland-urban interface in Yabucoa, PR.

Yabucoa

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

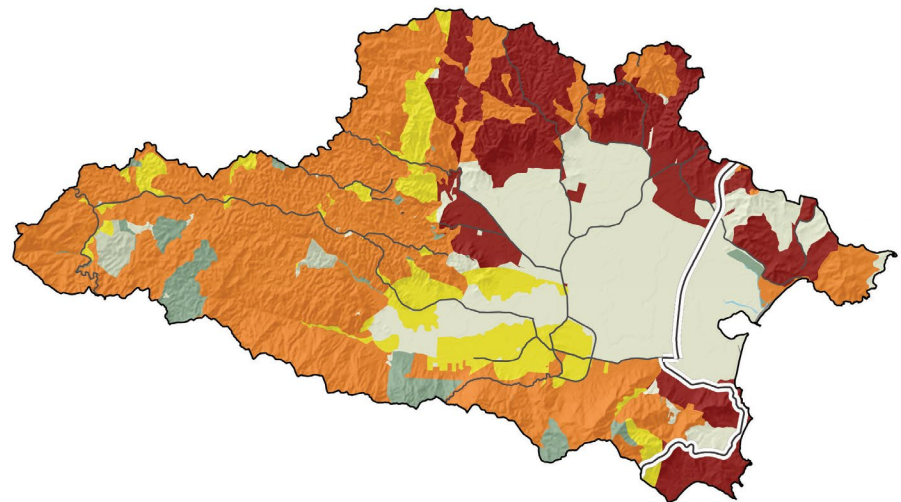
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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U.S. Virgin Islands 2013 Gap Analysis Project

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0 3.5 7 km



Figure 3-88. Wildland-urban interface in Yauco, PR.

Yauco

2010

**Wildland-Urban Interface (WUI)**

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

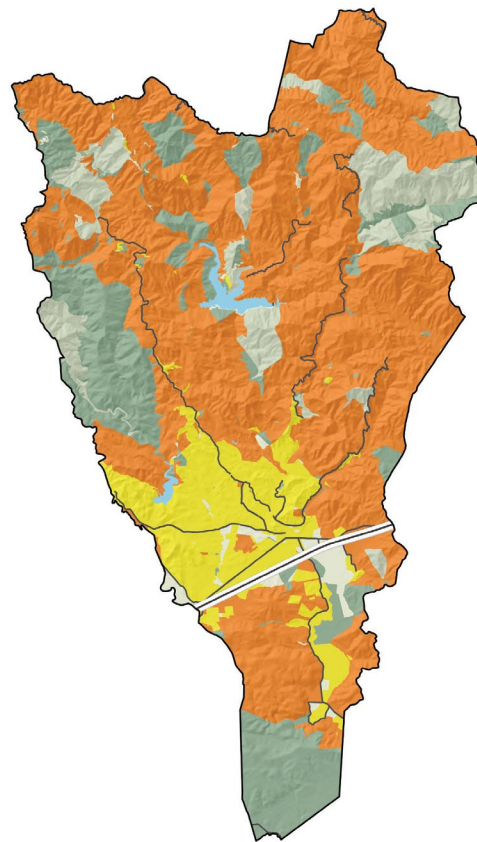
Housing: U.S. Census Bureau,
2010 Block Geography

Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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0 4 8 km



3. Results

3.6. WUI Maps for U.S. Virgin Islands Districts

The U.S. Virgin Islands include three populated islands or districts: St. Croix, St. John, and St. Thomas (fig. 3-89). In this section, figures 3-90 through 3-92 depict the wildland-urban interface in the three districts of the U.S. Virgin Islands in 2010.

Figure 3-89. Islands of the U.S. Virgin Islands.

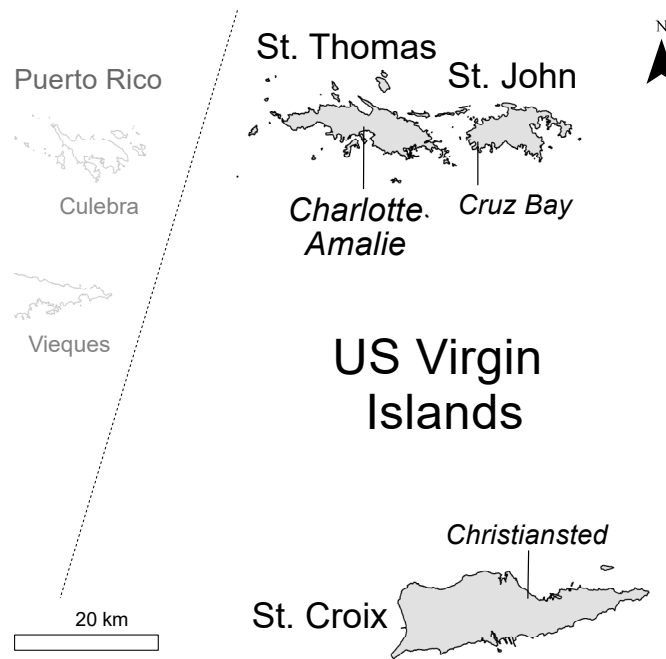


Figure 3-90. Wildland-urban interface in St. Croix, VI.

Saint Croix

2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density
- Water

- Primary roads
- Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

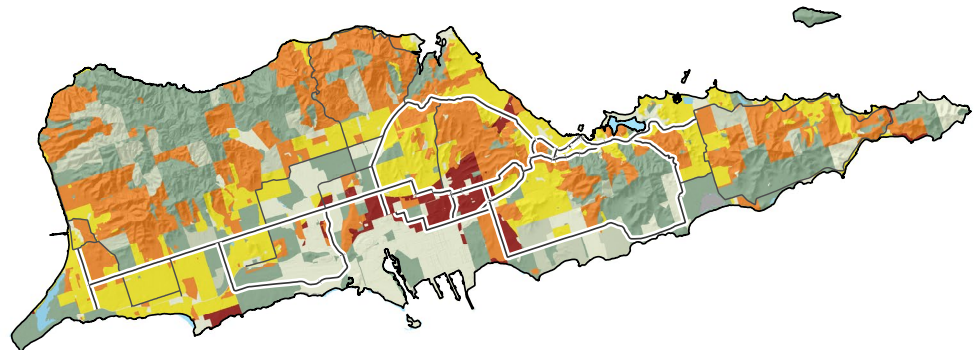
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
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0 5 10 km



Figure 3-91. Wildland-urban interface in St. John, VI.

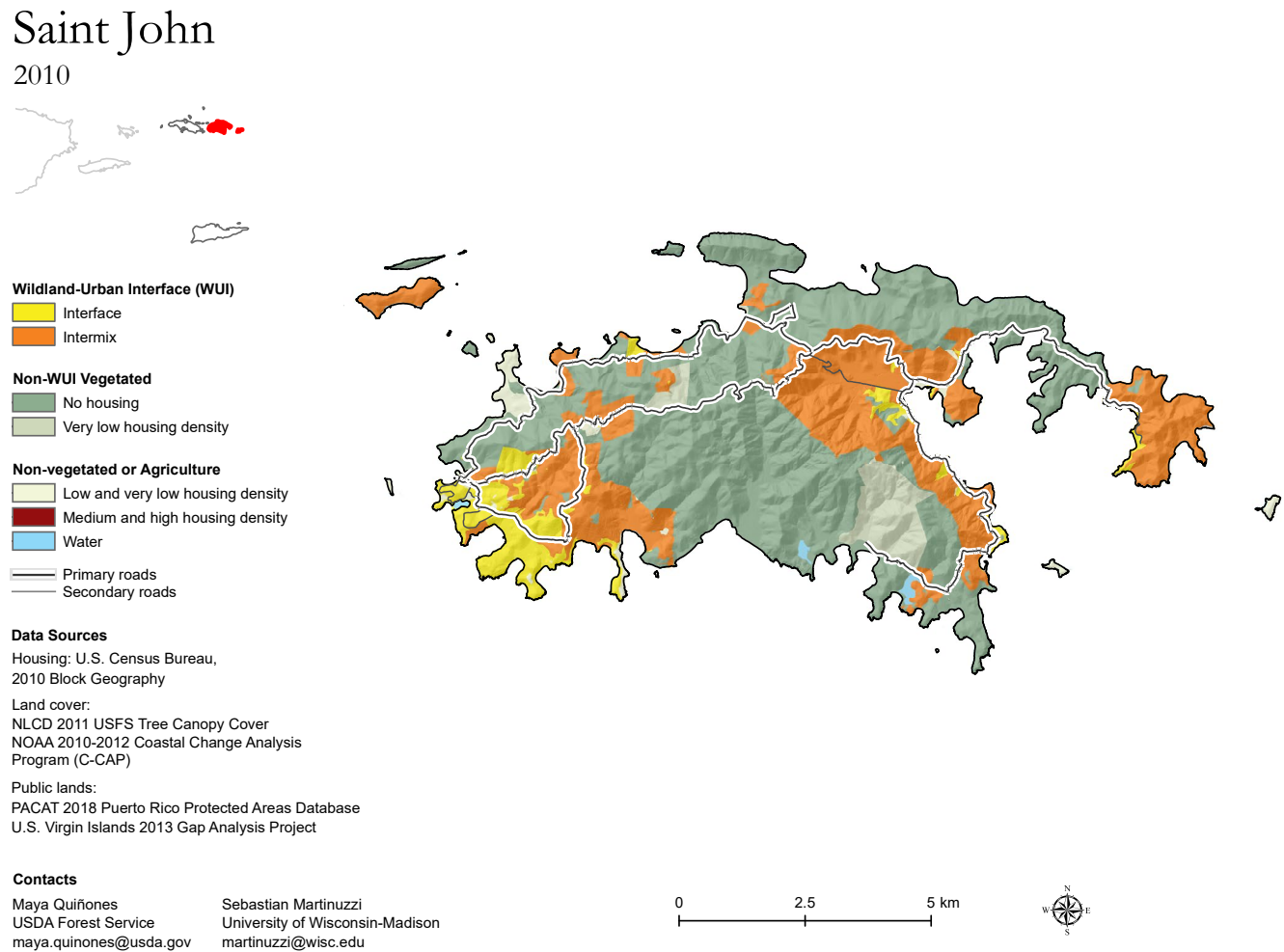
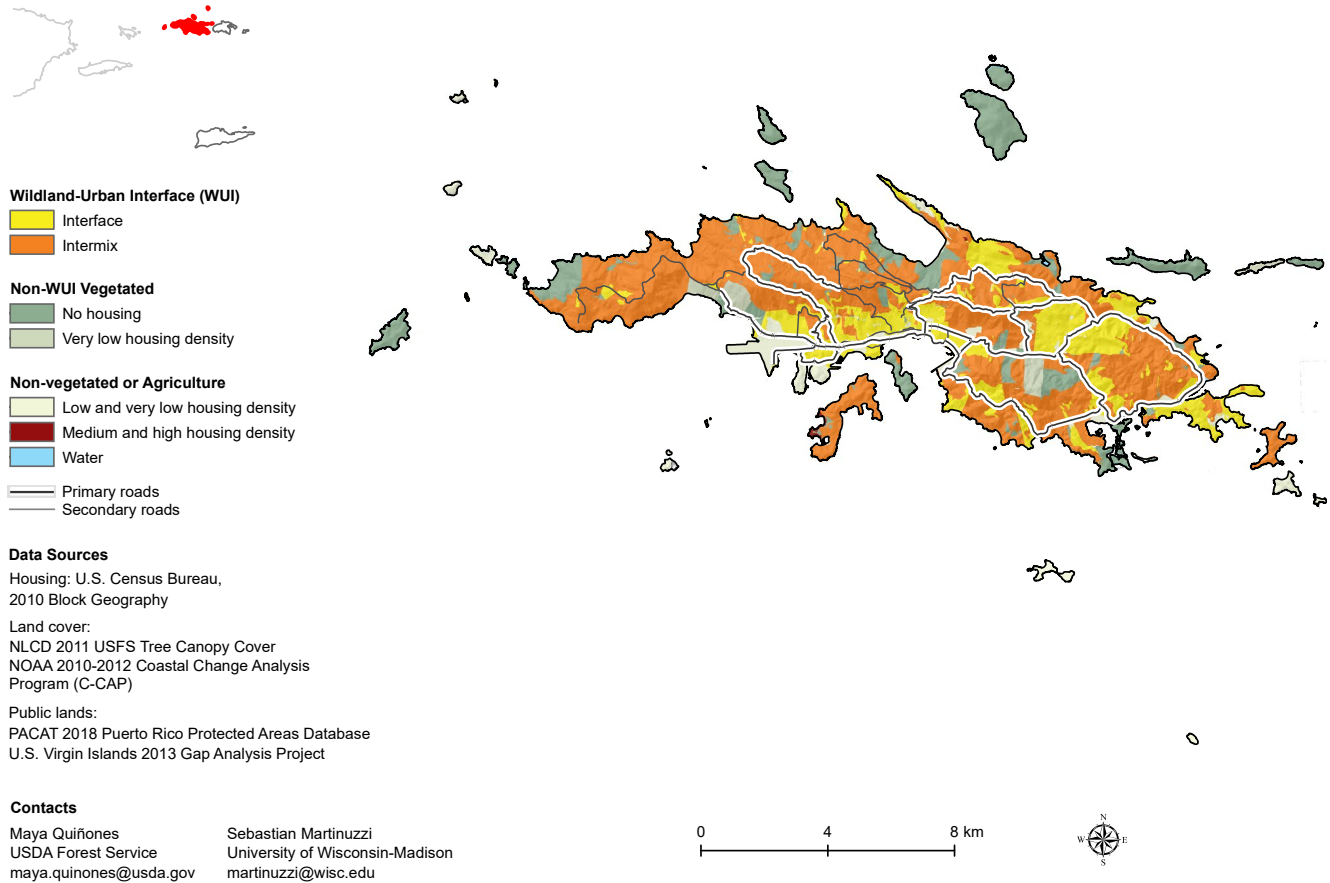


Figure 3-92. Wildland-urban interface in St. Thomas, VI.

Saint Thomas

2010



3. Results

3.7. WUI Case Studies

The following four case studies describe a range of conditions of interest in the WUI of the U.S. Caribbean. The first case focuses on the landscape surrounding the largest protected area in the U.S. Caribbean, the El Yunque National Forest. The second describes the surface freshwater systems in relation to their flow paths through WUI in the U.S. Virgin Islands and Puerto Rico. The third case describes some of the interconnected environmental conditions that move from the urban areas to WUI, and then into the wildlands/forests looking at the example of the San Juan Metropolitan Area. The fourth case presents the current fire vulnerability conditions in the U.S. Caribbean, including social factors to consider in light of increasing drought conditions.

Case study 1: Landscape around El Yunque National Forest

El Yunque National Forest, also known as the Luquillo Experimental Forest, is the only tropical rainforest in the Forest Service National Forest System, providing a variety of ecosystem services (e.g., clean air, water, and recreation) that are essential to the well-being of people in surrounding communities (López-Marrero and Hermansen-Báez 2011a). Yet rapid changes due to increases in housing, residential subdivisions, urban cover, and associated built-up areas have put El Yunque and its surrounding landscape under

high pressure from urban development (López-Marrero and Hermansen-Báez 2011a). Urban areas cover about 10 percent of the lands around El Yunque as of 2010 (López-Marrero and Hermansen-Báez 2011b) and increased by 21 percent from 1998 to 2010.

Various municipalities (counties) contain a portion of El Yunque lands or river systems within their boundaries (fig. 3-93). These areas, although outside the administrative

Figure 3-93. Distribution of WUI and non-WUI classes around El Yunque National Forest (EYNF), including adjacent municipalities that compose the regional special management area.

EYNF WUI Landscape 2010



Wildland-Urban Interface (WUI)

- Interface
- Intermix

Non-WUI Vegetated

- No housing
- Very low housing density

Non-vegetated or Agriculture

- Low and very low housing density
- Medium and high housing density

Water

- Primary roads
- Hydrology
- Municipalities

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

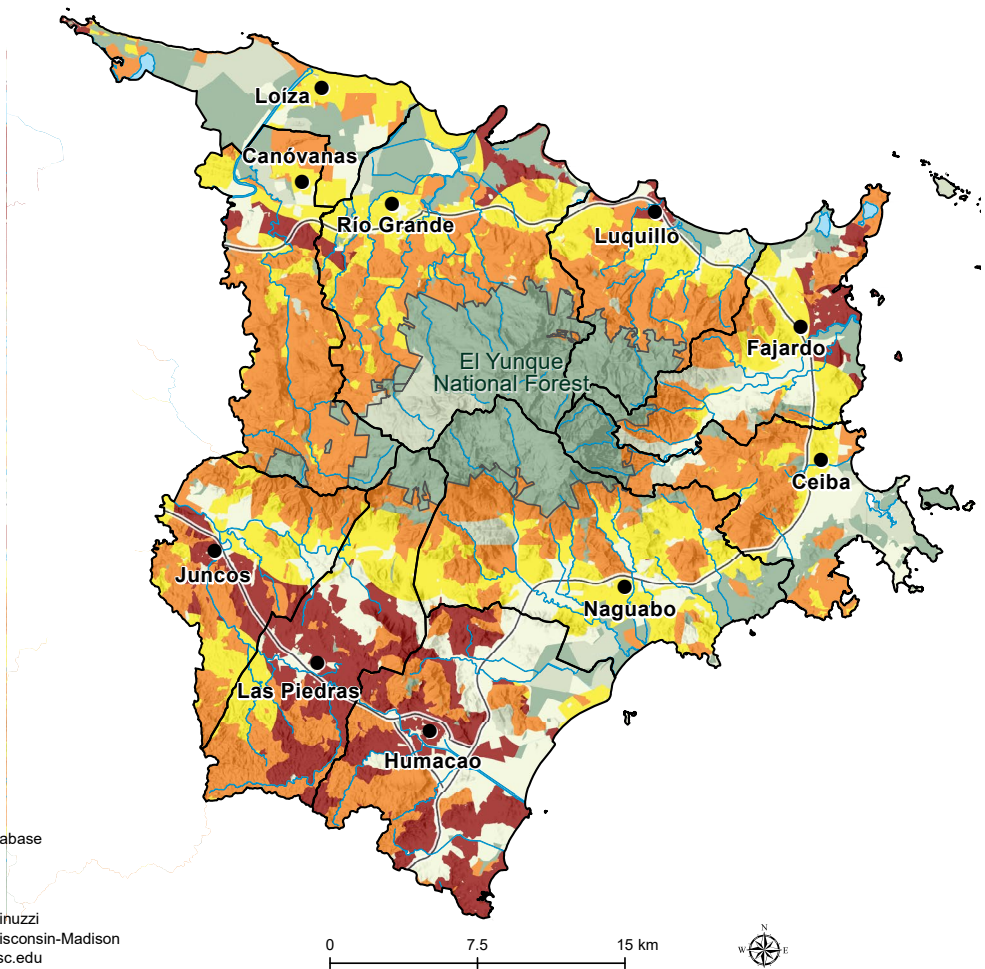
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
U.S. Virgin Islands 2013 Gap Analysis Project

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boundaries of El Yunque, have been identified as important to consider for forest conservation and management purposes per the new forest management plan (2019).

Figure 3-93 shows that El Yunque is surrounded by WUI, including by a ring of intermix WUI right outside the land management limits surrounding the forest (fig. 3-94), followed by another ring of interface WUI as it approaches the lowlands. WUI covers most of the lands in the municipalities (Canóvanas, Loiza, Rio Grande, Luquillo, Fajardo, Ceiba, Las Piedras, Humacao, Naguabo, and Juncos) that compose the landscape adjacent to El Yunque. These findings highlight the situation of urbanization in this unique ecological region and reinforce the problem of WUI expansion around national forests as a whole (Mockrin et al. 2022). Thus, efforts for managing and conserving the forests around El Yunque, such as for increasing connectivity of vegetated areas and ensuring the provision of ecosystem services, must consider the dominant presence of the WUI and the different biotic and abiotic effects of human settlements (Bar-Massada et al. 2014).

Case study 2: U.S. Caribbean WUI and hydrology

Land, vegetation, and water interactions affect the function and health of river systems, water bodies, and watersheds. In island systems, the potential effects of land cover change and fragmentation can reach coastal systems and affect coral reefs (Ramos-Scharrón et al. 2015). Generally, vegetation along streams helps reduce, settle, and retain sedimentation and pollution from soil erosion and urban stormwater runoff that would otherwise reach rivers and oceans (Naiman et al. 2005). Using the stream network dataset from the National Hydrography Dataset (USGS 2020), we found that a large part of the length of streams in Puerto Rico flows through the WUI (67 percent), and especially through intermix WUI areas (54 percent; table 3-12). In the U.S. Virgin Islands, streams, locally called ghuts, are mostly ephemeral, and about 54 percent of them flow through the WUI (table 3-12; fig. 3-95).

Understanding how stream conditions (temperatures, incident light, fauna diversity, water quality, flow channels) are affected by the WUI is important for the conservation and sustainability of water resources and the ecosystems that depend on them extending to coastal areas. Watershed processes and functions may be affected differently by the

Figure 3-94. Example of intermix WUI housing development and agriculture in the periphery of El Yunque National Forest, PR. USDA Forest Service photo by Tamara Heartsill-Scalley.



3. Results

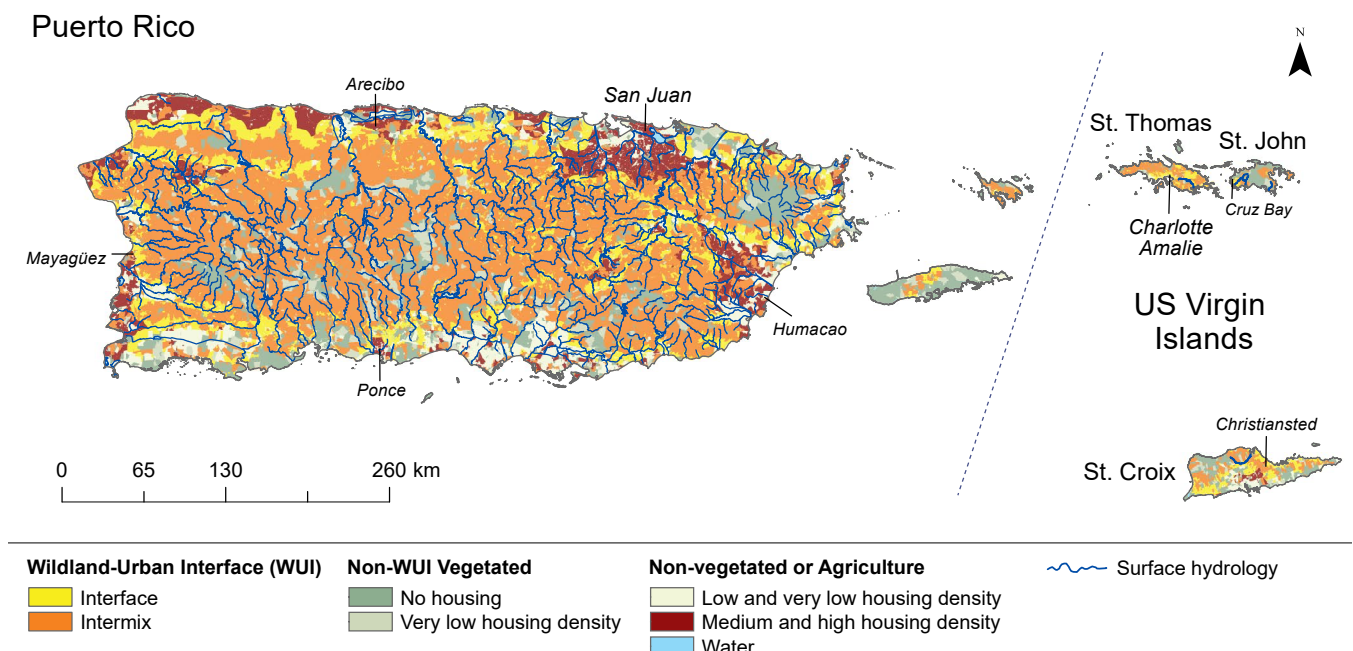
dominant WUI landscape compared to vegetated or urban areas (Groffman et al. 2003). WUI areas may contribute vegetation that shades and cools waterbodies, thus improving the condition of these hydrological systems that may be flowing through urban areas. The WUI may also increase ecosystem services compared to urban areas, where hydrological systems are exposed to higher temperatures and constrained water channels that result in faster flows that negatively affect aquatic organisms and ecosystem

processes within watersheds (Ramírez et al. 2012). Further, natural cycles and interactions that are essential between river channels and their riparian zones or floodplains are more likely to be maintained and occur in the WUI and not in urban areas. Our WUI map provides new information on land use integrating vegetation and housing, which is valuable for assessing the condition, health, and human pressures on hydrological systems and the resulting effects on tropical ecosystem processes and functions.

Table 3-12. Length of the streams in different wildland-urban interface (WUI) and non-WUI classes, based on the National Hydrography Dataset. Source: USGS (2020). Percentages are calculated relative to the total length of the stream network.

Land use category	Puerto Rico		U.S. Virgin Islands	
	km ²	%	km ²	%
Intermix WUI	5,651.2	53.6	82.4	33.3
Interface WUI	1,395.4	13.2	52.2	21.1
Non-WUI Vegetated—No housing	1,382.8	13.1	67.2	27.1
Non-WUI Vegetated—Very low housing density	519.4	4.9	23.7	9.6
Non-vegetated or Agriculture—Low and very low housing density	918.1	8.7	20.4	8.2
Non-vegetated or Agriculture—Medium and high housing density	657.8	6.2	1.9	0.8
Non-vegetated or Agriculture—Water	21.6	0.2	0.0	0.0

Figure 3-95. Stream network and wildland-urban interface (WUI) in Puerto Rico and U.S. Virgin Islands.



Case study 3: San Juan Metropolitan Area

While the northern, low-elevation section of the San Juan Metropolitan Area (SJMA) is dominated by high-density developments, our study revealed that the southern, more mountainous part is dominated by WUI (fig. 3-96). It has been suggested that WUI around the highly urbanized metropolitan area of San Juan acts like a heat-retaining buffer that exacerbates the urban heat island effect (Murphy et al. 2011). The amount of impervious surface cover, along with transportation infrastructure and other social-technological activities, are sufficient to increase local daytime and nighttime temperatures, creating a WUI/urban heat island effect extending beyond the urban areas and WUI. Vapor and evening warming in the WUI can seep from the urban areas

and reach the wildland edge. Studies in the SJMA are needed to understand how spatial configuration and connectivity of vegetated areas may be managed to mitigate effects of urban heat and maximize the role of the adjacent WUI in cooling and heat re-radiation. Information needed for effective adaptive management of vegetated (green areas) in the SJMA should consider complexity and roles of vegetated areas, including vegetation layers (trees, palms, shrubs, grasses), soil compaction, soil depth, and connections (potential dispersal or corridors) with vegetated cover in the WUI (Gould et al., in preparation; Heartsill-Scalley and López-Marrero 2021; Vázquez Plass and Wunderle 2013).

Figure 3-96. Distribution of WUI and non-WUI classes in the San Juan Metropolitan Area, PR.

San Juan Metro Area 2010



Wildland-Urban Interface (WUI)

Interface

Intermix

Non-WUI Vegetated

No housing

Very low housing density

Non-vegetated or Agriculture

Low and very low housing density

Medium and high housing density

Water

Primary roads

Secondary roads

Data Sources

Housing: U.S. Census Bureau,
2010 Block Geography

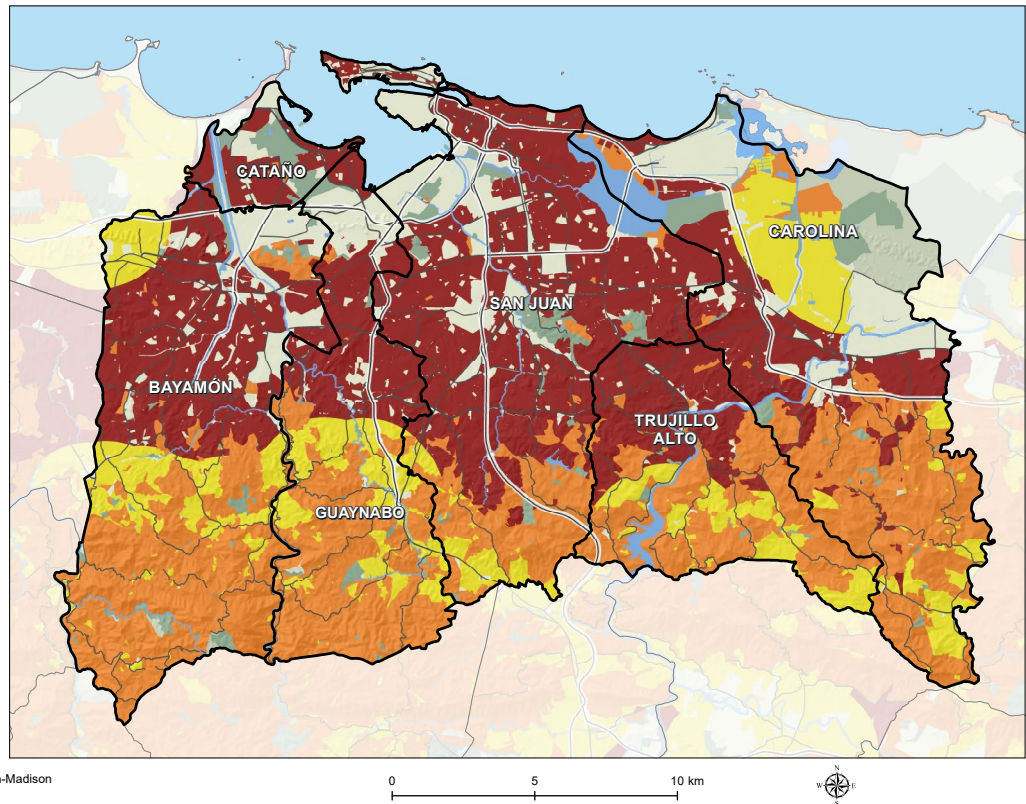
Land cover:
NLCD 2011 USFS Tree Canopy Cover
NOAA 2010-2012 Coastal Change Analysis
Program (C-CAP)

Public lands:
PACAT 2018 Puerto Rico Protected Areas Database
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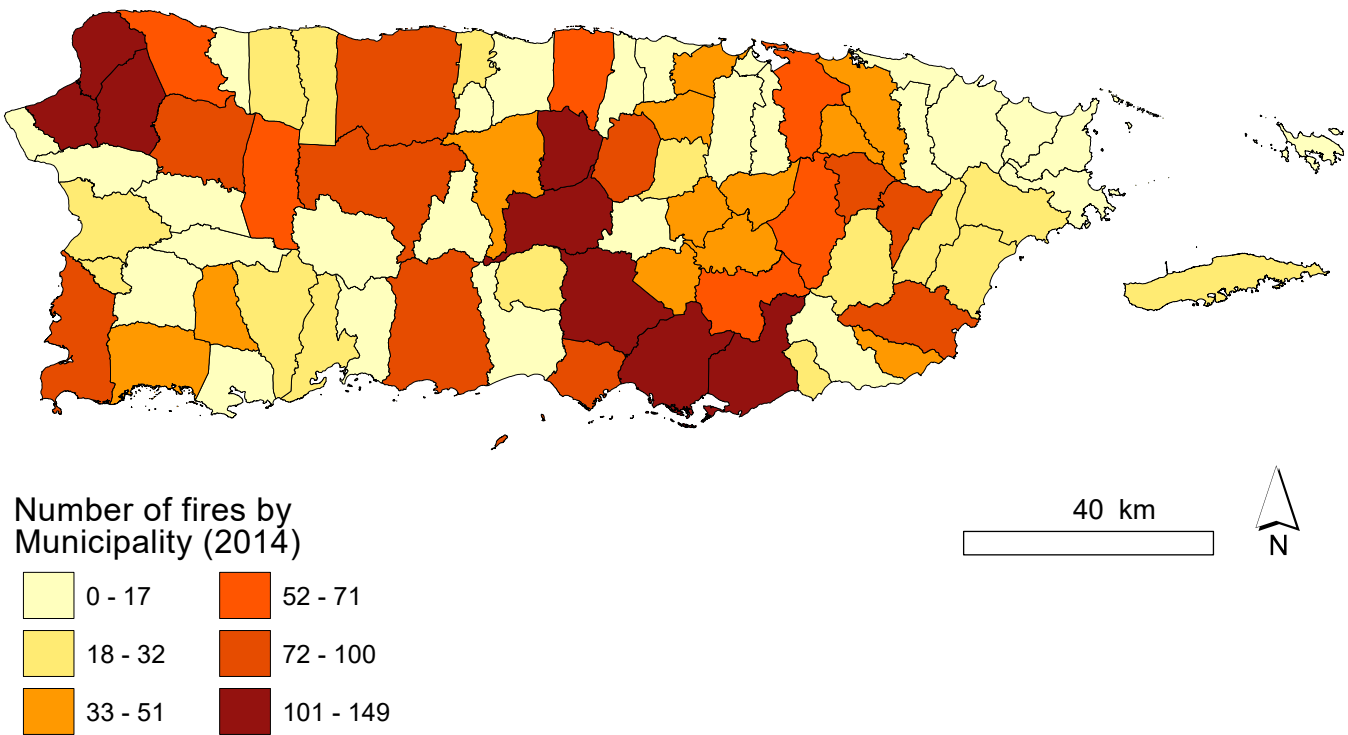
3. Results

Case study 4: Considerations for fire potential in the U.S. Caribbean

Although wildfires in wildland or WUI areas had not been common in the U.S. Caribbean region, environmental conditions are changing (Herrera et al. 2020, Robbins et al. 2008). Currently, small-scale fires for land management (e.g., land clearing, reduction of hazard fuel loads, etc.) occur in regions with dry and moist climates (fig. 3-97). However, Puerto Rico and the U.S. Virgin Islands are projected to see increases in temperature and decreases in rainfall, which will likely favor conditions for fires in wildlands (Monmany et al. 2017, USDA Forest Service IITF 2021). The ongoing drought conditions in Puerto Rico and the U.S. Virgin Islands have important consequences for residents and fire danger potential, with drought status updates reported bimonthly (NIDIS 2023). The dry and moist forest regions, where fire occurrence is highest, already have substantial amounts of WUI, and in Puerto Rico, dry forest areas seem to be increasing (Marcano-Vega 2017), providing additional potential areas for development of fires. The dry and moist forests of the U.S. Caribbean are not ecologically dependent on fire and therefore are highly susceptible and vulnerable to fire events (Monmany et al. 2017).

The extensive WUI in the dry and moist areas of Puerto Rico and the U.S. Virgin Islands is vulnerable to increased fire. Vulnerability to increasing wildfire occurrence is exacerbated when drought-prone areas are also economically depressed communities (Herrero-Corral et al. 2012). The drought-prone WUI areas also have increased risk of other hazards such as landslides and erosion. In addition, the lands with dry and moist climates contain many of the remaining and locally important subsistence agriculture areas. The location of agricultural areas in proximity to WUI in the drier part of the landscape increases their existing vulnerability to the drought and fire combination (Barker 2012). Therefore, these areas may require special initiatives to mitigate existing conditions and management that addresses current and future multiple stressors. The identification of WUI communities with increased potential for wildfire and awareness of the potential loss of livelihoods and well-being is an important step to mitigate and manage ongoing changes in U.S. Caribbean landscape conditions.

Figure 3-97. Distribution of fires in Puerto Rico, using the year 2014 as an example. Source: Monmany et al. (2017).





4. Discussion

We developed the first map of the WUI for Puerto Rico and the U.S. Virgin Islands using the same technique as in the conterminous United States, which is essential for consistent comparison, environmental management, and policy efforts across all U.S. lands. We found that the WUI is widespread, encompassing 65.3 percent of the land, 61.5 percent of the houses, and 63.6 percent of the people in Puerto Rico, and 52.3 percent of the land, 93.4 percent of the houses, and 91.2 percent of the people in the U.S. Virgin Islands, thus representing a common landscape feature in these places. Further, we showed that the percentage of area in WUI found in Puerto Rico and the U.S. Virgin Islands is higher than most States in the conterminous United States, reinforcing the need to include the Caribbean territories when developing WUI-related policies and management efforts across the Nation.

The abundance of WUI and the range of levels of built-up infrastructure, economies, environmental conditions, and social-cultural norms found in the WUI can be explained by multiple factors. First, Puerto Rico and the U.S. Virgin Islands have extensive networks of paved roads that facilitate both easy communication within the islands and the presence of sprawled developments typical of the WUI. Second, urban areas abound, as there is at least 1 urban center in the form of a city or town for each of the 78 municipalities of Puerto Rico, and for each of the 3 districts of the U.S. Virgin Islands. Having so many urban or town centers distributed across the islands means there are many locations where one could live and be relatively close to services and commercial areas. Third, land division may often be informal, with various family members establishing homes in a shared land parcel, thus favoring the presence of houses in rural areas (Ocasio 2018, Padilla-Eliás et al. 2016). And finally, the abundance of wildland vegetation, due to the combination of abandonment of agricultural lands, growth of secondary forests across the island, and restoration efforts that started in the 1940s associated with an economic shift toward manufacturing, service, and tourism (Dietz 2018).

The fact that the intermix WUI had a larger area than the interface WUI, but the interface WUI had more houses, is a similar pattern to what is observed in the conterminous United States (Martinuzzi et al. 2015). However, the forests that make the WUI in our study area include native vegetation types, novel combinations of native species, novel combinations of nonnative and native vegetation species, and naturalized food trees, making it a distinctive

type of wildland vegetation compared to that of the U.S. mainland (Lugo and Helmer 2004; Marciano-Vega 2019, 2020). The range of vegetation types encompassed in the WUI invites further analyses on the role of vegetation succession and social values that maintain this vegetation cover in light of factors such as changes in conditions of built-up infrastructure, shifting economies, environmental constraints, and social-cultural norms. Therefore, the WUI defined as a socio-ecological system has an important and fundamental role to play in the mitigation of changing environmental conditions predicted for the U.S. Caribbean.

Our study also shows that there is substantially more WUI than previously reported by Martinuzzi et al. (2007) and Gould et al. (in preparation), which is likely due to the different methodologies employed. Interestingly, the WUI mapped in previous efforts generally coincides in space with one of our intermix classes, the medium-density housing class, thus highlighting some common patterns. However, our mapping approach shows that the intermix WUI can extend into areas with lower housing density that were previously considered non-WUI. Overall, our study confirms the abundance of WUI in Puerto Rico and the U.S. Virgin Islands, thus highlighting the value of the intermix and interface subclasses to better understand the patterns and gradients of WUI.

Environmental management and planning in Puerto Rico and the U.S. Virgin Islands should consider the widespread presence of WUI. In this sense, our study supports the notion that Puerto Rico and the U.S. Virgin Islands are large social-ecological systems (Lugo 2014, 2019, 2020; Muñoz-Erickson et al. 2014; Zimmerman et al. 2020), and therefore should be studied and managed as such. Doing so requires incorporating the role of WUI into current and future social-ecological research and management efforts. Recently, Jenerette et al. (2022) developed a framework for WUI research and management that emphasizes tradeoffs among development, multiple ecosystem processes, and stakeholders in the context of local conditions and larger government policies. The framework can be adapted to different settings and is therefore worth investigating.

One of the advantages of using U.S. census data is that they are updated every 10 years, allowing for decadal assessments of WUI growth (Radeloff et al. 2018) as well as consistent comparisons with the U.S. mainland. In this sense, both Puerto Rico and the U.S. Virgin Islands

4. Discussion

have seen sharp population declines between 2010 and 2020, including by 11.8 percent for Puerto Rico and 18.1 percent for the U.S. Virgin Islands. These strong population declines are associated with the aftermath of an enduring economic recession that started in the early 2000s and were exacerbated during the COVID-19 (coronavirus) pandemic, combined with the social infrastructure disaster from the most recent hurricane disturbances (Irma and Maria in September 2017), which forced some people to migrate to the U.S. mainland. The recent release of the 2020 census data, not available when we started this project, will make it possible to quantify population changes within the WUI and better understand recent WUI dynamics.

The census data have some limitations. In particular, the block polygon sizes are variable, and in rural areas the blocks can be several times larger than in urban areas. As explained by Carlson et al. (2022), this can lead both to errors of omission—where a block is not mapped as WUI even though housing density is high enough to qualify in a portion of the block—and errors of commission—where areas that are void of houses are included if a high-density housing cluster causes the entire block area to exceed the housing density threshold. These problems affect rural areas where the census blocks tend to be large. An alternative to mapping the WUI using census block polygons is to use individual

building locations (Bar-Massada 2021, Bar-Massada et al. 2013, Godoy et al. 2019). The advantage of this approach is that it allows for a more consistent method for aggregating building densities while also identifying the precise locations where buildings interact with wildland. Recently, Microsoft has released a freely available product of building footprints for different parts of the world (available at <https://www.microsoft.com/en-us/maps/building-footprints>), which has opened new opportunities for mapping the WUI at the housing levels across large areas, such as for the entire conterminous United States (Carlson et al. 2022). While Microsoft buildings for Puerto Rico and the U.S. Virgin Islands were not available at the time of this report, these data are frequently updated and could provide an exciting opportunity for detailed WUI mapping in this region.

The WUI, corresponding to the area where houses and wildland vegetation interact, consists of increasingly conspicuous features that are hotspots of rapid environmental change. The WUI dataset for Puerto Rico and the U.S. Virgin Islands generated here covers an important gap in WUI data for the United States, providing valuable information for understanding spatial patterns in human land use and to guide future research and environmental management efforts.

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The wildland-urban interface (WUI) is the area where houses are in or near wildland vegetation and where many environmental problems concentrate. Consistent WUI maps across all U.S. lands and territories are therefore needed for effective environmental management and policy efforts. However, such maps are lacking for Puerto Rico and the U.S. Virgin Islands. Here, we mapped the WUI in Puerto Rico and the U.S. Virgin Islands for 2010 using the same mapping approach as in the conterminous United States and integrating population census, land cover, and land ownership information. We found that the WUI in these territories is widespread, encompassing 65.3 percent of the land, 61.5 percent of the houses, and 63.6 percent of the people in Puerto Rico, and 52.3 percent of the land, 93.4 percent of the houses, and 91.2 percent of the people in the U.S. Virgin Islands. We summarized the WUI by municipality (for Puerto Rico) and district (for U.S. Virgin Islands), compared the amount of WUI in Puerto Rico and the U.S. Virgin Islands to that of the conterminous United States, and discussed four WUI cases of local environmental relevance related to urbanization, hydrology, and wildfire. The dataset generated here covers an important gap in WUI data for the United States, providing valuable information for understanding patterns in human land use and guiding environmental management and policy.

Keywords: wildland-urban interface, Caribbean, tropical, census, land cover



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