Lajas Valley Agricultural Reserve
Farm Inventory of the Guánica Lagoon, El Anegado and Adjacent Areas
Guánica, Puerto Rico

Picture of the Lajas Valley by Jeiger Medina Muñíz, Protectores de Cuencas, Inc.

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Center for Watershed Protection

8390 Main Street, 2nd Floor
Ellicott City, MD 21043

By:

Roberto Viqueira Rios
Louis Meyer Comas
Box 673 Yauco,
Puerto Rico 00698
Tel: 787-457-8803
rviqueira@hotmail.com

With the collaboration of:

Paul Sturm
6618 Stirrup Ct.
Eldersburg, MD 21784
Tel. 410-227-7689
paul@ridgetoreefs.org
www.ridgetoreefs.org

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1. Acknowledgements

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2. Introduction

2.1 Project Description and Location

The Lajas Valley is located in the southwestern region of Puerto Rico (Figure 1). It extends from the Boquerón Bay in the west to the town of Yauco in the east. Lajas Valley watershed is located in the zone of least precipitation in Puerto Rico with an annual average rainfall of 45 inches. The Lajas Valley drains to both the Guánica Bay to the south and to the Boquerón Bay through Laguna Cartagena on the west. The Valley is surrounded by mountains—a small chain of mountains in the south and a more complex mountain formation in the north. The length of the Valley is approximately 30 kilometers long, and its width is approximately 6 kilometers. The area of the true valley consists of approximately 17,000 acres. Prior to drainage in the 1950's, the Lajas Valley was composed of a complex of wetlands that included the Guánica Lagoon, El Anegado and Laguna Cartagena. Guánica Lagoon covered an area of approximately 1,200 acres in the east end of the Valley and the El Anegado covered an area of approximately 2,000 acres located in the middle of the Valley. The Guánica Lagoon and El Anegado were connected by a small channel called La Bajura or La Angostura located north of Cuesta Blanca Community (Figure 2). El Anegado drained into the Guánica Lagoon and then into the Guánica Bay. El Anegado was composed mostly of aquatic vegetation with a web of low depth small channels that converged to the La Angostura, while Guánica Lagoon was mostly composed of open water with some aquatic vegetation in the northeast and northwest portions. Both systems, El Anegado and Guánica Lagoon, depended upon surface water emanating from a series of small creeks mostly from the northern mountain ridge. Water levels were controlled predominantly by evaporation and evapotranspiration processes due to the low permeability of the Lajas Valley soils. Guánica Lagoon was also used for irrigation of adjacent farm land that pumped water with a series of pipes causing the Lagoon to dry periodically. Guánica Lagoon was also used as a food source for communities who eat fish, shrimps and waterfowl and for other recreation activities and hunting. It also provided habitat for a vast variety of native, endemic and migratory birds.

Guánica Lagoon and El Anegado were drained in 1955 through the construction of a main drainage channel and a series of lateral channels connected to the main drainage channel draining into the Guánica Bay through the Loco River. They were drained as part of the *South West Puerto Rico Project* that consisted of converting wetlands areas in the Valley to agricultural lands. It also consisted of construction of a series of five lakes in the upper central mountain watershed that carried water for irrigation from one lake to another, connected through underground tunnels, to the Valley through a main irrigation channel from the Loco lake throughout the north side of the Valley with a series of connections for most of the Valley's farms. The irrigation channel has been used more recently as a source for potable water for the municipalities of Yauco, Sabana Grande, San Germán, and Cabo Rojo. This project was also developed to generate electricity with two hydroelectric power plants located in the Yauco municipality (which are currently in use). As a consequence of this action, more than 3,000 acres of wetland in the south of Puerto Rico were lost.

Lands that were claimed from wetland to farm land in the El Anegado Area were most successfully used for agriculture; while lands inside the Guánica Lagoon historic footprint were scarcely used for intense agriculture as intended, mainly because of persistent wetland conditions, frequent inundation, and challenging soil conditions for agriculture. It is important to mention that farming conditions in the Lajas Valley are very dependent upon drainage and rainfall. Farming is almost impossible during the rainy season—predominately in the months of May and through September and October. The Guánica Lagoon area is partially inundated for most of the year and completely inundated during the rainy season; while the El Anegado area floods during big rain events and stays inundated between one to four weeks.

The restoration of the Guánica lagoon has been a National issue for the past few decades, and has been more actively discussed for the past two years gaining a lot of support from communities, environmental groups, the scientific and academic community, Federal and Puerto Rico agencies, as well as the Executive and Legislative branches of the Puerto Rico Government. It is important to also state that the community of farmers within the Lajas Valley Agricultural Reserve has been historically opposed to the restoration of the Guánica Lagoon project because they have genuine

concerns that the Lagoon will negatively affect farm land in the area. The major elements that concern farmers the most are as follows: 1) that having the Lagoon restored will increase the drainage problems that already exist in the Valley where the drainage channels have not been properly maintained for the past decades; 2) that water uprising will occur in areas that have actively been used for farming, bringing underground salts to the surface, damaging productive agricultural lands, and causing the eventual loss of land dedicated to agriculture.

To be able to answer these uncertainties about the potential impacts of restoring the lagoon, a series of studies are currently taking place (including this Farm Inventory). These include a Hydrologic and Hydraulic Study and a Groundwater and Soil Salinity Study. The proper maintenance of the drainage system is also recommended. Once all of these studies have been completed and integrated, we will be able to determine more precisely the impacts that restoring the Guánica Lagoon may have on the agriculture of the surrounding area.

The proposed restoration project consists of restoring the Guánica Lagoon as close to its historic levels as possible, with the limiting factor that the impacts stay within the historic footprint of the Lagoon or smaller, without affecting (or negatively impacting) farming in the El Anegado area. A key aspect of any restoration scenario is the construction of a water control structure that can raise water levels iteratively in order to be able to measure impacts at each interval before continuing with inundation. This will also allow the optimal level of lagoon elevation to be determined and managed to effectively support agricultural activity and the native ecology of the area.

2.2 Soil Description of the Area

A knowledge of soil types in the Lajas Valley is critical to understand the potential agricultural uses and how water movement behaves in the area in terms of drainage, potential water logging problems, and the surface water table and ground water interaction. There are 43 different soil types within the study area (Table 1). Soil types in the study area of the Lajas Valley consist primarily of clays at over 90%. The three

most abundant clays are the Guanica clay (24.77%), Aguirre clay (23.63%) and Fraternidad clay (12.93%) (Figure 3).

The Aguirre series consists of very deep, poorly drained, very slowly permeable soils in depressions and on valley floors of the Semiarid Coastal Plain. They formed in clayey marine sediments and material derived from limestone and igneous rock. Slopes range from 0 to 1 percent. Near the type location, the mean annual precipitation range is 25 to 66 inches and means annual air temperature is 66 to 89 degrees F. They are very dark gray clay; moderate fine angular blocky structure; very hard, very firm; very sticky and very plastic. Most areas of Aguirre soils are used for hayland and native pasture. The native vegetation includes Pajon, Paraguita, and Malojillo; which is now joined by a number of introduced species.

The Guánica series consists of very deep, somewhat poorly drained, very slowly permeable soils on basin floors of the Semiarid Coastal Plains. They formed in clayey alluvial sediments weathered from igneous, metamorphic, and sedimentary rocks. Near the type location, the mean annual temperature is about 75 degrees F., and the mean annual precipitation is about 45 inches. Slopes range from 0 to 1 percent. Most areas of Guanica soils have been used for sugarcane and native pasture. The vegetation consists of Angletongrass, Paraguita grasses, Rayo, Mesquite, halophytic plants, and other native and introduced species.

The Fraternidad series consists of very deep, moderately well drained, very slowly permeable soils on fan skirts of basins and flood plains of the Semiarid Coastal Plains. They formed in clayey sediments that weathered from volcanic rock and limestone. Near the type location, the mean annual temperature is about 75 degrees F., and the mean annual precipitation is about 45 inches. Slopes range from 0 to 12 percent. Most areas of Fraternidad soils are used for cultivated crops—Including rice and cash crops. Some areas are used for hay land and native pasture. The native vegetation consists primarily of guinea grass, kleberg bluestemgrass, and hurricane grass.

3. Objectives

The main objectives of this study were:

- To determine the actual agricultural uses of areas within the Lajas Valley Agricultural Reserve that may be potentially affected with the restoration of the Guánica Lagoon in order to be able to measure the possible impacts that this project may have on the agriculture of the area,
- to identify land ownership,
- to focus the survey in the areas adjacent to the main drainage channels and laterals in the Lajas Valley Agricultural Reserve and areas adjacent to *Laguna de Guánica* and *El Anegado* within the 5m contour boundary which is the area more likely to be impacted under a restoration scenario. Additional contiguous parcels beyond the 5 m contour were surveyed based on elevation and the intensity of agriculture,
- to be able to use this study results to determine with more accuracy the possible impacts of the different restoration alternatives on agriculture of the area by integrating them with results of the Hydrological and Hydraulic study from different flooding alternatives of the restored Guánica Lagoon.

4. Study Site

The Guánica Bay watershed is approximately 151 square miles and the drainage to the historic Guánica Lagoon is approximately 50 square miles and represents roughly 33% of the entire watershed (Figure 1). Guánica Lagoon was drained in the 1950's to increase the amount of sugar cane agriculture in the Lajas Valley. The historic lagoon area has seen more limited agricultural production in the last 40-45 years and represents 7% of the 17,000 acres of the true valley area. The area of the Lajas Valley receives approximately 40-50 inches of rain annually based on local gauges in the Lajas valley. Though rainfall amounts are likely highest in the north and lowest in the south part of the valley; the majority of that rainfall falling during the peak of the rainy season between September and October.

It should be noted that for the purposes of this project, we defined a number of specific areas (Figure 4) based on the historic and current land uses. These include:

- El Anegado area – A historic freshwater wetland drained and located to the west of Guánica Lagoon that was inundated seasonally. Today it is productive farmland;
- Former Lagoon area – Includes the former lagoon and parcels which intersect with the former historic lagoon footprint area;
- North of the Lagoon area – Includes all parcels in the north region of the Guánica Lagoon that don't intersect with the lagoon historic footprint;
- South of the Lagoon area – Includes all parcels in the southern region of the Guánica Lagoon that don't intersect with the lagoon's historic footprint. Most of this land is composed of hillsides used for grazing.
- West of El Anegado area – It is the area west of the historic El Anegado area and the farthest western area from the Guánica Lagoon.

5. Study Approach and Methodology

This study summarizes 14,932 acres of the Lajas Valley Agricultural Reserve—including all the parcels within the 5 meter contour line plus areas of adjacent contiguous agricultural land (Figure 5). For the purpose of spatially, identifying the different farms a GIS layer was used prepared by the Municipal Revenues Collection Center of Puerto Rico (CRIM). A number was assigned to identify each parcel (Figure 6). This layer was used as base for all the survey as well as for the new GIS maps created. The CRIM layer was incorporated into a 2010 Puerto Rico aerial orthophoto and printed into a large field map (3' x 7') for the purpose of taking to the field and using for public meetings with the farmers. A GPS was used to ensure that we were looking at the correct locations on the farms while entering farm information.

For this study, a total of 179 parcels with an average of 80 acres per parcel were surveyed. Farms were surveyed for a total 14,932 acres corresponding to 38 farmers that were visited individually at their farms between May 12, 2011 and October 18, 2011. A total of 2 open meetings were conducted with farmers to discuss the study. The first meeting was to introduce and explain the study and to get the farmer's support for the survey process. The second meeting was to update farmers on the study, and a third meeting will be held to present the survey results. Three other meetings were conducted with the Puerto Rico Land Authority (PRLA) Guánica office personnel to identify lands owned by PRLA and Land Administration of Puerto Rico and the information for the farmers who are renting the public lands for farming. Two other meetings were held to compare information gathered in the farms and farmers meetings with PRLA personnel. Another meeting with farmers will be conducted after completion and submission of this final report so the information can be presented to them.

A survey questionnaire was developed to be completed during the visit to the farmers (Appendix A). The questionnaire included general information about farmers and parcels, ownership of lands, infrastructure present in farms, source of irrigation water, irrigation system, detailed description of the different types of crops, fertilizer and pesticide application, conservation practices implemented, problems affecting farming in the area, and comments and concerns of farmers about the project. All of the data from

the questionnaire were incorporated into an Excel database that was then used to develop this report and all the GIS maps.

The Excel database was developed to track the specific ownership and management characteristics of the farms and land use present in the Lajas Valley--including the specific uses of parcels, typical yields, animals, as well as problems with flooding, fire, and saline soils. Data entered into the database will be used to evaluate the impacts of restoration on the economy and productivity of the area.

Data from the questionnaire was corroborated using ARCGIS 9.3 with 2010 Puerto Rico orthophotos of the area. When discrepancies or doubts arose in this process, farmers were called to clear up the information; and in some cases, farmers were revisited.

6. General Results

In general, agricultural uses of the study area are mostly forage hay production (37%), Grazing Cattle (29.4%) and rice seed production (8.6%). Grazing is divided into cattle meat production (27.8%) and cattle milk production (1.6%). The other use identified in the study area is horse production (0.8%). Between 24% and 25% of the total study area is not in actual farm use. Other minor types of agriculture were identified, but not included in this report because of the small amount of land (less than an acre) when compared to the main uses of the area. These are goat production, coriander, pineapples, sweet peppers and plantains. A total of 14,932 acres were surveyed. Of these, 5,545 acres are dedicated to forage production, 4,127 acres are used for grazing meat cattle, 1,288 acres are used for rice seed production, and 123 acres for horse production. Of the total area surveyed, 10,882 acres are privately owned (69%), and 4,050 acres are publicly owned corresponding to 31%.

The area of study generates a total of approximately $8,163,152 of gross income per year, including $259,887 for the Lagoon Area; $433,244 for the South of the Lagoon area; $819,522for the North of the Lagoon Area; $2,778,549for the El Anegado Area; and $3,871,449 for the West of El Anegado area.

In general, land use for agricultural increases in an east to west pattern as you move away from the Lagoon area. Of the total area not in actual farming use, 1,971 acres are in contact with the main drainage channel, 2,009 acres have lateral channels, and 368 acres do not have any type of irrigation (Figure 7).

6.1 Forage Production

Hay production is the most common agricultural use in the Lajas Valley Agricultural Reserve (LVAR) (Figure 8). Of the 14,932 acres surveyed, 5,545 acres are dedicated for hay production. The vast majority of this hay is being produced without the application of pesticides and fertilizers and with a minimum of irrigation, mostly because of the high cost of fertilizer and fossil fuels. The area is producing an average of 117 packs/acre (1 pack = 35 lbs. approximately) per harvest time. The average

harvests for the area is 2.4 times a year, but it varies from 1 to 4 times a year depending of the location on the parcel; the limiting factors are inundation and drainage conditions caused by rains; and poorly maintained drainage channels. Farmers are producing an average of 282 packs per acre yearly, for a total of 28,000 tons per year for the total area of study. The average actual price per ton farmers are receiving for hay is $200, which equals a total of approximately $5.5 million dollars of gross income on a yearly basis for the study area. Due to frequent inundation and poor drainage of the area, farmers are losing an average of close to 1 harvest time per year. This loss equals a total of approximately 8,200 tons of hay not harvested that could earn an extra $1,640,000 of gross income per year for the area (it should be noted that at least a portion of this loss is due to the natural hydrology of the area, and only a portion of this lost production could be expected to be recovered under significant improved drainage scenarios).

Forage production increases in the area in a south to west pattern as you move away from the area of the historic Guánica Lagoon (Figure 9). In contrast, net loss decreases following that same pattern as well as drainage problems (Figure10a). When taking into account proximity to the main drainage channel, parcels that are in contact with the main drainage channel have more loss of production caused by water logging compared to parcels that are not in contact with the channel (Figure 10b). Of the 5,545 acres used to produce hay, 2,615 acres are within parcels that are in contact with the main drainage channel, produce an average of 111 packs/acre for each harvest and have an average of 2.1 harvests a year with an average of 1 harvest loss per year. Parcels that are not in contact with the main drainage channel, but are in contact with other small lateral drainage channels (2,720 acres), are producing an average of 120 packs/acre and an average of 2.5 harvests a year with an average of 0.59 times of harvest loss. Parcels that are not in contact or don't have any lateral drainage channels (210 acres) have an average of 118 packs/acre and an average of 2.2 harvests and 0.83 times of harvest loss.

From the 5,545 acres used for hay production, just 1,408 acres are applying fertilizers—for a total of 3,396 Hundred Weight (cwt) of fertilizer applied annually. The area that is applying the most fertilizer for hay production is the North of the Lagoon

(1,302 cwt) area followed by the West of El Anegado area (806 cwt), El Anegado (606 cwt), and the Lagoon area (15 cwt). The different types of fertilizers used are 15-5-10, Ammonium Sulfate, Urea, and Chicken Manure. The 15-5-10 and Ammonium Sulfate are the most commonly applied. According to farmers, parcels applying fertilizers are producing an average of 113 packs/acre with average of 2.1 harvests a year and 0.96 harvests lost for a total average year production of 241 packs/acre, and parcels that are not applying fertilizers are producing an average of 119 packs/acre with average of 2.5 harvests a year and 0.62 harvests loss for a total average yearly production of 306 packs/acre. These results may reflect the application of insufficient amounts of fertilizers. Of the 5,545 acres used for hay production, 4,739 acres are privately owned, and 806 acres are publicly owned (Table 2).

6.2 Rice Seed Production

Rice seed production is the fourth most common (by acreage) agricultural use in the study area (Figure 11). Rice Tec, Inc is the only company producing rice seed in the study area at this moment. Rice Tec, Inc owns 212 acres of land in the Western portion of El Anegado area where all of their infrastructure is located and are renting 1,075 acres for rice seed production for a total of 1,288 acres dedicated. Almost all of Rice Tec seed production takes place West of El Anegado (1,137 acres) with some production in the Lagoon area (151 acres). The study area is producing a total of 3,487 tons of rice seed annually. The lagoon area is producing an average of 10 cwt of seeds per acre for a total of 75 tons produced annually, and the West of El Anegado area is producing an average of 60 cwt of seeds per acre for a total annual production of 3,412 tons (Figure 12). In the study area, 3,786 cwt of fertilizer (15-5-10) are being applied for rice seed production annually, 111 cwt in the Lagoon area and 3,675 cwt for the West of El Anegado area. Pesticides used for rice seed production include: Propanil (52 cwt/year), Facet (7.5 g/year), Basagran (322 g/year), and Asana XL (60g/year). Gross incomes estimates generated by rice seed production cannot be calculated at the moment because Rice Tec, Inc. does not have that information available in Puerto Rico.

6.3 Cattle Meat Production

Cattle for meat production is the second most common agricultural activity in the study area (Figure 13.). A total of 4,127 acres of the study area are dedicated for this practice. At the moment of the study a total of approximately 2,359 animals are present with an estimate of 1,271 animals produced annually for a total of 548,682 selling pounds produced annually. The term *selling pounds* means that 38% of the total weight of the animal has been subtracted from the actual weight of each animal because this portion represents bones, skin and other parts of the animal not used for meat consumption for which the farmer is not paid at the time of sale.

Farmers are losing approximately 37,696 selling pounds of meat each year mostly due to death of animals. The average selling weight of animals for the study area is 451 pounds for a total gross income of $947,431 for the study area. Most of cattle for meat production is taking place in the hill sides in the South of the Lagoon Area followed by the North of the Lagoon Area, the Anegado Area, the West of the Anegado Area and the Lagoon Area. Cattle meat production increases in a west to east pattern, the opposite of forage production, as you get closer to the Lagoon area (Figure 14). The South of the Lagoon Area dedicates 728 acres for cattle meat production, has a total of 240 animals, and produces a total of 175 animals annually with an average of 469 selling pounds per animal, generating approximately $139,190 of gross income. The North of the Lagoon area dedicates a total of 718 acres with a total of 595 animals, producing a total of 365 animals a year with an average selling weight of 462 pounds per animal—generating an estimate annual gross income of $289.811. The Lagoon area dedicates a total of 641 acres with 169 animals yielding 55 animals per year with an average of 494 selling pounds per animal—generating an estimate annual gross income of $40,000. El Anegado area dedicates 1,413 acres with a total of 1,086 animals—producing 462 animals per year with an average weight of 445 selling pounds per animal for an estimate annual gross income of $353,476. The West of the Anegado area dedicates 627 acres with 269 animals—producing 214 animals per year with an

average weight per animal of 399 selling pounds and generating an approximate annual gross income of $124,936. Of the 641 acres dedicated to cattle meat production in the Lagoon Area, 521 acres (81.3%) are affected by drainage problems. In the El Anegado Area, 1,255 acres (88.8%) of the 1,413 acres dedicated are affected by drainage problems; and for the West of the Anegado Area, of the 627 acres dedicated, 302 acres (48.2%) are affected by drainage problems (Figure 15 and Table 3).

Of the total area dedicated to cattle meat production, 2,851 acres are on private land and 1,276 acres are on public land. Of the total area dedicated for cattle meat production, 1,443 acres of the parcels are in contact with the main drainage channel and are producing 111,682 selling pounds of meat with an average selling weight of 453 pounds for a total of 548 animals present producing 250 animals per year. A total of 2,022 acres are not in contact with the main channel, but have lateral drainage channels producing 386,080 selling pounds with a total of 1,579 animals producing 844 animals a year. 662 acres are not in contact or have any drainage channels and are producing 83,258 selling pounds of meat with a total of 232 animals present producing 177 animals per year.

6.4 Cattle/Dairy Milk Production

Cattle/Dairy milk production is the third most popular agricultural use by land area in the study area (Figure 16). Cattle milk production is concentrated in the El Anegado (114 acres) and West of El Anegado Areas (132 acres). The area dedicated for milk production is the area used for the milk parlors and areas dedicated for grazing milk cattle, and this does not include areas that produce hay for milk cattle. The area producing hay for milk cattle is included in forage production estimates of this study. There are a total of four dairies present in the area of study occupying an area of approximate 246 acres. Dairies are producing 1,976,475 liters of milk on a yearly basis. A total of 670 animals are present for milk production in the area of study. The average price that farmers are selling milk is $0.81 per liter, and the average liters produced per animal is 5,475 per year. All of the area dedicated for milk production is private land.

6.5 Horse Production

Horse Production is not as common an agricultural use as the others described in this study. In the study area, there are a total of 123 acres dedicated for horse production, and it generates approximately $81,000 of gross income per year. Horse production is limited to the El Anegado and West of El Anegado Areas (Figure 17).

6.6 Not in Actual Farming Use

A number of parcels were identified that currently are not in farming production. Most of these areas are fallow and some have re-grown both native and non-native vegetation (mostly shrubs and small trees). Of the total 14,932 acres surveyed, there are 3,603 acres that are not in actual agricultural use at the moment of the study. Of these, 1,969 acres are described as public land, 1,607 acres are described as private land, and 27 acres are unknown in terms of ownership. Of the total area not in actual farm use, 1,586 acres correspond to the Lagoon Area, 126 acres to the South of the Lagoon, 634 to the North of the Lagoon Area, 1,075 acres to El Anegado Area, and 183 acres correspond to the West of El Anegado area (Figure 18).

6.8 Ownership

Most of the total area surveyed is privately owned (Figure19). A total of 10,855 acres are privately owned, a total of 4,050 acres are publicly owned, and 27 acres were described as unknown. Most of the public land in the study area is administrated by the Puerto Rico Land Authority (2,870 acres) and the Puerto Rico Land Administration (1,145 acres). Other minor public land administrators in the area of study are: Puerto Rico Electrical Authority (24 acres), Municipality of Guánica (7 acres), and Puerto Rico Department of Housing (3 acres).

6.9 Fertilizers and Pesticide Usage

Fertilizer and pesticide usage in the study area is relatively low as our survey shows only 49 of 187 parcels apply fertilizer and generally at relatively low application rates (Figure 20). Fertilizer and pesticide usage is most commonly associated with rice production (100% of farms applying) and to a much smaller degree hay production. Summaries of application rates and totals can be found earlier in the document in the write up on Rice and Forage/Hay production.

6.10 Conservation Practices

Based on our inventory, approximately 28 of 179 parcels employ conservation practices; this indicates the potential for additional conservation measures that could be employed on farms, but also the nature of some of the farm operations, particularly the lack of fertilizer and the predominance of hay operations and grazing operations in the Lajas Valley. Parcels that are applying conservation practices are in actual contracts with Natural Resources Conservation Service (NRCS) (Figure 21).

6.11 Irrigation

Irrigation water used in the Lajas Valley study area is almost extensively from the Lajas Valley Irrigation System, part of the SW Puerto Rico Project which developed reservoirs in the high mountain areas to bring fresh water to the arid southwest Puerto Rico. There are five primary types of irrigation being practiced in the valley, these include furrow, traveler, drip, pivot and sprinkler irrigation systems. Fifty-three small reservoirs were inventoried in the study area with a surface area of roughly 71 acres. Most of the farms employ or have access to some form of irrigation.

7. Key Agricultural Challenges Present in the Study Area

7.1 Drainage Problems

Drainage problems are another long-term concern in the Lajas Valley. Drainage problems are define as acres of individuals parcels that are affected by waterlogging problems during the rainy season, where it is difficult, if not impossible, to do agriculture. The relief/slope of the land is very slight, and drainage from the valley is slow under natural and even modified conditions where a system of drainage channels has been put into place to provide for more rapid drainage of the valley. This system is in various stages of maintenance with many channels in the middle and lower portion of the valley not receiving frequent or effective management in the form of maintenance. Most of the channels are filling in with sediment and vegetation and need to be dredged properly. In the case of drainage problems, we have identified parcels that currently contain drainage issues so that it will help us project impacts of potentially restoring Guanica lagoon. These drainage problems are summarized in Figures 22 and 23.

7.2 Soil Salinity Problems

Salinity issues in the Lajas Valley have been an issue since the land originally began being used for agriculture—there are areas that are prone to high salinity where groundwater naturally comes to the surface, and there are areas and soils that were likely damaged from past agricultural practices which may have included irrigation with saline water and also perhaps due to the replenishment of the groundwater with saline water from water desiccation from upland dry forest. Concerns about increasing soil salinity (due to a potentially higher groundwater table after restoration of Guanica lagoon) have been a chief concern of members of the agricultural community. Therefore, a critical piece of information to collect was to identify the specific farms and parcels which contained existing soil and water salinity issues. The salinity problems in the study area are summarized in Figures 24 and 25.

7.3 Water Uprising Problems

Water naturally comes to the surface in many areas if the Valley and this occurrence is more concentrated in the south and north sides of the Valley. The water is either fresh or saline in nature. Knowing the areas where water naturally comes to the surface was important for us to understand and summarize existing conditions before future alteration. The water uprising areas are summarized in Figures 26 and 27.

7.4 Fire Problems

Fires can be a common occurrence, particularly in the dry season in the southern portion of Puerto Rico, since there is such a dry climate already and often months go by with very little rainfall in the valley. We have summarized the farms which have reported problems with fires in the past. The locations where fire can be a problem seasonally are summarized in Figure 28.

8. Summary and Conclusions

8.1 Summary

This study summarizes 14,932 acres of the Lajas Valley Agricultural Reserve including, all the parcels within the 5 meter contour plus areas of adjacent contiguous agricultural land (Figure 5) for a total of 179 parcels. It began in the spring of 2011 with the preparation of a survey instrument and database and was completed in the fall of 2011; when all the farm interviews were completed. Since that time, we have analyzed the data, and received assistance from our GIS specialist Idelfonso Ruiz Valentín, and finalized our agricultural inventory database. This report represents a summary of the collected information and was undertaken to better understand the existing impacts of salinity and hydrology on the agricultural lands in the Valley and to inventory the existing uses and economic activity. This effort will enable us to more precisely project the specific impacts that may occur with the restoration of a permanently inundated Guánica Lagoon in a portion of the historic footprint. This information is actively being combined with results of the hydrology study and the salinity study to produce an integrated report.

8.2 Conclusions

The Lajas Valley study area is an important agricultural area in Puerto Rico-- producing over $8 million dollars in annual agricultural production, critical in its contribution to overall food security and to agricultural production in Puerto Rico.

This productive agricultural land has the potential to provide additional output with the use of parcels that are currently un-utilized—at a minimum this figure is estimated at over 2000 acres, though some improvement/reclamation of soils impacted by past practices may be necessary (we will examine this as part of the soil salinity study and survey) . Inadequate drainage is an existing issue demonstrated by the reduced yields and harvests in the Lajas Valley which limits the total output and production of the

area—though it is likely only a portion of this output can be recovered with improved drainage because of the natural hydrology of the area.

Much of the area which was historically occupied by Guánica Lagoon has limited production and experiences frequent flooding, which constrains its agricultural production.

9. References

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TABLES

Table 1. Soil types in the area of study

Map Unit	Map Unit Name	%
GnA	Guánica clay, 0 to 1 percent slopes	24.77
Aka	Aguirre caly, occasionally ponded	23.63
FrA	Fraternidad clay, 0 to 2 slopes	12.93
CeA	Cartagena clay, 0 to 2 percent slopes	7.74
FeA	Fe clay, 0 to 2 slopes	6.46
CuF	Costa-Pitahaya complex, 20 to 60 percent slopes	3.76
AgD	Aguilita silty clay loam	2.08
DsD	Descalabrado clay, 12 to 20 percent slopes	1.53
FrB	Fraternidad clay, 2 to 5 slopes	1.52
ScA	San Antón clay loam, 0 to 2 percent slopes	1.45
AtD	Altamira gravelly clay 2 to 20 percent slopes	1.33
PzC	Pozo Blanco clay, 5 to 12 percent slopes	1.23
DsF	Descalabrado clay, 20 to 60 percent slopes	1.21
SgF	San German-Duey complex, 20 to 60 percent slopes	1.16
VaA	Vallas silty clay, 0 to 2 percent slopes, occacionally flooded	1.08
Ua	Urban land	1.02
JaB	Jacana clay, 0 to 5 percent slopes	0.94
CtA	Cortada silty clay loam, 0 to 2 percent slopes, occasionally flooded	0.87
DsC	Descalabrado clay, 2 to 12 percent slopes	0.63
SgD	San German-Duey complex, 5 to 20 percent slopes	0.59
MnC	Melones clay, 2 to 12 percent slopes	0.46
PzB	Pozo Blanco clay, 0 to 5 percent slopes	0.46
EpD	El Pspayo gravelly clay loam, 12 to 20 percent slopes	0.41
EpF	El Pspayo gravelly clay loam, 20 to 60 percent slopes	0.35
BmD	Bermeja-Cerro Mariquita complex, 12 to 20 percent slipes	0.34
PgB	Parguera clay, 2 to 5 percent slopes	0.3
SiA	Santa Isabel clay, 2 to 2 percent slopes	0.27
PzD	Pozo Blanco clay, 12 to 20 percent slopes	0.17
PgA	Parguera clay, 0 to 2 percent slopes	0.16
MoB	Montalva clay, 0 to 5 percent slopes	0.15
PsF	Pitahaya-limestoneoutcrop-Seboruco complex, 40 to 60 percent slopes	0.15
LdA	La Luna silty clay loam, 0 to 2 percent slopes, occasionally flooded	0.12
GyC	Guayacán clay, 5 to 12 percent slopes	0.11
GyB	Guayacán clay, 0 to 5 percent slopes	0.1
JaC	Jacana clay, 5 to 12 percent slopes	0.1
MoC	Montalva clay, 5 to 12 percent slopes	0.1
EpC	El Pspayo gravelly clay loam, 2 to 12 percent slopes	0.08
CuD	Costa-Pitahaya complex, 5 to 20 percent slopes	0.07
W	Water	0.06
BmC	Bermeja-Cerro Mariquita complex, 5 to 12 percent slipes	0.04
PaC	Palmarejo Loam, 2 to 2 percent slopes	0.04
MiD	Mariana gravelly clay loam, 12 to 20 percent slopes	0.02
MnA	Melones clay, 0 to 2 percent slopes	0.02
	Total	**100**

Table 2. Production, yields, harvests, and estimated values based on data collected in the farm inventory

Sub Area	Area Dedicated (acres)	Average Packs produced per acre/ harvest	Harvest Times a year (average)	Harvest times loss a year (average)	Average Annual Yields (packs)	Average Annual Yields (Tons)	Average Annual Loses (Tons)	Estimated Annual Gross Income
El Anegado	2,232	107	2.2	0.83	239	9,530	3,466	$1,905,278
North of El Anegado	106	117	2	1	233	384	192	$76,711
West of El Anegado	2,189	118	2.6	0.5	319	12,541	2,036	2,508,152
Lagoon	166	155	3	1	420	1,198	500	$219,873
North of Lagoon	641	114	2.1	1	235	2,649	1,280	$529,711
South of Lagoon	210	200	2.5	1	500	1,700	735	$294,050
All Lagoon Area	1,017	128	2.2	1	285	5,546	2,516	$1,043,634
Total Area Surveyed	**5,545**	**117**	**2.4**	**0.74**	**282**	**28,000**	**8,209**	**$5,533,776**

Table 3. Cattle meat production summarized data

Sub Area	Area Dedicated (acres)	Actual Amount of Animals	Actual Annual Animal Production	Average Selling weight (pounds) per Animal	Estimated Annual Gross Income	Estimated area affected by Drainage problems (acres)	Estimated area affected by salinity problems (acres)	Estimated area affected by Water uprising problems (acres)
Lagoon	641	169	55	494	$40,014	521	5	0
South of Lagoon	728	240	175	469	$139,194	125	2	0
North of Lagoon	718	595	365	462	$289,811	457	23	7
All Lagoon Area	2,087	1,004	595	473	$469,019	1,102	30	7
El Anegado	1,413	1,086	462	445	$353,476	1,255	54	10
West of El Anegado	627	269	214	399	$124,936	302	1	0
Total Area dedicated	4,127	2,359	1,271	451	$947,431	2,660	85	17

FIGURES

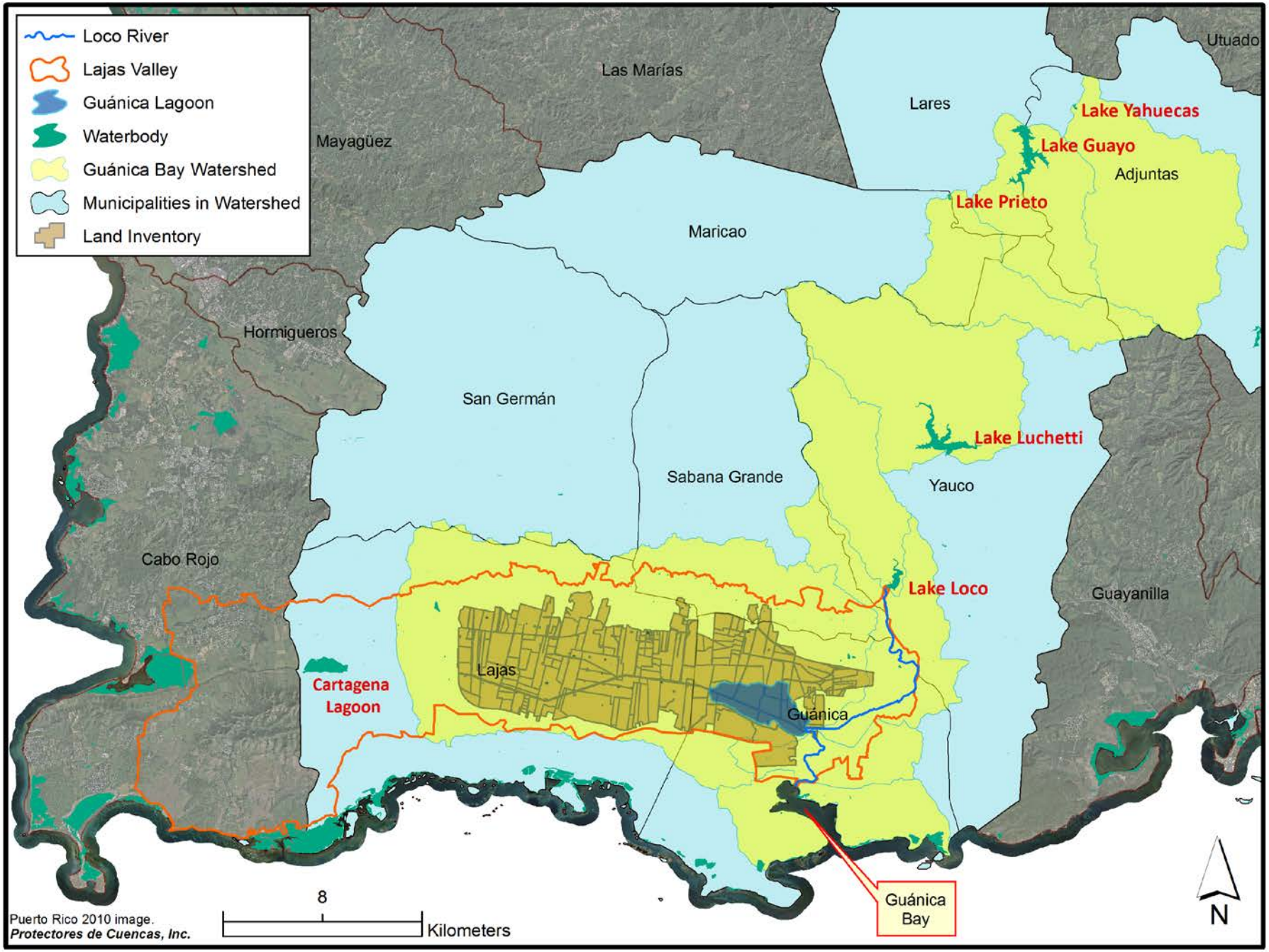


Figure 1. Guánica Bay watershed, Lajas Valley Agricultural Reserve, Municipalities in watershed and the area of study.

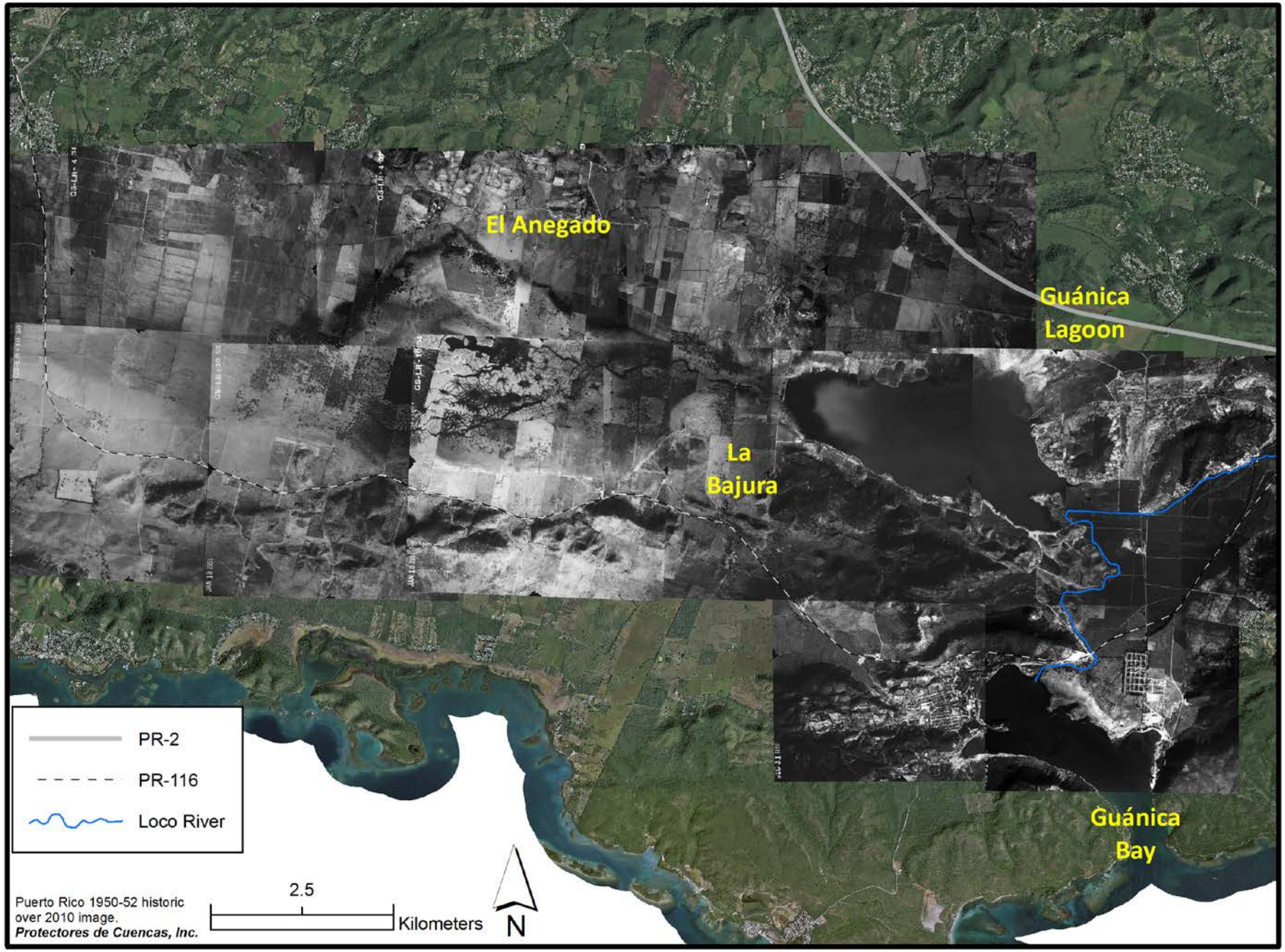


Figure 2. **Historic 1950-1952 georeferenced aerials over a 2010 Puerto Rico aerial image.**

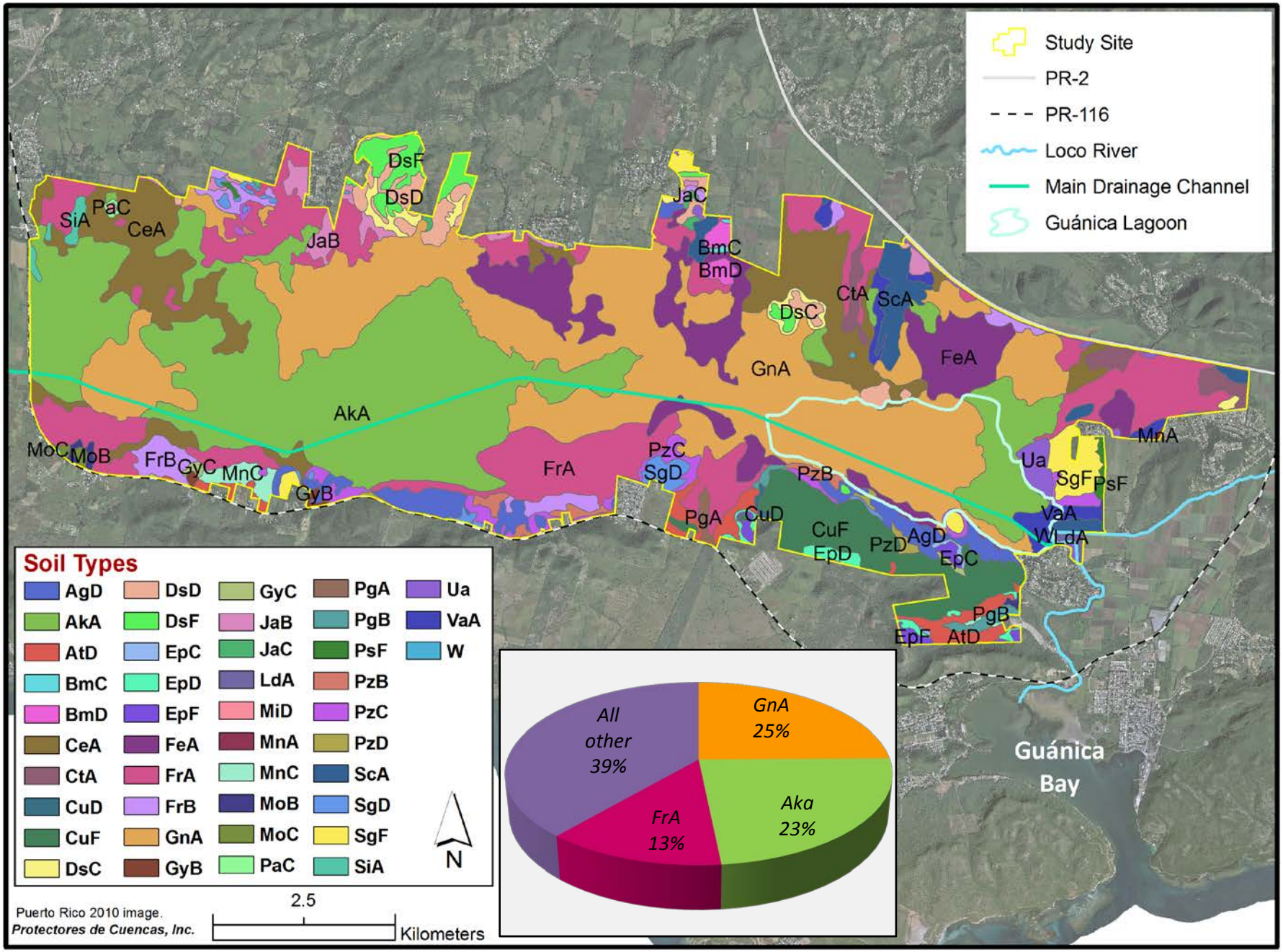


Figure 3. **Soil types present in the study area.**

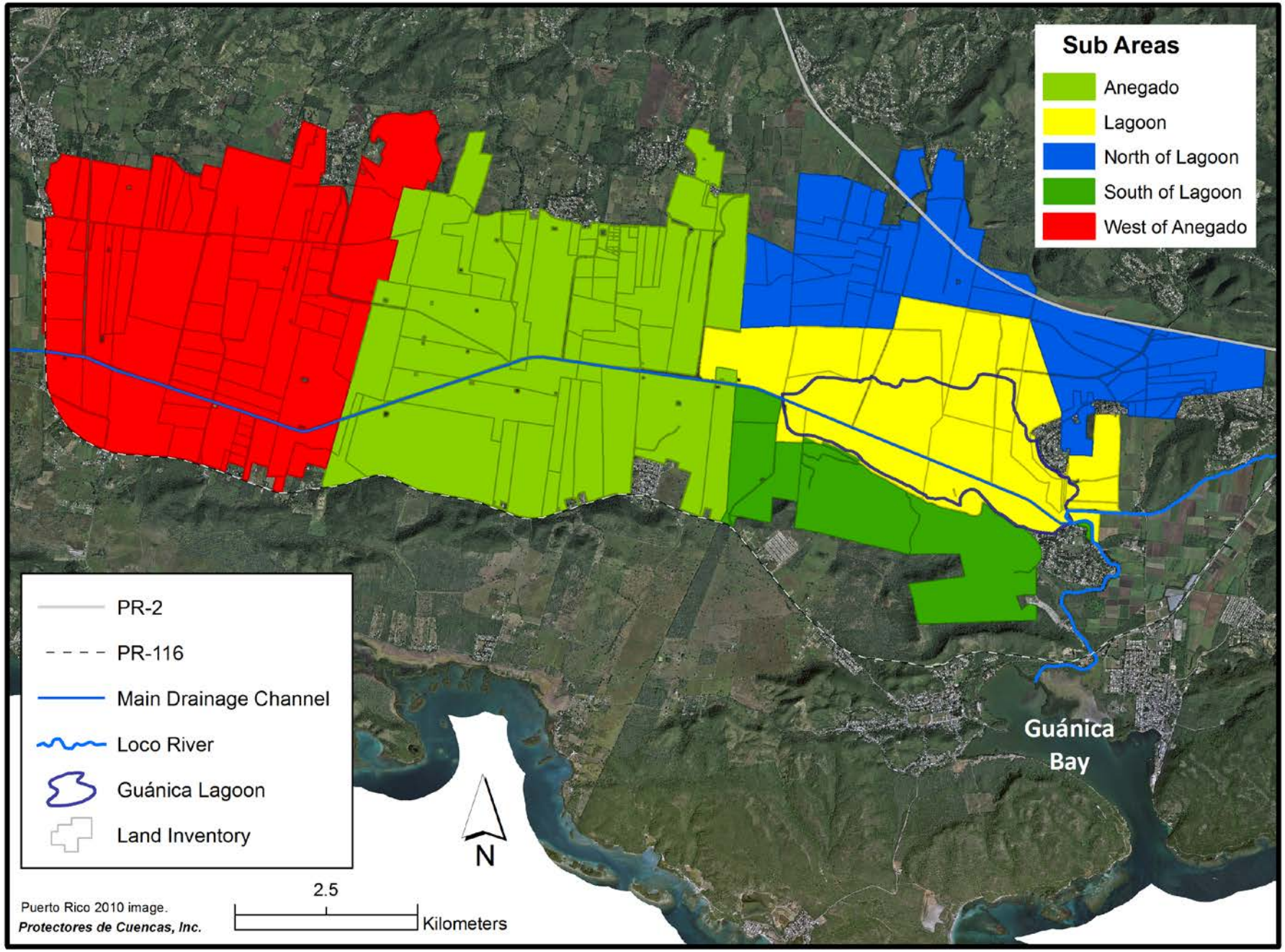


Figure 4. Sub areas in the study site.

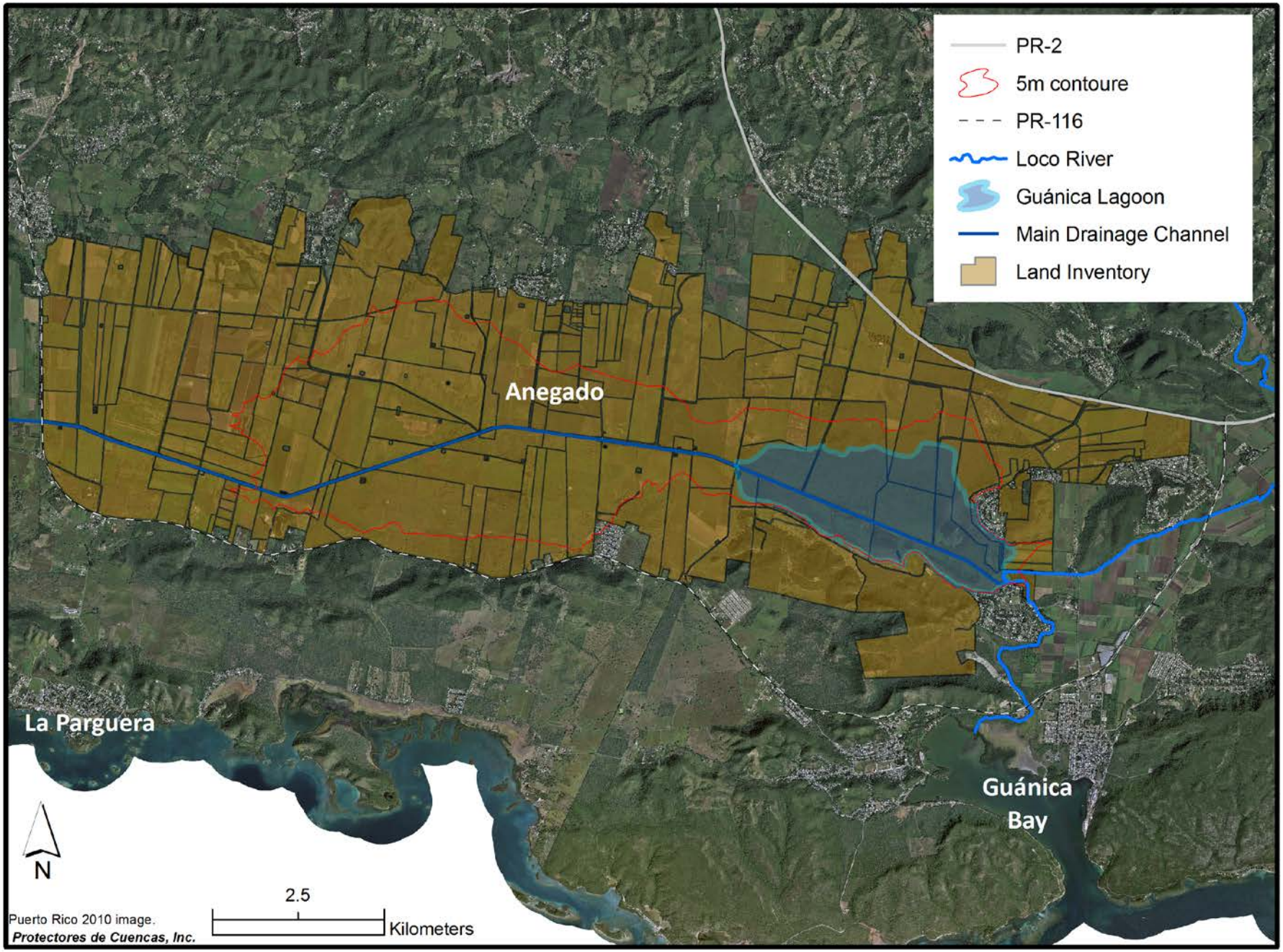


Figure 5. Area that was covered in this study compared to the 5m contour line area.

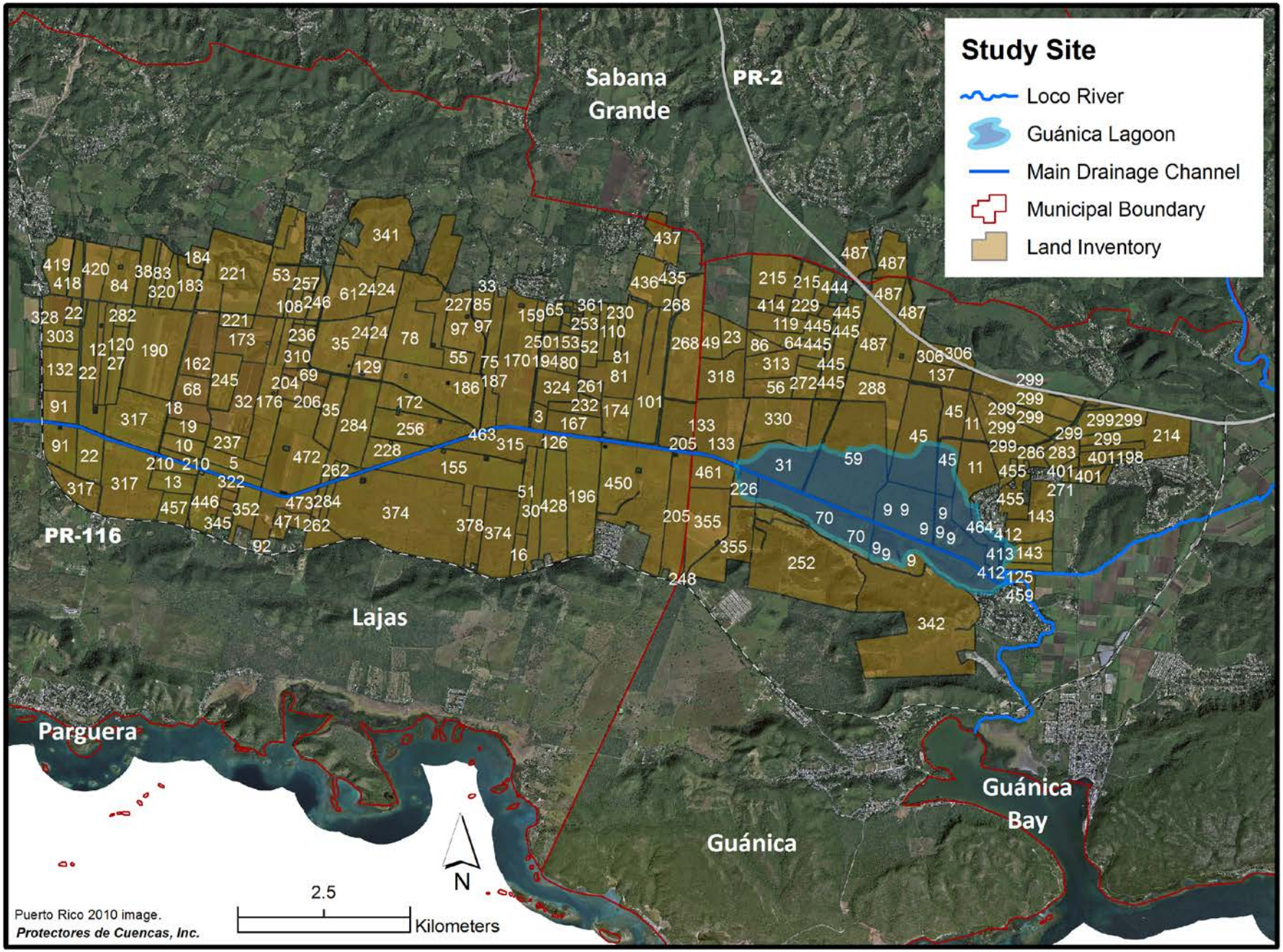


Figure 6. Individual parcel identification.

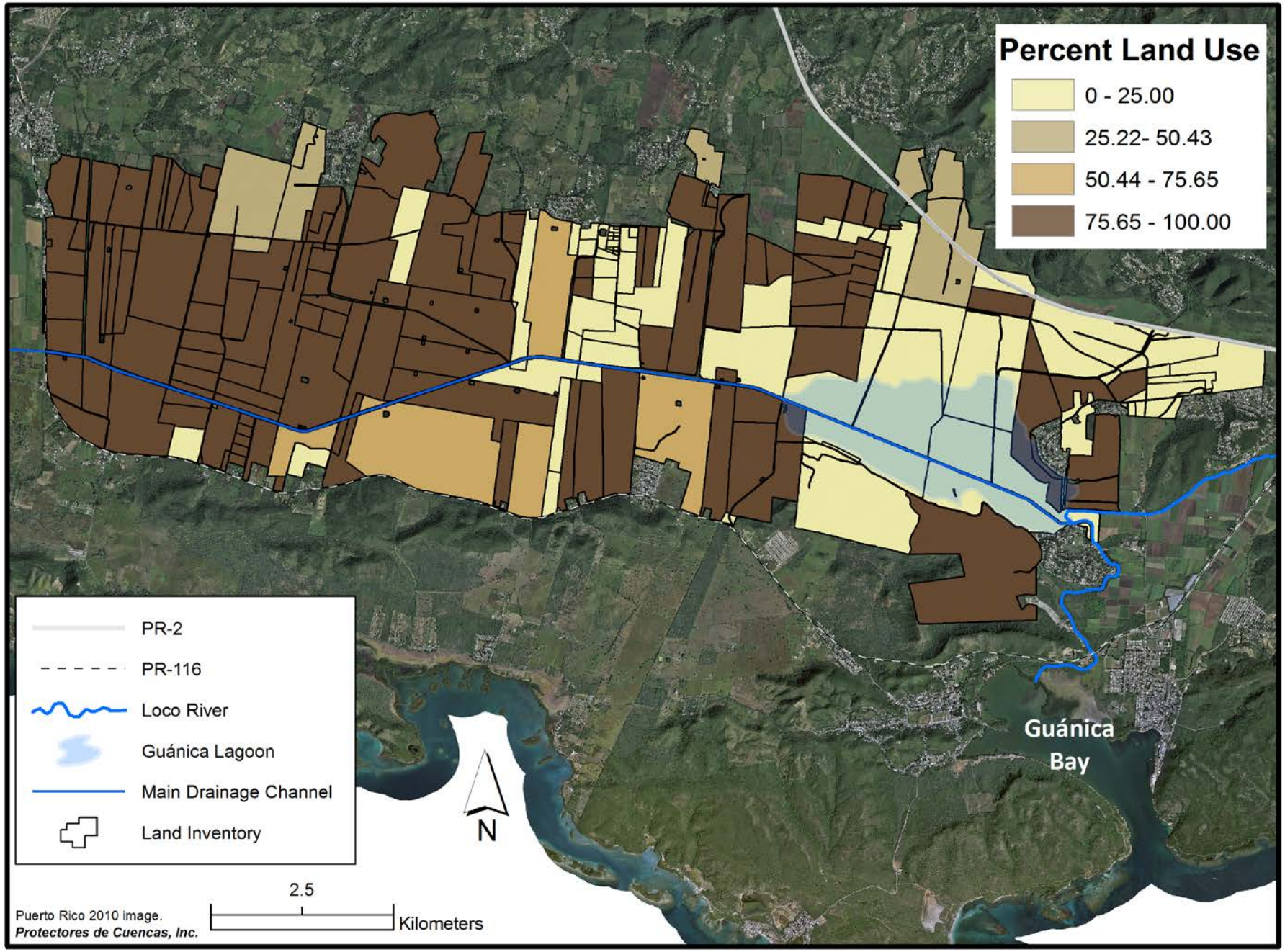


Figure 7. **Percent land use for agriculture in the study area.**

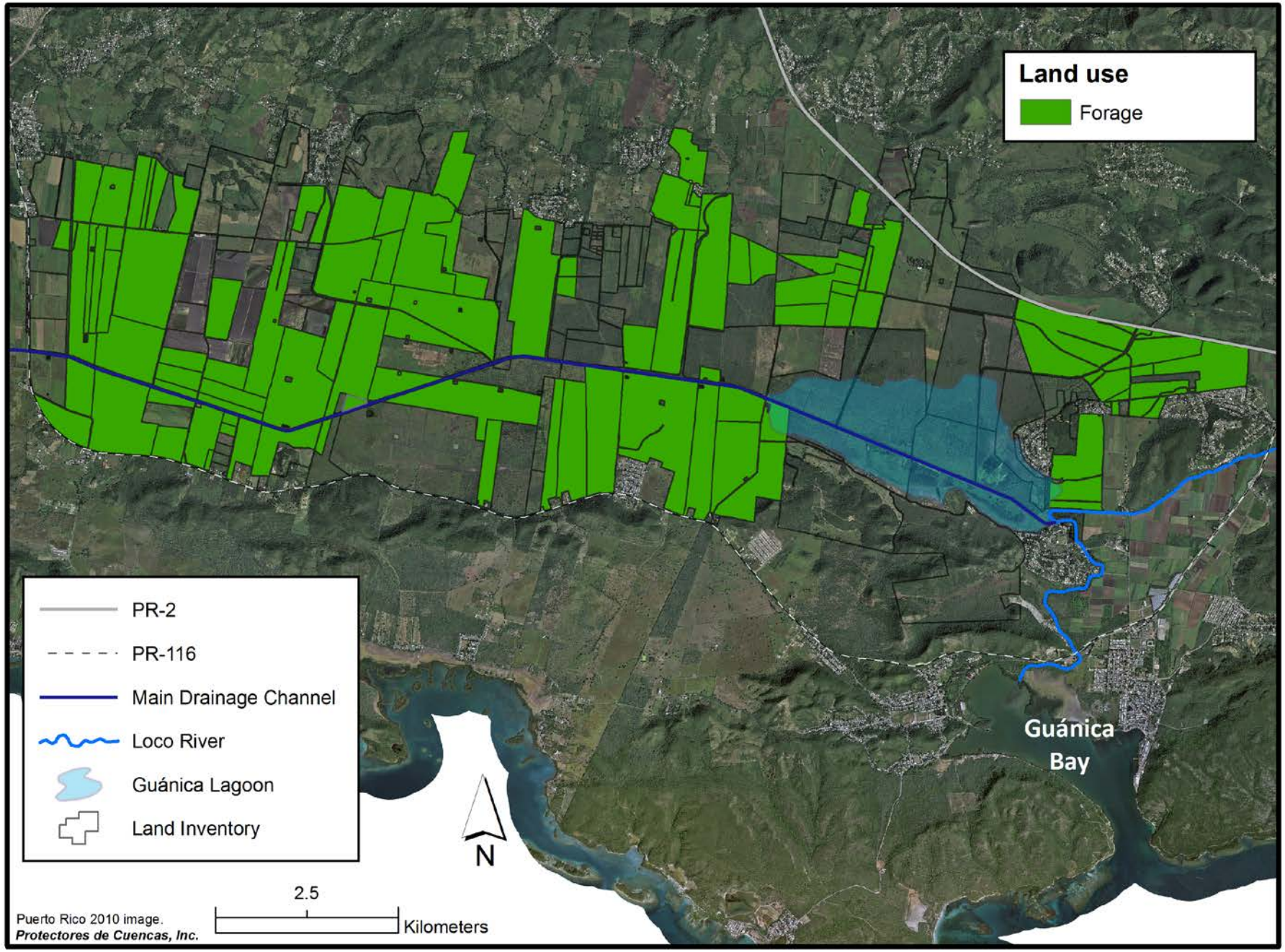


Figure 8. **Parcels that are in forage production.**

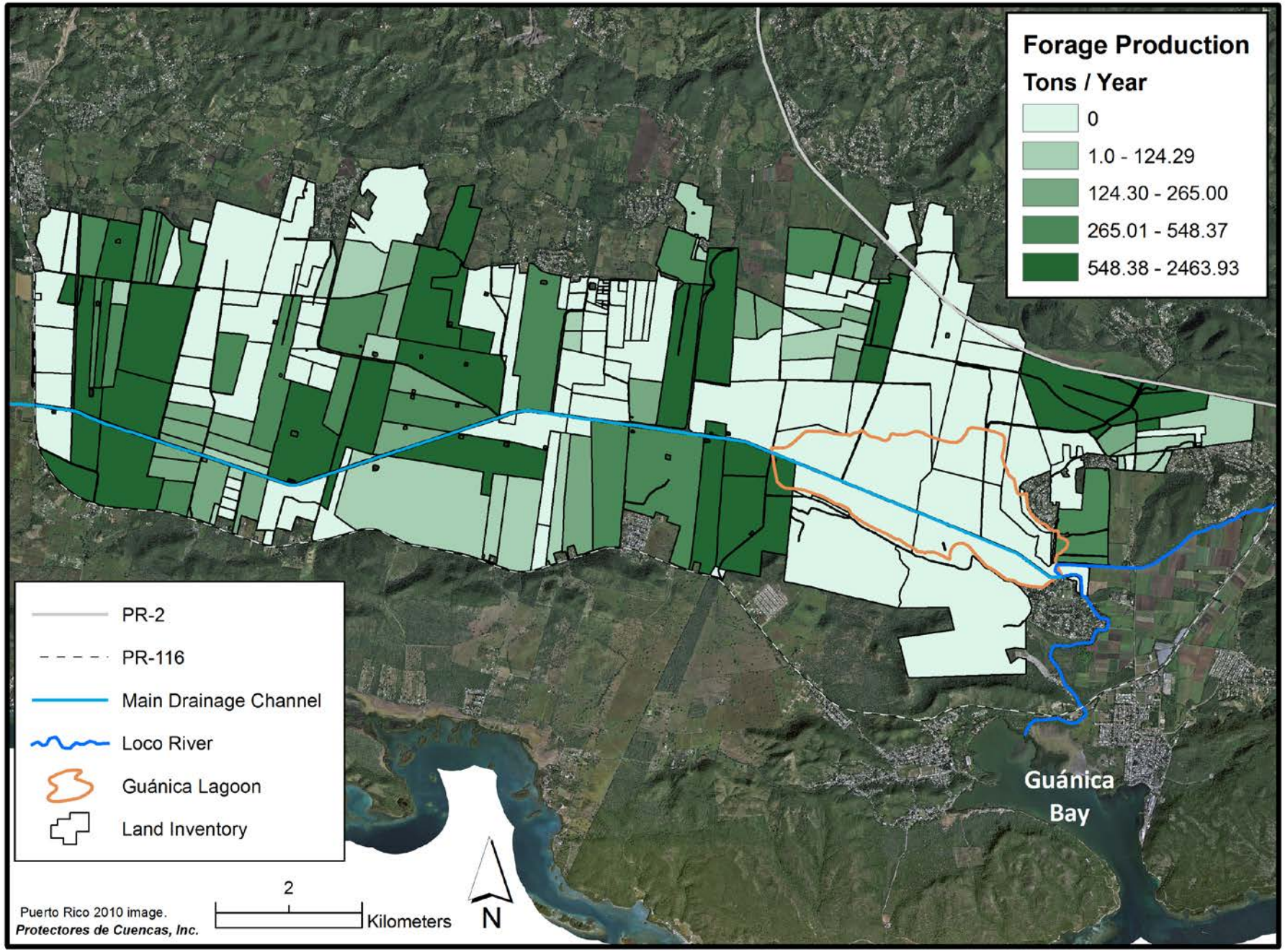
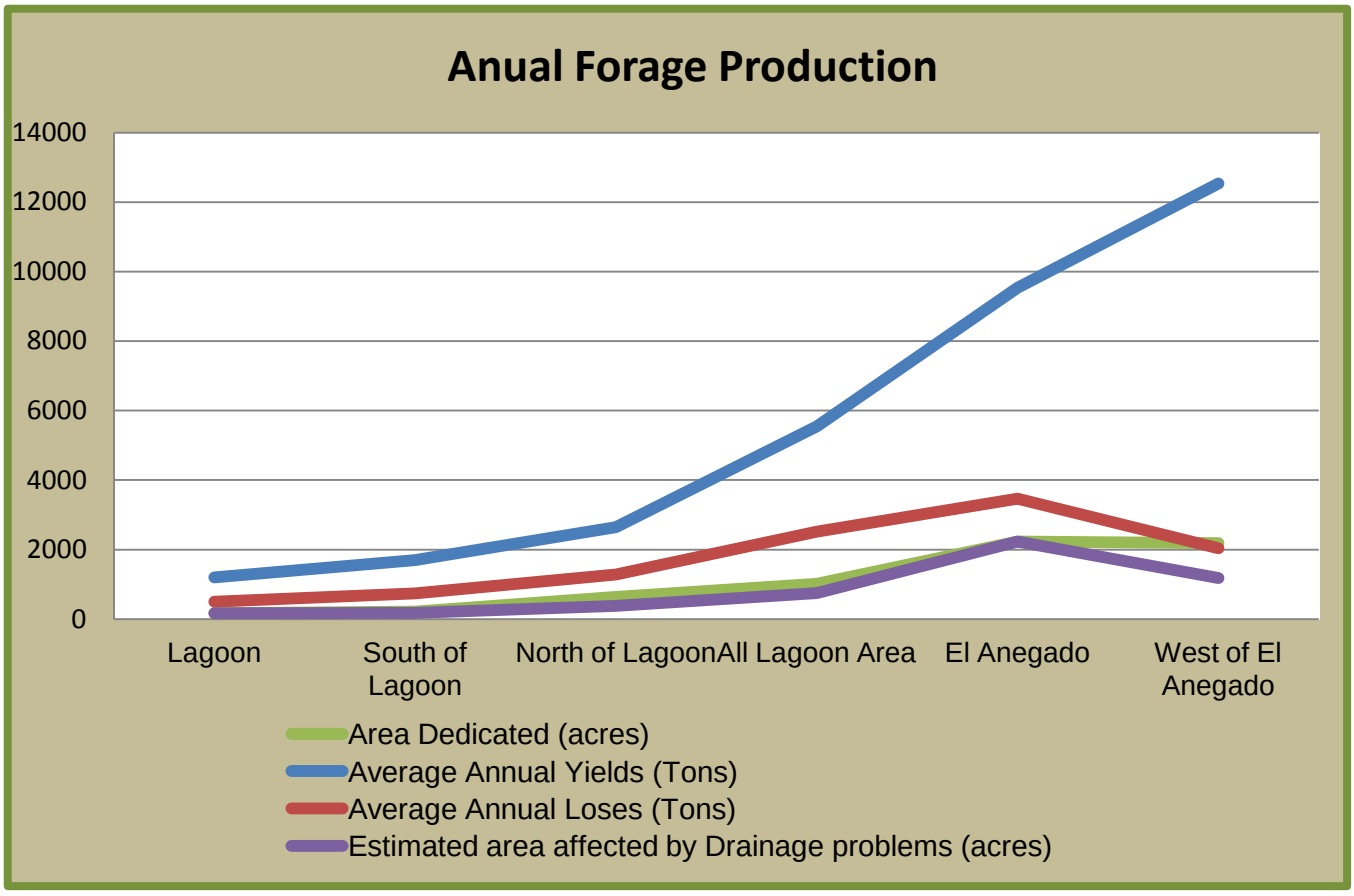


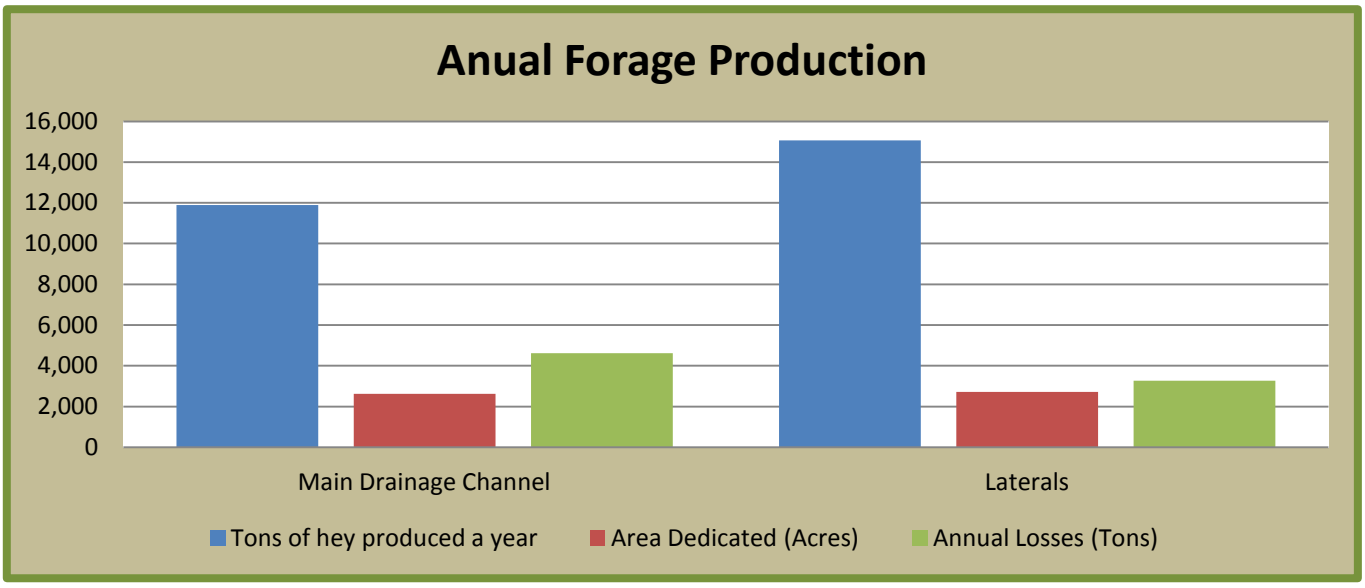
Figure 9. **Gradient of forage production based on tons/year produced per parcel.**

Figure 10. **a.** **Graph describing forage production for the five subareas of the study site.**
b. **Forage production related to the main drainage channel.**

a.



b.



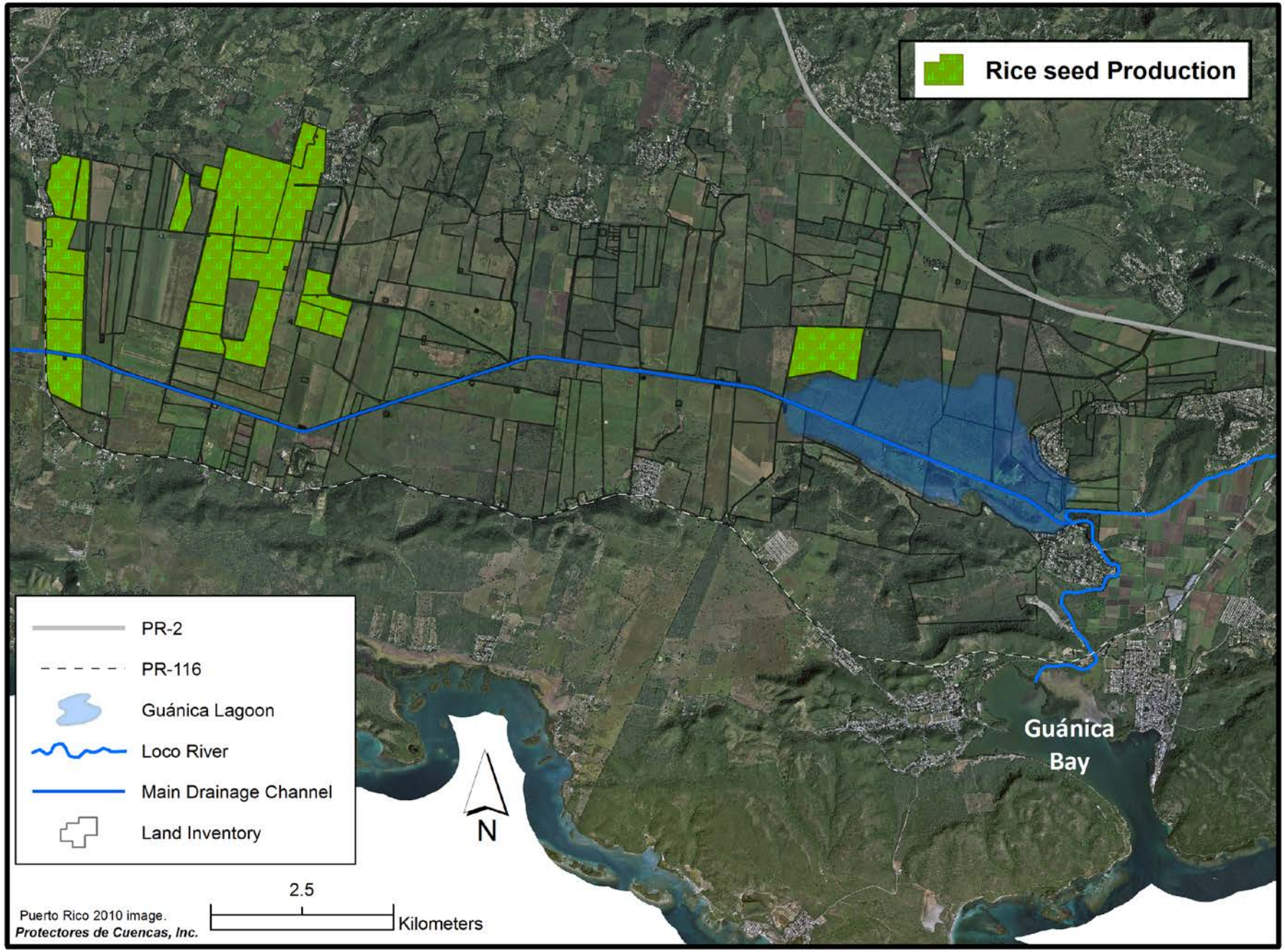


Figure 11. Parcels that are in rice seed production

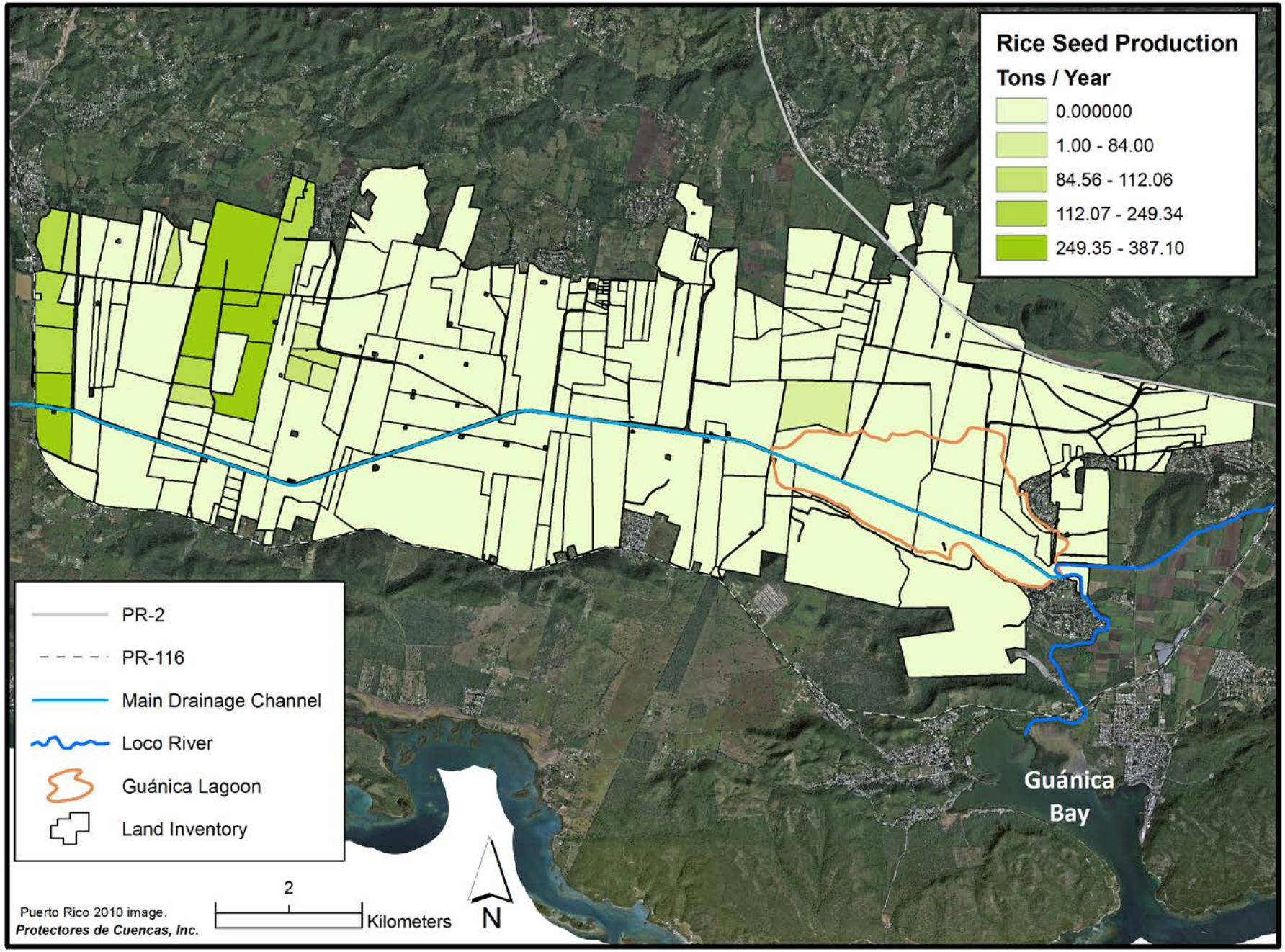


Figure 12. Gradient for rice seed production based on tons/year per individual parcel.

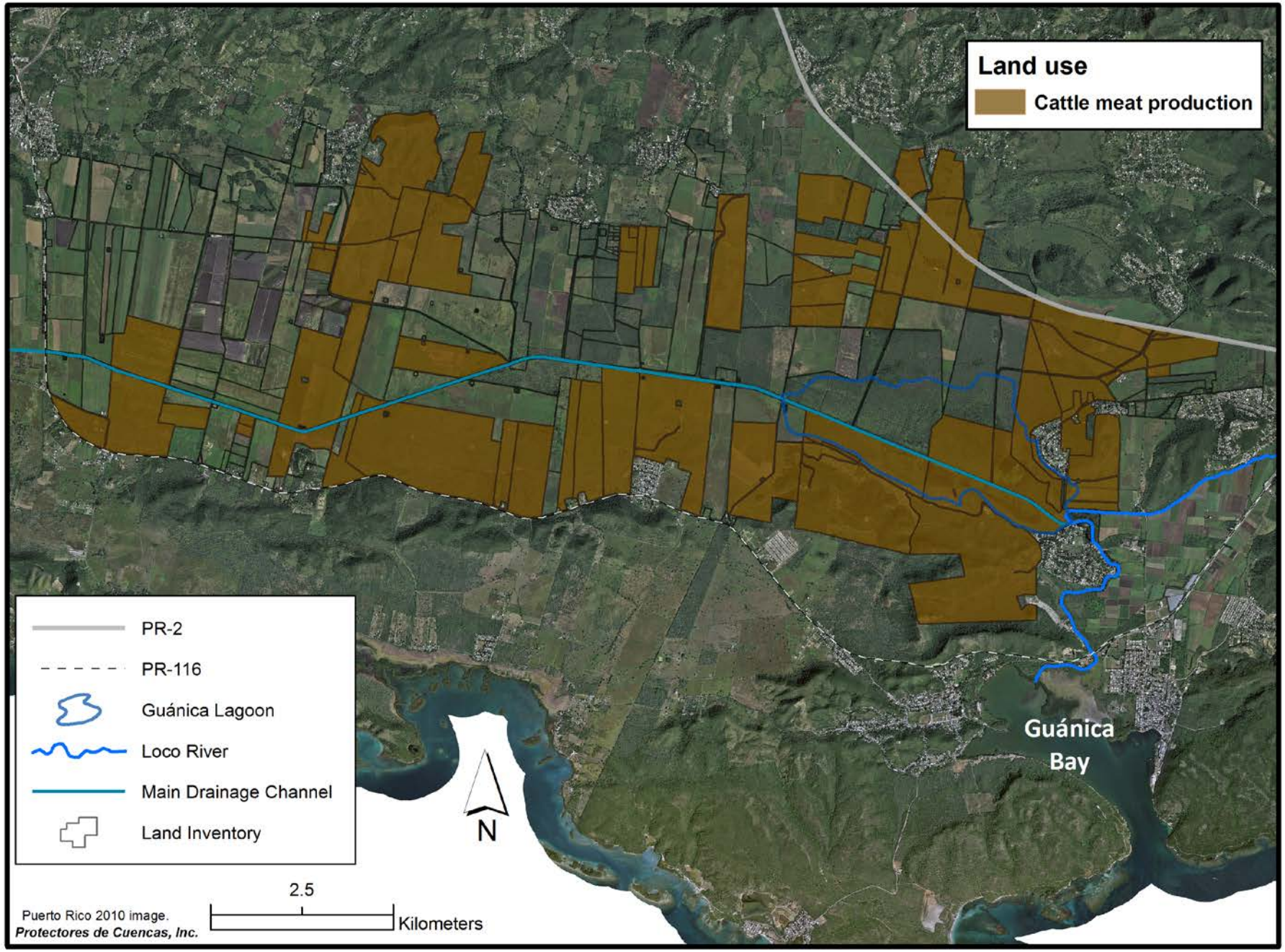


Figure 13. Parcels that are in cattle meat production.

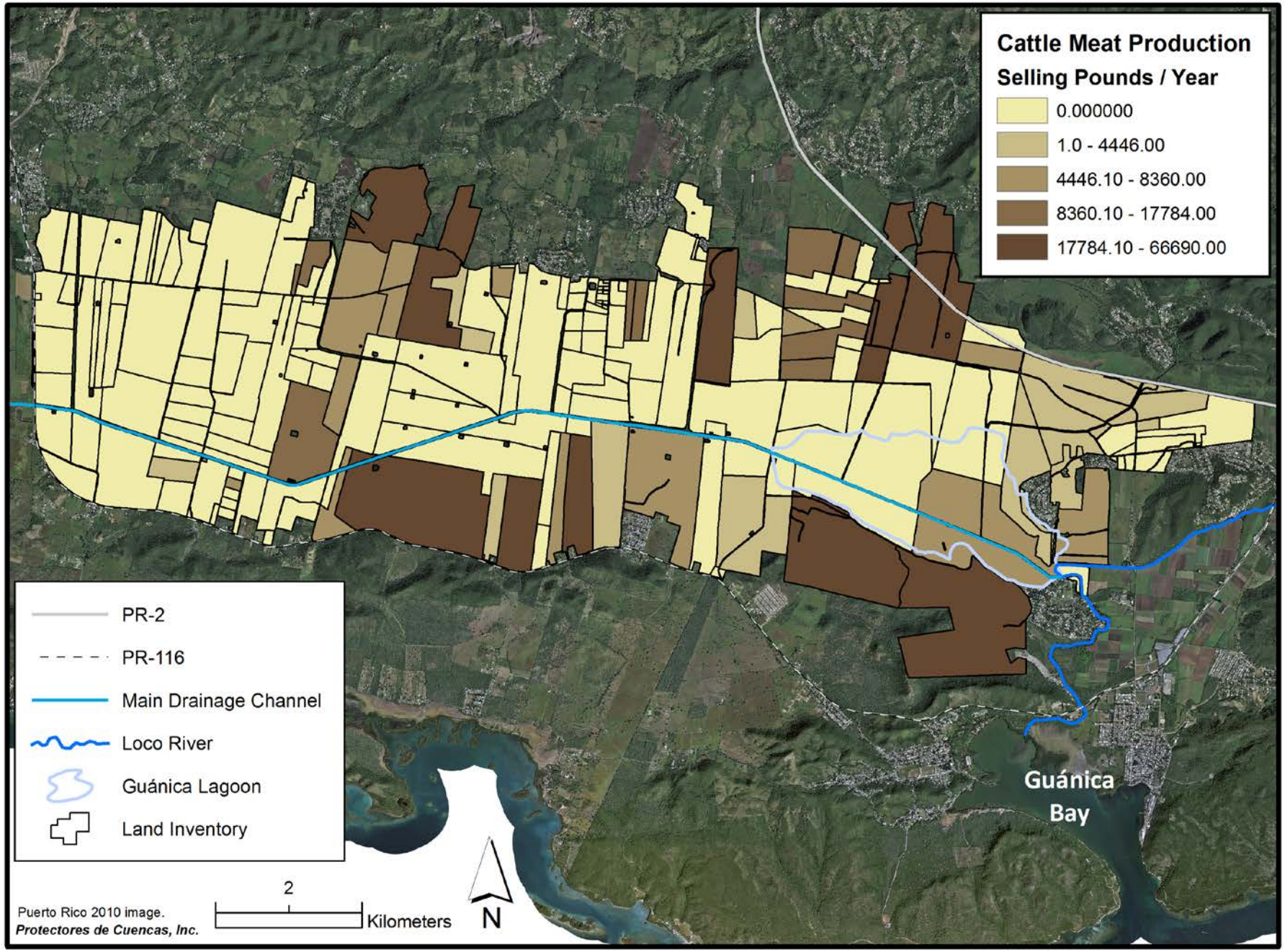


Figure 14. Gradient for cattle meat production based on selling pounds/year per individual parcel.

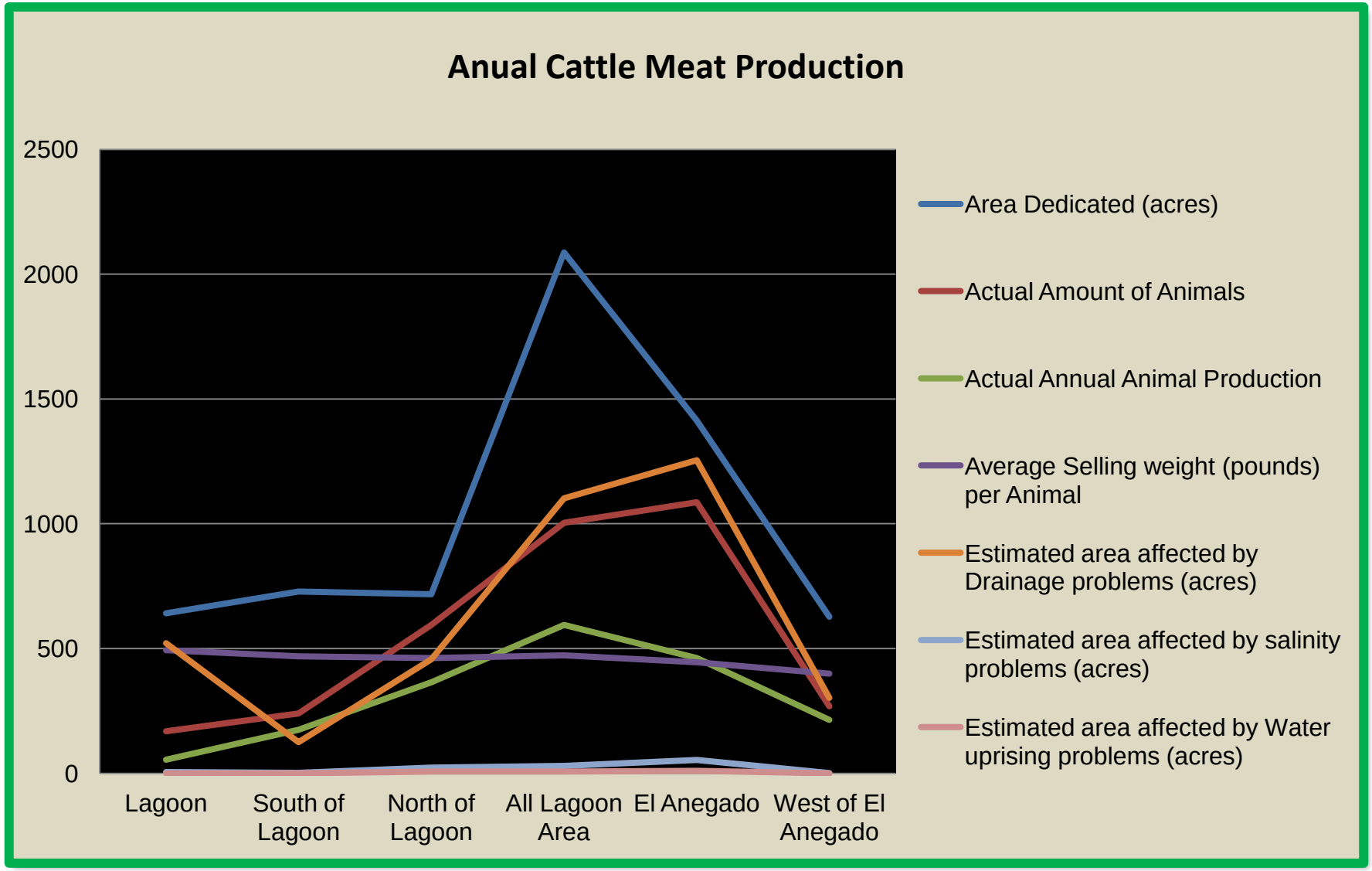


Figure 15. **Graph describing cattle meat production for the five subareas of the study site.**

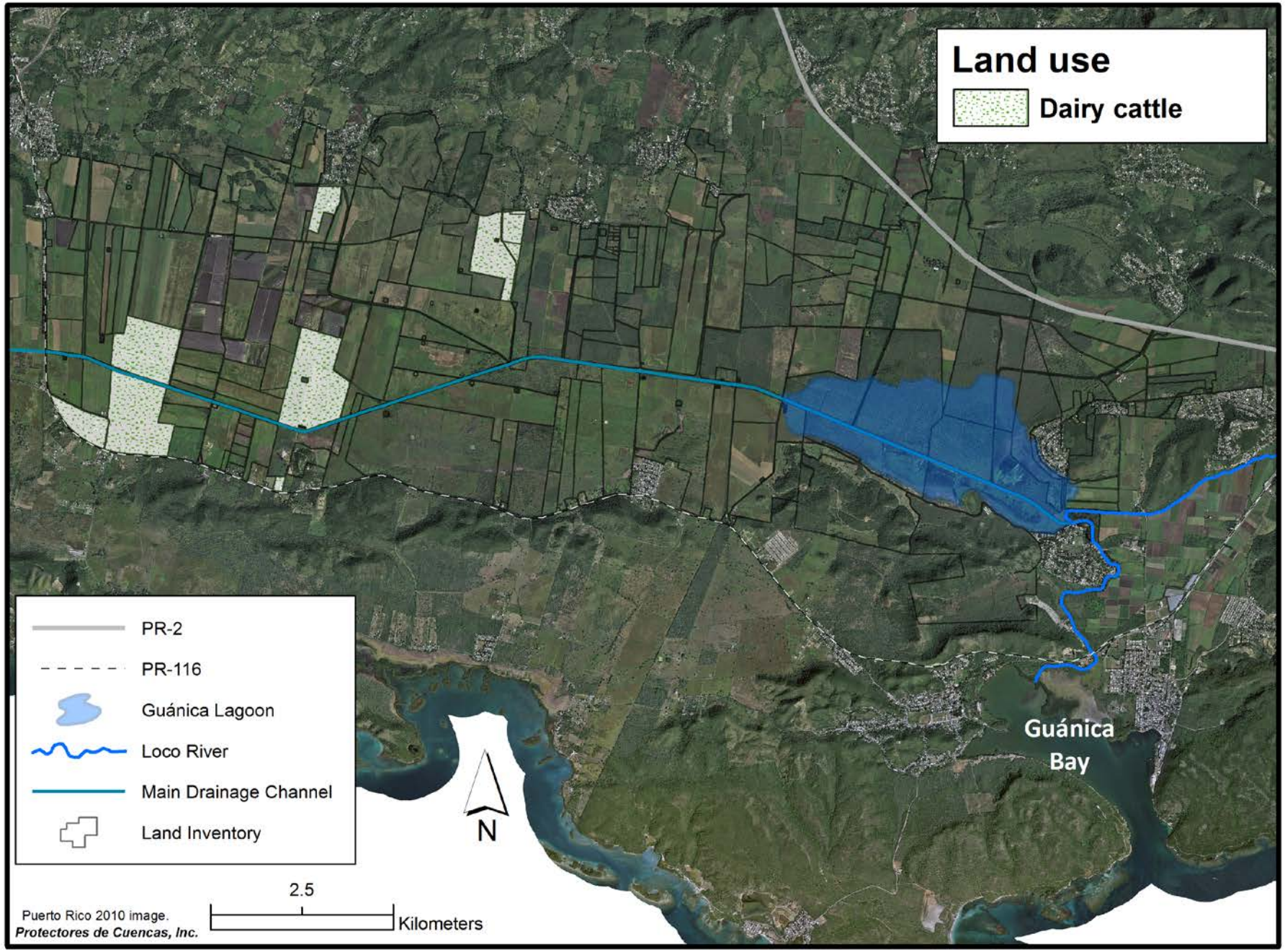


Figure 16. Parcels that are in cattle milk production.

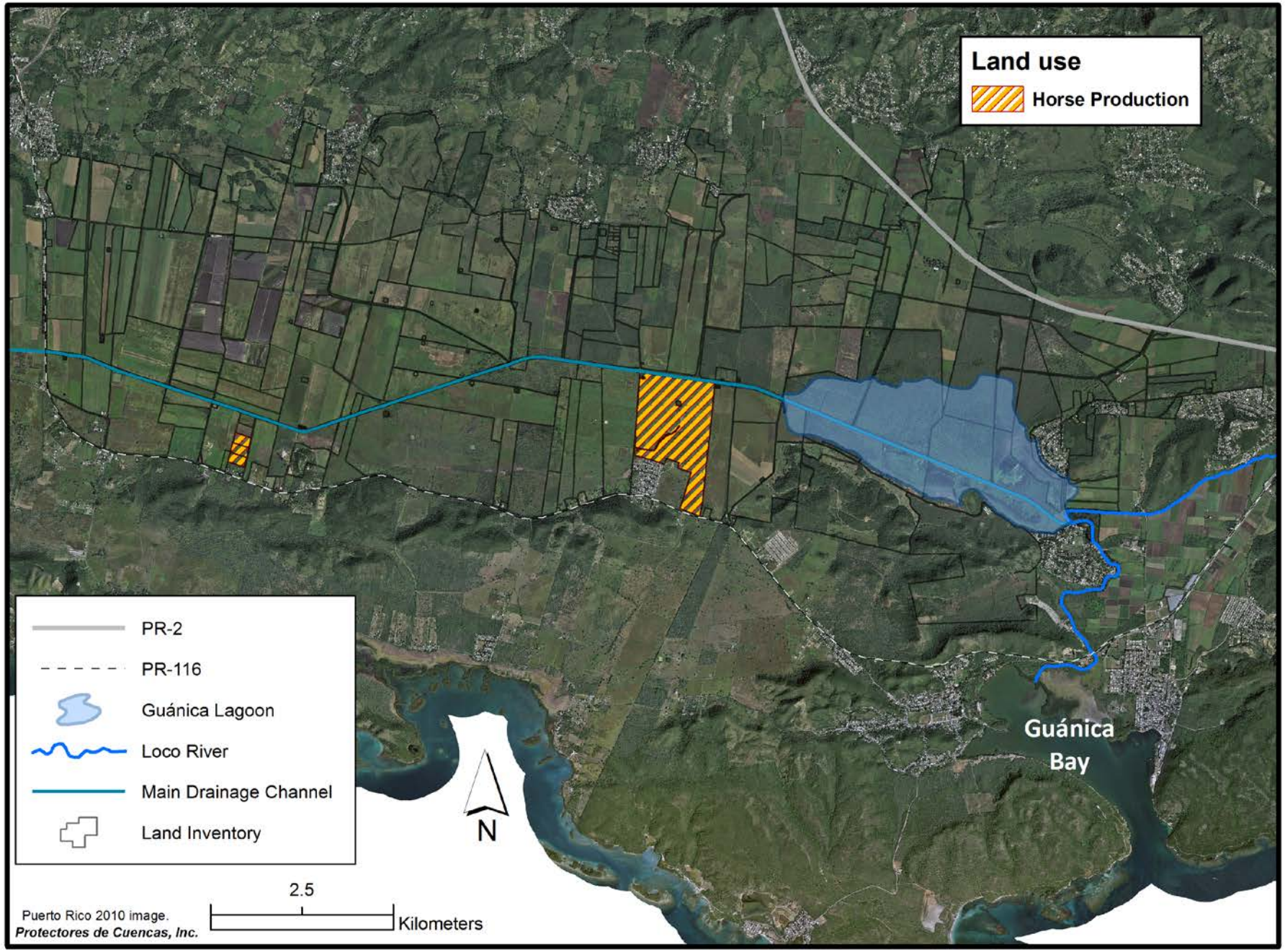


Figure 17. Parcels that are in horse production.

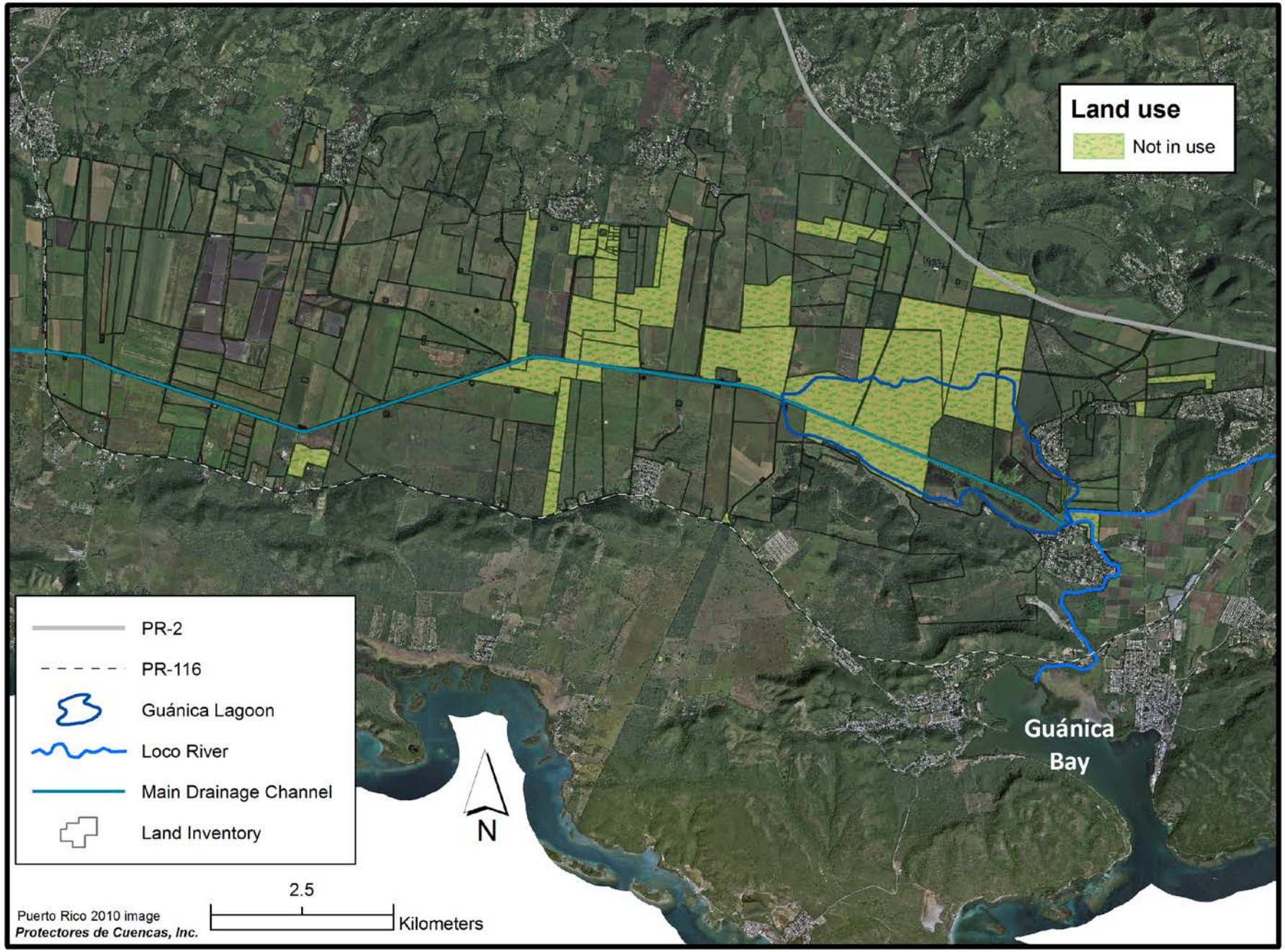


Figure 18. Parcels that are not in actual farm use.

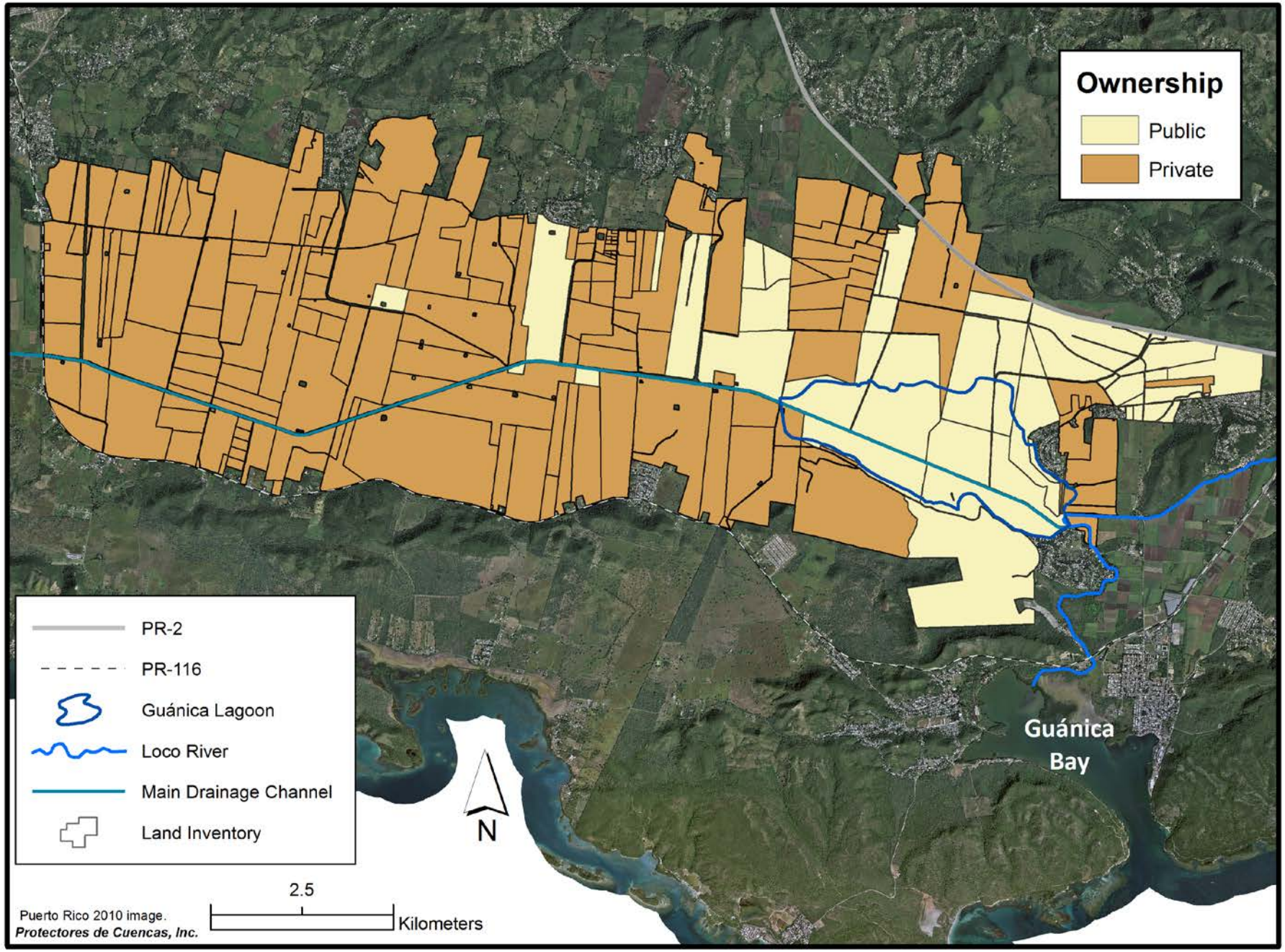


Figure 19. Ownership.

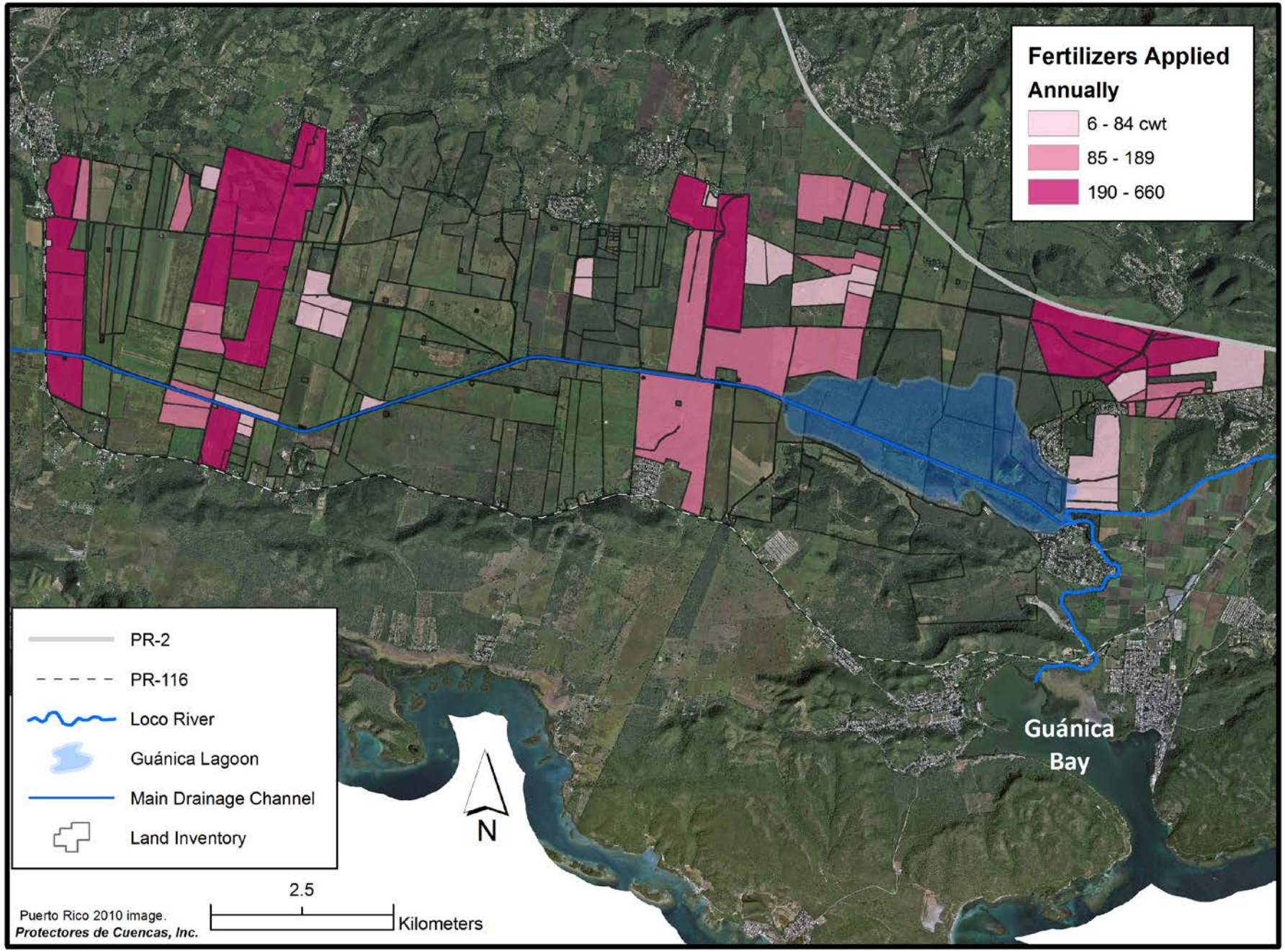


Figure 20. Fertilizer usage in the study area.

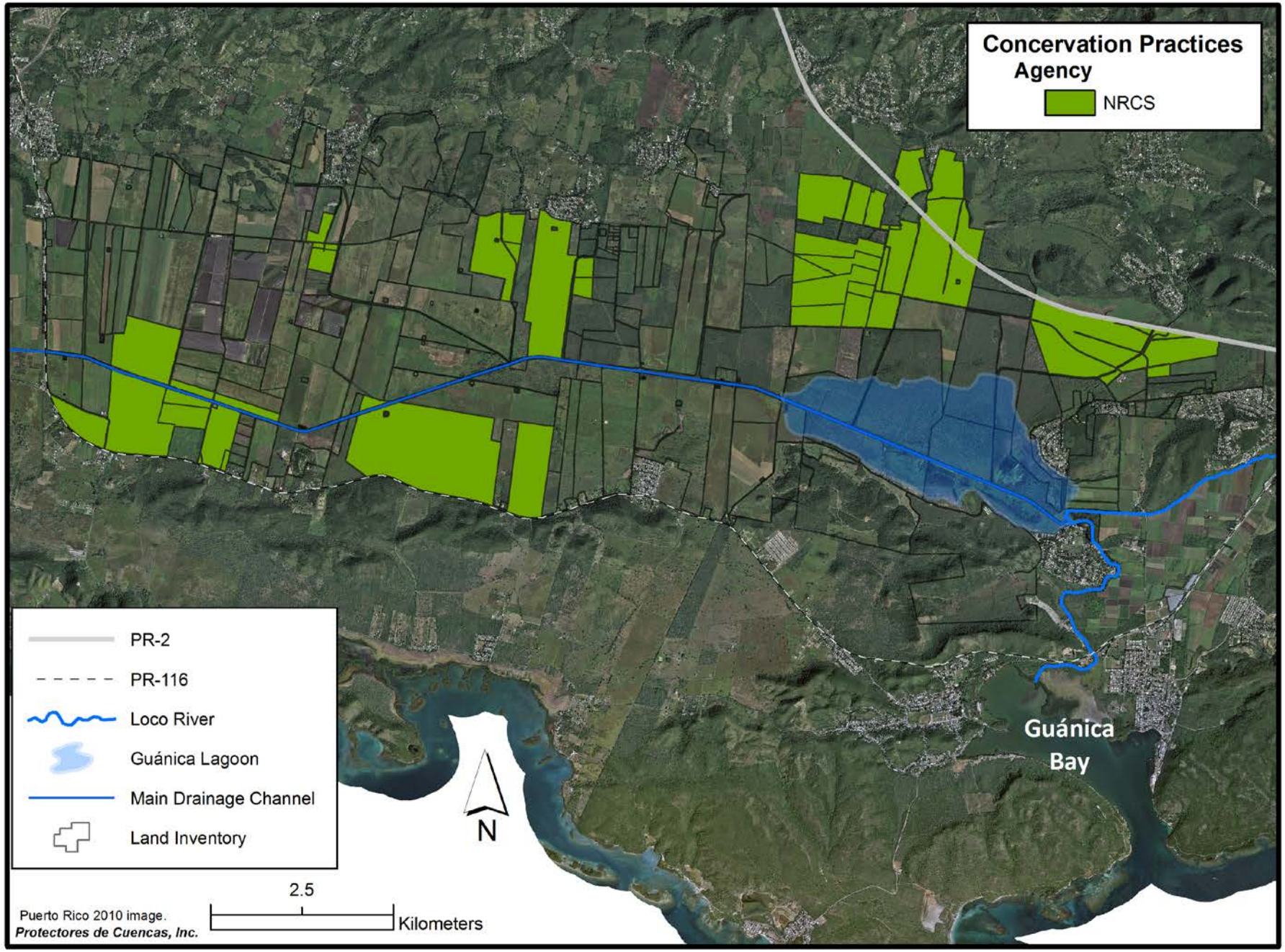


Figure 21. Farms applying conservation practices according to farmers.

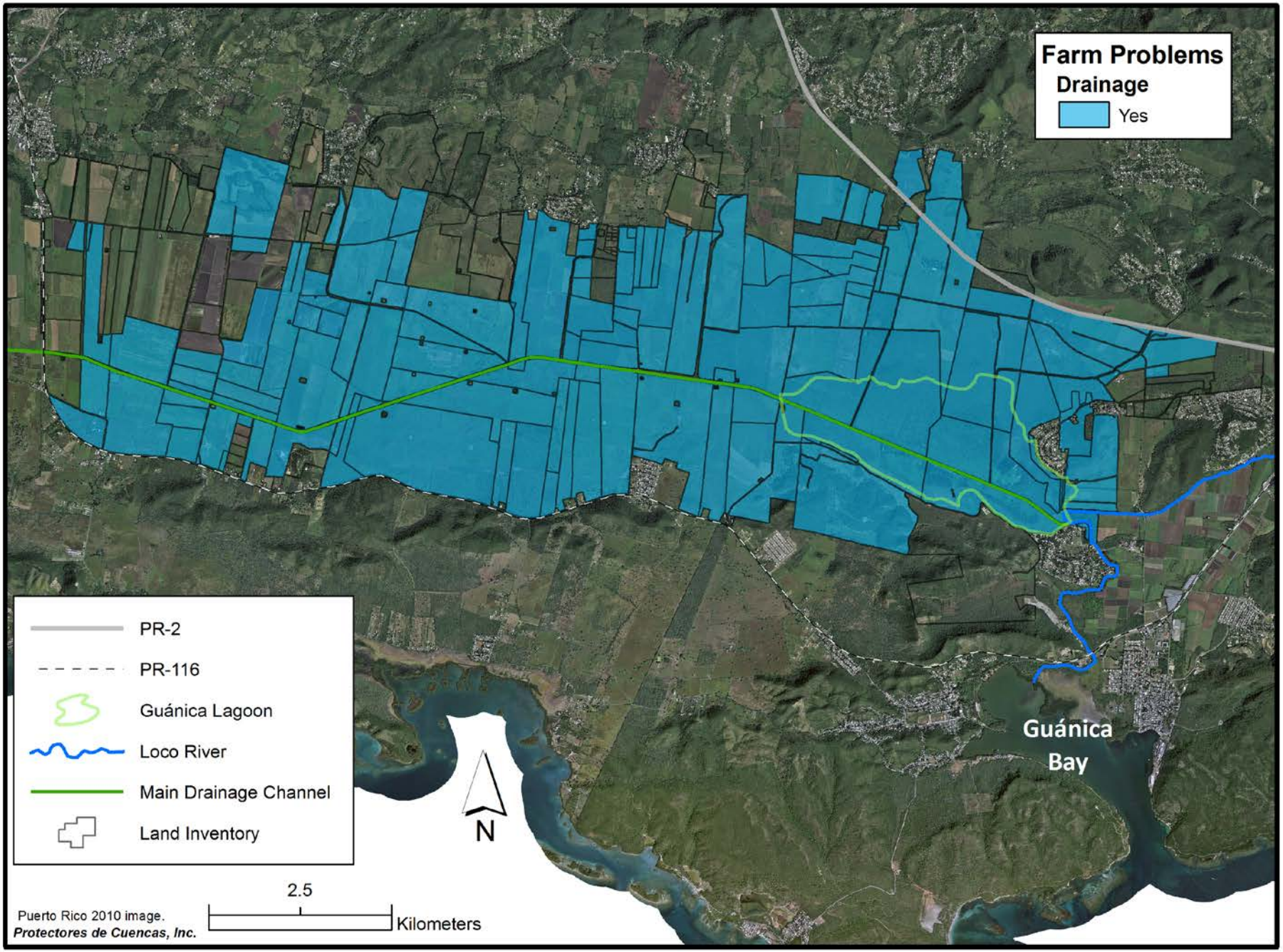


Figure 22. Parcels that have been identified by farmers as having drainage problems.

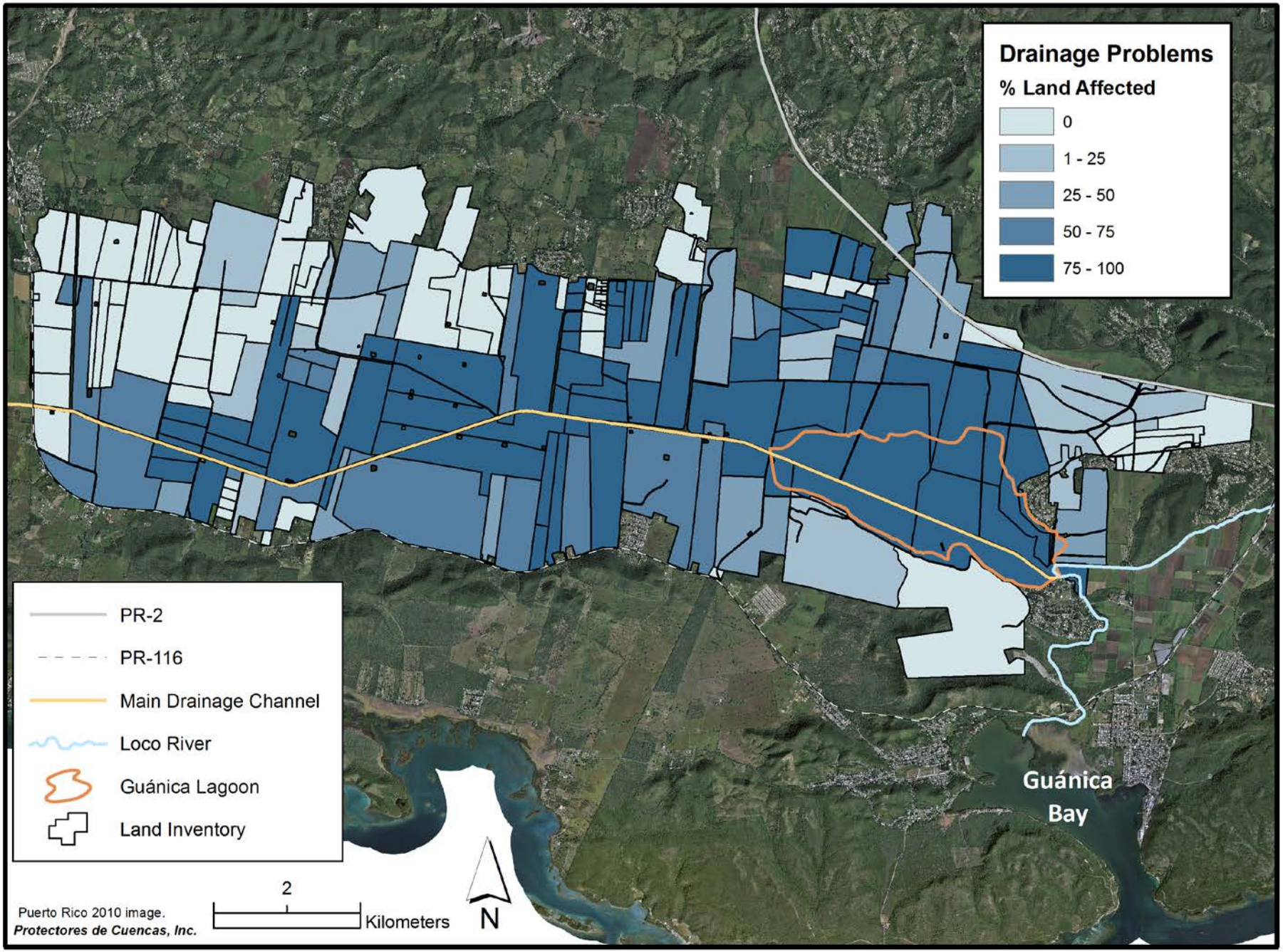


Figure 23. Gradient for drainage problems based on a % of land affected for individual parcels.

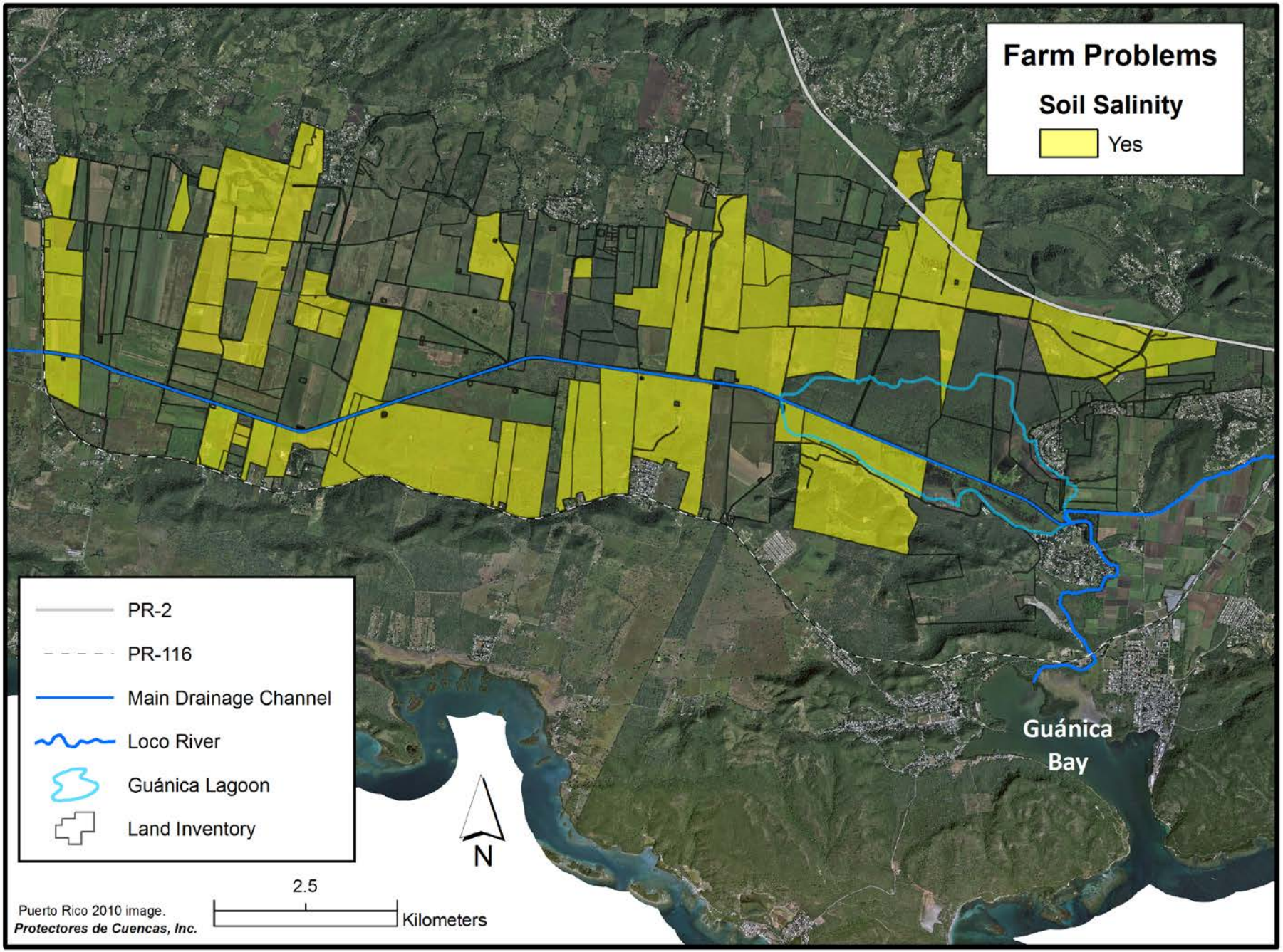


Figure 24 **Parcels that have been identified by farmers as having soil salinity problems.**

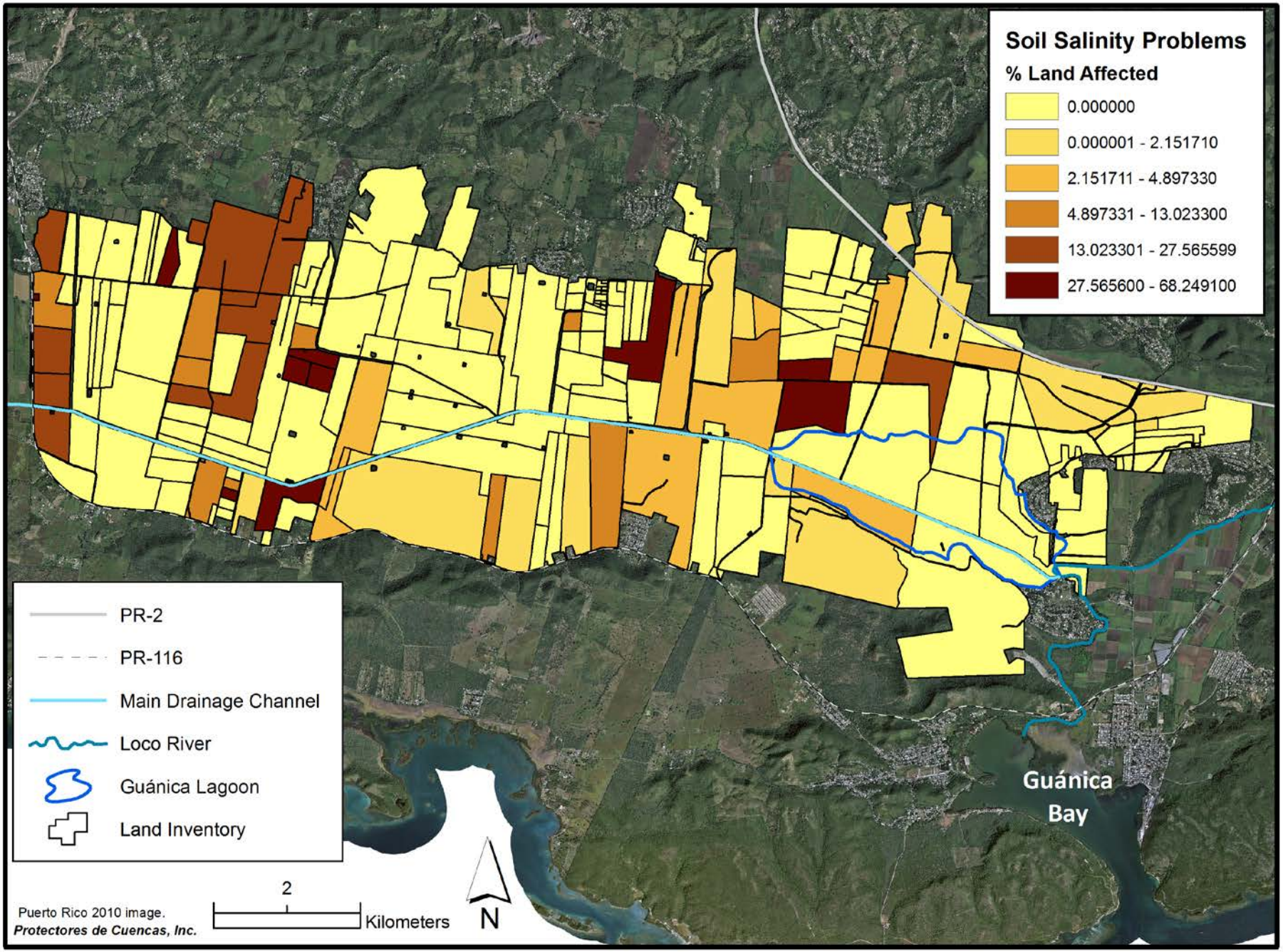


Figure 25. Gradient for soil salinity problems based on a % of land affected for individual parcels.

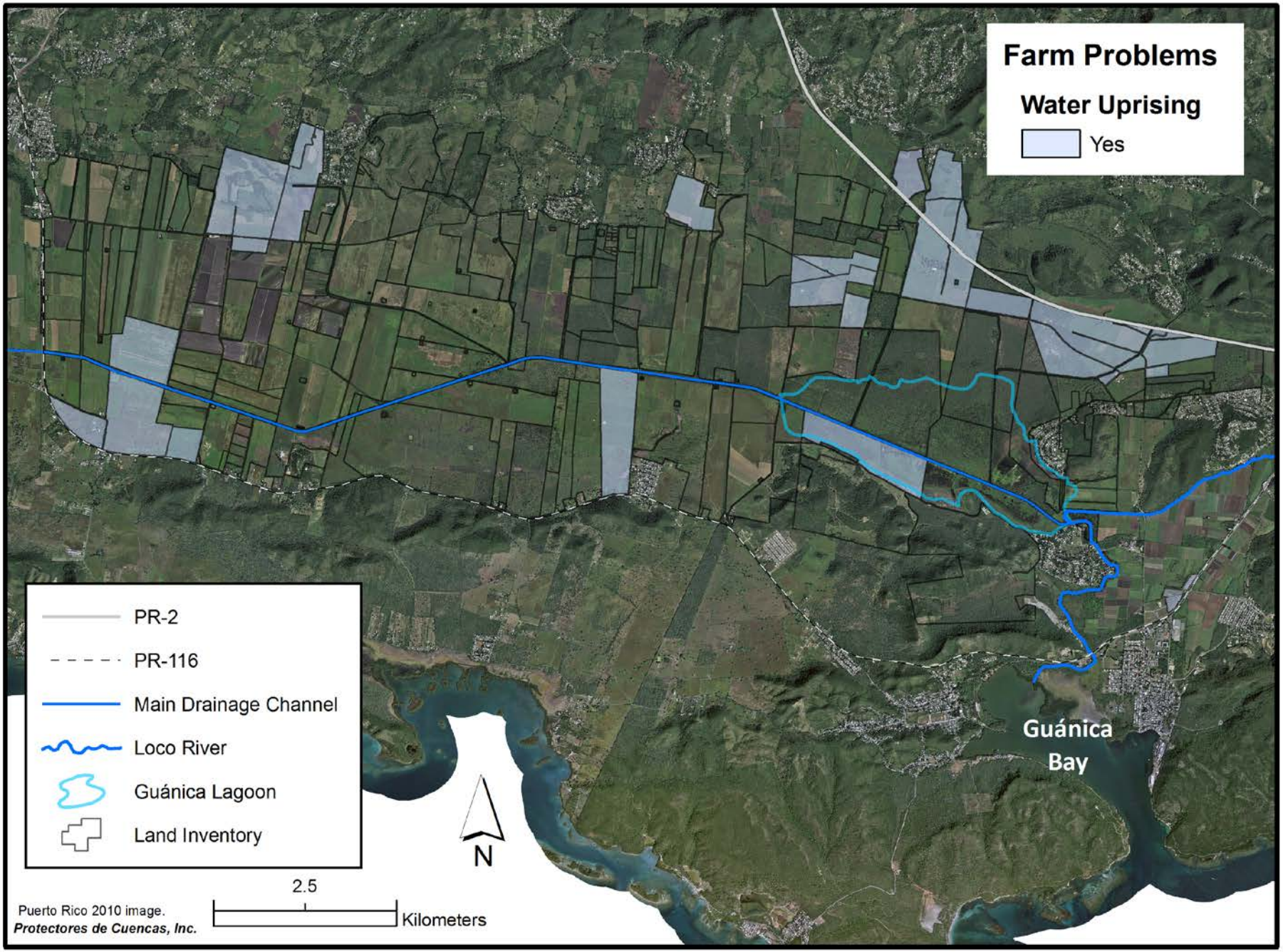


Figure 26. Parcels that have been identified by farmers as having water uprising problems.

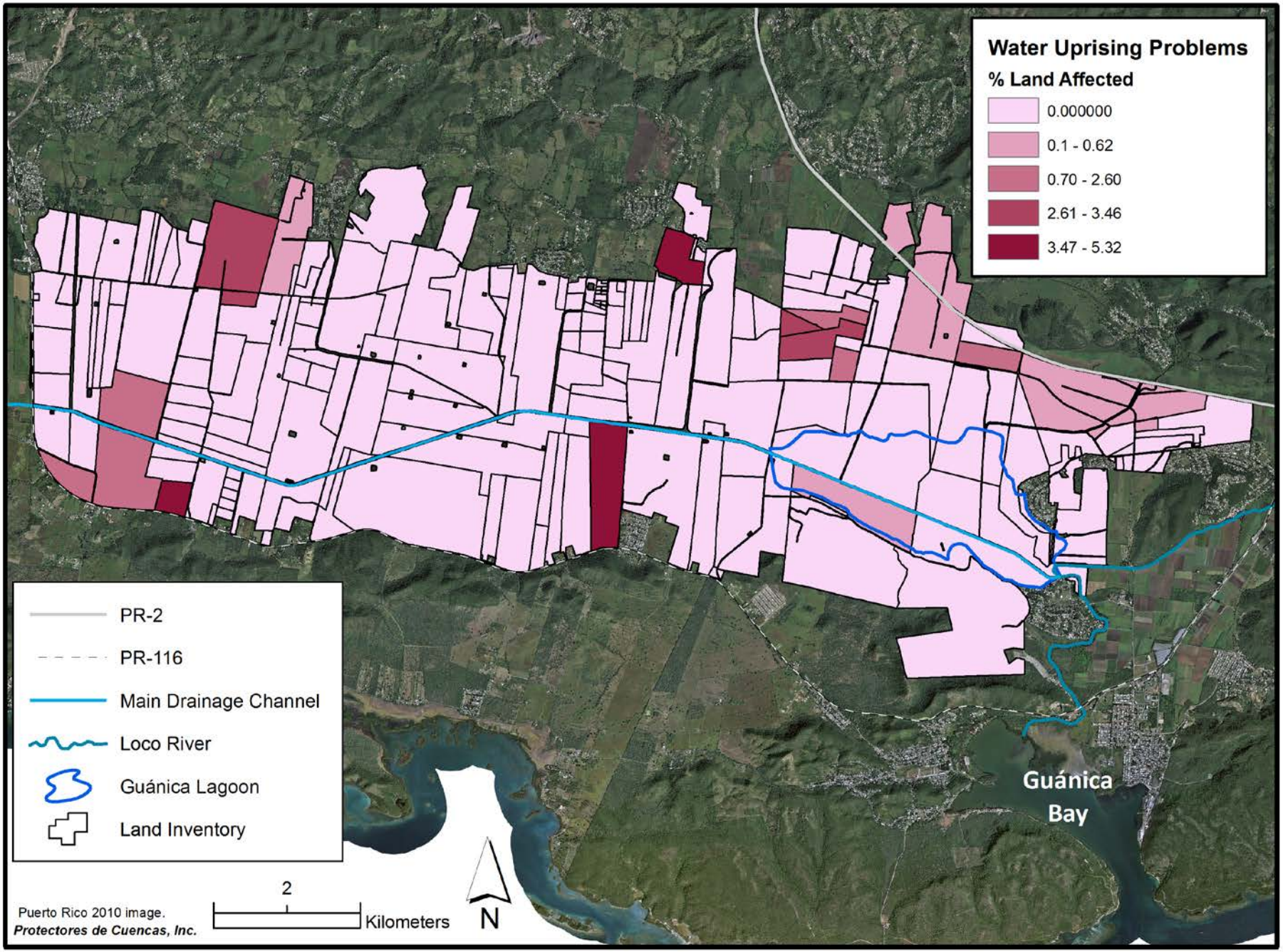


Figure 27. Gradient for water uprising problems based on a % of land affected for individual parcels.

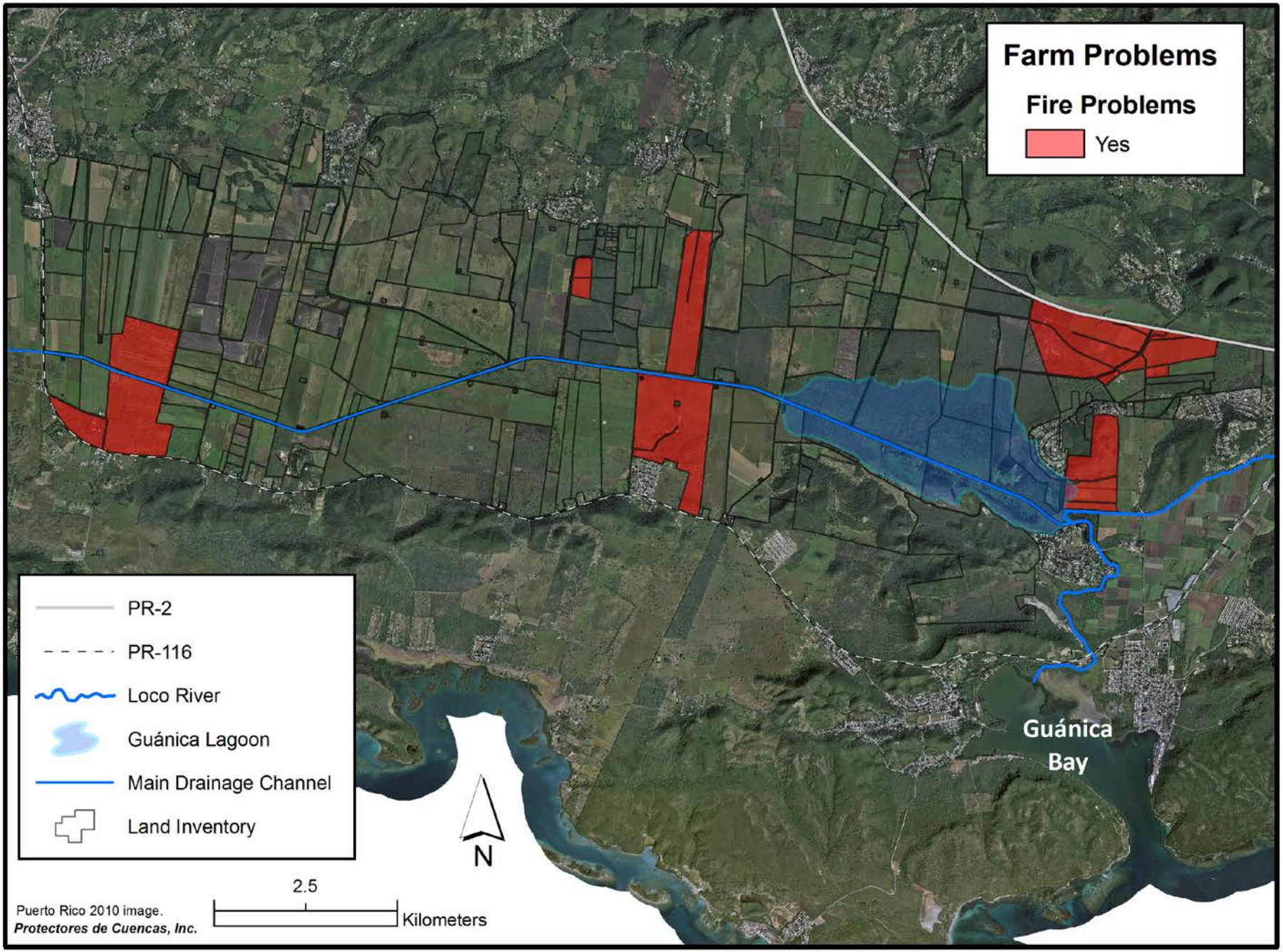


Figure 28. Parcels that have been identified by farmers as having fire problems.

APPENDIX A

Survey Questionnaire

Centro para la Protección de Cuencas
Guánica, Puerto Rico

Inventario de Fincas en La Antigua Laguna de Guánica, El Anegado y el Canal de Drenaje Principal en la Reserva Agrícola del Valle de Lajas

Nombre del Entrevistador: _____.

A. Propósito

La documentación de las tierras agrícolas, los usos y las condiciones actuales en el área de la Antigua Laguna de Guánica y el Anegado al igual que las fincas aledañas al canal principal de drenaje en la Reserva Agrícola del Valle de Lajas.

B. Información del Agricultor

Nombre:		
Años como agricultor:	Edad:	Teléfonos:
Tipos de Agricultura a la que se dedica:		
Dirección Postal:		Correo Electrónico:
Dirección Física:		Fecha en que recibió este cuestionario:

C. Información General de La Finca

Nombre de la Finca:		
Nombre del Operador:		
Nombre del Propietario:		
Área *(cuerdas):*	Tipo de Suelo:	Canales de Drenaje existentes:
Dirección Física:		Punto de Acceso:

1. Ubicación

Número de Parcela(s): *(basado en el mapa provisto)*	**Área Cultivada** *(cuerdas)*	**Área no Cultivada** *(cuerdas)*	**Área Total** *(cuerdas)*

2. Infraestructura

Tipo	**Marque con ✓ si la infraestructura mencionada existe en su finca**	**Descripción**
Vivienda:		
Taller:		
Almacén:		
Equipos: *Ej. Empacadoras, Sistemas de bombeo, caseta de filtros, separadores de sólidos etc.)*		
Umbráculos:		
Otras		

3. Fuente de Agua

Tipo	Marque con √ la/s fuente/s de agua en la finca	Descripción	
Sistema de Riego del Valle de Lajas		Número de toma:	
		Consumo Anual: *(acres/pie)*	
		Disponibilidad del Agua:	
		¿Se le ha racionado el agua en algun momento?	
		¿En cuántas ocasiones le han racionado el agua? *(favor incluir fechas)*	
Pozo Profundo		Nombre del pozo:	
		Número del Pozo:	
		Profundidad Estimada:	
		Localización:	
		Descarga Estimada:*(Indique unidad)*	
		Consumo Anual:*(Indique unidad)*	
Autoridad de Acueductos y Alcantarillados			
Otras			

4. Sistema de Riego

Tipo	Marque con √ el tipo de riego que posee la finca	Descripción
Sistema de Riego del Valle de Lajas		
Pozo		
Inundación		
Goteo		
“Traveler”		
Pisteros Fijos		
Pivote Central		
Pivote		
Otros		

5. Reservas de Agua

Indique el tipo de reserva de agua, si alguno, existente en la finca	Tamaño	Capacidad	Condición Actual

D. Patrones de Producción Agrícola

1. Cosechas *(Favor especificar el cultivo o los cultivos en su finca)*

Tipo de Cultivo *(Hortalizas, Farináceos, Frutales, etc.)*	**Área Cosechada Anual** *(cuerdas)*	**Área no Cosechada Anual** *(cuerdas)*	**Producción Anual** *(especifique unidad)*	**Rendimientos Anuales**	**Fertilizantes Aplicados Anualmente**		**Plaguicidas aplicados Anualmente**	
1.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
2.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
3.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
4.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	

2. Pastos y Forrajes

Tipo de Gramíneas	**Área Cosechada Anual**	**Área no Cosechada Anual**	**Producción Anual** *(especifique*	**Rendimientos Anuales**	**Fertilizantes Aplicados Anualmente**		**Plaguicidas aplicados Anualmente**	
1.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
2.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
3.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	
4.					Tipos		Tipos	
					Cantidad Aplicada		Cantidad Aplicada	
					Modo de Aplicación		Modo de Aplicación	

3. Animales

Animal	Raza	Área Dedicada	Cantidad de Animales	Producción Anual *(especifique unidad)*	Rendimientos Anuales
Vacuno					
Porcino					
Caprino					
Equinos					
Aves					
Otros					

E. Conservación de Recursos Agrícolas y Naturales

1. ¿Posee usted un programa de conservación? Sí ___ No ___

2. Indique el tipo de prácticas de conservación, si alguna, que implementa en la finca.

Práctica de Conservación	Tiempo que lleva implementando la práctica	Descripción

3. ¿Recibe usted algún tipo de Asistencia Gubernamental, Federal o Estatal para su finca?

Agencia	Tiempo que lleva recibiendo asistencia	Tipo de Asistencia

F. Problemas Agrícolas existentes en la Finca

1. Identifique, si alguno, los tipos de problemas que posee la finca.

Tipo de Problema	Marque con √ El tipo de Problema	Descripción	Frecuencia con que ocurre	Periodo en que ocurre	Área Estimada Afectada
Drenaje:					
Afloramiento de Agua:					
Salinidad:					
Sequía:					
Disponibilidad de Agua					
Incendios Anuales					
Plagas					
Erosión					
Fertilidad de Suelo					
Otros					

G. Comentarios adicionales

Consentimiento

Yo, voluntariamente, accedo a participar de este estudio y que no he sido o seré compensado monetaria o de ninguna otra forma o manera por mi participación en este estudio. Certifico que he leído y se me han contestado todas las dudas relacionadas a este estudio.

Nombre	Firma	Fecha