Title
A Geospatial Approach to Conservation Prioritization: Examining the Applications of GIS-based Vegetation Data in Los Angeles County

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A Geospatial Approach to Conservation Prioritization:
Examining the Applications of GIS-based Vegetation Data in Los Angeles County

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Honors Thesis

The California Floristic Province is one of the world's biodiversity hotspots, one of 36 regions which contain over half of the world's vegetation. With projected increases in anthropogenic land transformation and use, omnipresent impacts of global climate change, and threats of habitat fragmentation and loss, understanding the vegetation composition of Los Angeles County is integral to prioritizing conservation efforts. By creating one continuous dataset with regional dominant alliance type for the entirety of the county, rare vegetation types and their locations can be identified. The goal of this project is to create such data set and produce maps and associated analyses to create a comprehensive overview of the rare vegetation in Los Angeles County, highlight at-risk regions and any current gaps in protection, providing information and framework for structuring future management and conservation projects.

Introduction

Los Angeles County presents a unique opportunity for research not only in that it is within a biodiversity hotspot, but in the sheer range of ecosystems it encompasses. The county extends over coastal regions to high elevation ranges in the San Gabriel ranges, with diverse habitats arising as a consequence.

Biodiversity Hotspots

Despite covering less than three percent of the globe's surface area, biodiversity hotspots contain over 2,000 species of endemic vegetation (Burge, et al. 2016). Hotspot regions are often defined by their common biological factors (Myers, et al. 2000). The California Floristic Province extends from the Southern part of Oregon down the entire state to Baja California (Burge et al.). California's diverse geographic and topographic features and abundance of ecosystem types allow for a wide range of diversification among flora and faunal taxa alike (Lancaster and Kay, 2013). The highly endemic zones present a unique opportunity for conservation management. Considering limits to funding and simply manpower to implement conservation plans, prioritizing highly endemic and at-risk zones allows for efficient and effective management. However, most analysis of hotspots for biodiversity and conservation planning fail to account for rare species (Reid, 1998). Finding cost-effective strategies to mitigate biodiversity loss should be considered a priority, and by focusing on these biodiversity hotspots, conservation projects can tackle a larger amount of threatened species without needing to cover as much ground (Myers, et al. 2000). Biodiversity hotspots should remain a conservation priority in order to maximize species protection, both in diversity and function, and maximizing levels of endemism.

Current Threats to CFP Biodiversity

Threats to the California Floristic Province (CFP) are two-fold, between the threats from the current global climate crisis and from anthropogenic influences (such as development) on the landscape. Increased urbanization has direct impacts on biodiversity through destruction and fragmentation of habitats. This is especially of concern in an urban center like Los Angeles, where population and city spread are increasing with time (Keeley and Swift, 1995). Habitat fragments behave like islands, and by applying the Island Biogeography Theory, it seems clear that with increasing fragmentation, there is more and more risk that these areas will continue to lose vital components of the present-day biodiversity (Soulé, et al. 1992). While anthropogenically caused habitat fragmentation is a global phenomenon, Los Angeles County being a part of the California Floristic Province - a biodiversity hotspot, which by definition, is already an extremely small percentage of land on the globe - should be considered especially high risk. These threats to habitats are heightened when combined with the ubiquitous threat of the climate crisis. While Mediterranean landscape are co-adapted with fire, fire regimes in California have been directly impacted by climate change. Increases in intensity and timing of fires have led to destruction of chaparral habitats, leaving little time for vegetation to regenerate (Keeley, 2005). With increases in temperatures, higher elevation niches are being pushed further north, which could leave rarer mountainous vegetation alliances with shrinking viable habitat. It is important to understand how hotspots in conjunction with urban areas will be impacted, and how the climate crisis compounds the impacts.

Use of GIS in Conservation Research

The use of geospatial information systems (GIS) for conservation research is a growing sector. With increasing accuracy of remote sensing and other GIS technologies and increasing data accessibility, the variety and scope of spatial data for conservation projects is impressive (Gillespie, et al. 2008). With more and more data being produced, and the potential to create personal datasets and imagery with the use of small unmanned aerial vehicles (sUAVs), projects assessing presence of rare vegetation types and associated land area can successfully be replicated across many locations and levels (Koh, et al. 2012). It is imperative to create large spanning datasets to provide baselines for future analysis of vegetation cover change. Given threats to native and rare vegetation, knowing current locality data can inform where management strategies should be implemented, along with identifying where current gaps in protection exist (Scott, et al. 1993). Current species locality data can also be used and applied in modelling software to simulate potential losses and gains in habitats, and identifying future habitats that comply with species' niche and environmental requirements (Chefaoui, et al. 2005). GIS and related technologies can be used to develop multi-criteria decision making and thresholds for conservation, improving efficiency and decision making in conservation prioritization and management (Phua and Minowa, 2005).

Datasets

CALVEG Polygons

The United States Department of Agriculture Forest Service CALVEG data provides vegetation cover data for the state of California. The state is divided into 9 zones, with vector data available to download in 11 ESRI geodatabases.

GAP Land Cover Raster

The United States Geological Survey's "goal of the Gap/LANDFIRE National Terrestrial Ecosystems 2011 data is to provide accurate, seamless data on the vegetation and land cover of the United States" (USGS). This data provides national coverage, but is downloadable by state. The format of the data is raster, and cell values correspond to land cover type. The metadata and provided key show correspondence between cell value and associated data type.

Methods

Dataset Manipulation and Merging

To create a dataset that covers Los Angeles County in its entirety, manipulation and merging of datasets was required. The ultimate output resulted in one vector dataset derived from several CALVEG datasets and the USGS GAP land cover data.

Two CALVEG geodatabases were downloaded: the South Coast and South Interior regions (Refer to Figure 3). The data was reprojected into the California Teale Albers 1927 coordinate system. This was done both for better visual cartographic output and geometry calculations (unit is meters). The two vector datasets were merged and dissolved based on Regional Dominance Type. The merged CALVEG dataset was then clipped to the LA county boundaries. To fill in the gap of coverage north of the San Gabriel's, the GAP land cover raster was used (Refer to Figure 4). Due to discrepancies in data format (i.e. feature class polygons and raster data), the GAP data first had to be converted. The GAP raster data uses raster values to correspond to dominant vegetation type, with a range of approximately 0 to 600 statewide (with the Los Angeles subset of course containing a smaller sampling of those values). After clipping the raster to LA County, the dataset was converted to polygons, using cell values to differentiate dominant vegetation type. The GAP polygons were then merged with the CALVEG polygons to complete coverage for LA County (Refer to Figure 5). This merged dataset was then used for all subsequent analysis. This form was ideal for this project as polygons were grouped by dominant vegetation type, and multi-part polygons allowed for viewing all the vegetation alliance presence at a county-wide scale.

Vegetation Alliance Area Calculations

Once the merged vector dataset was completed, a simple calculation of geometry in the attribute table was conducted. The output field provides area in square kilometers for each vegetation dominance type (Refer to Figure 6).

Data Limitations

With any conversions from raster to vector data, detail in coverage and area will be altered. The pixelated nature of raster data also takes away from the accuracy of boundaries, by simplifying them into straight lines - this accounts for discrepancies in total county area. Another important point to remember about the data is the difference in vegetation type classification. In combining the CALVEG and GAP data, the output fused raster had arguably overlapping classification schemes, leading to less accurate counts in coverage before merging vegetation types (e.g. Developed [CALVEG] and Urban General [GAP]).

Rare Type Classification

Vegetation alliances with less than 1 square kilometer area in the county was designated as rare. However, certain alliances were flagged as rare simply because the vegetation is rare within the county, but not a rare vegetation type for the area as a whole. This is due to the fact that the LA county vegetation dataset was created from subsetting larger datasets, which resulted in non-rare vegetation polygons being included due to a small area size (from clipping to the county borders). Vegetation alliances were handpicked from the list of existing types to create a set of truly rare species present in the LA County dataset (Refer to Table 2, Figures 9 and 10).

Results

Dominant Vegetation Alliances and Habitat Types

The dataset resulted in 137 unique habitat alliances in Los Angeles County. The largest dominant area type in the county is ‘Urban or Developed’ at 2679 square kilometers. The largest natural habitat type is ‘Lower Montane Mixed Chaparral’ at 1469 square kilometers. The smallest dominant alliance type is ‘California Coastal Live Oak Woodland and Savanna’ at 0.0006 square kilometers. The San Gabriel ranges are home to a majority of the smaller habitat dominant types (Refer to Figure 6).

Singapore Index Classification

Using the Singapore Index (SI) of classification, the vegetation alliance dataset was reclassified into distinct broad land cover types (Refer to Table 1 and Figure 7). The Singapore Index classification scheme provides a framework for urban areas to identify the current baseline of biodiversity (Convention on Biological Diversity). Over 60% of Los Angeles County fell under the SI classification of Natural. Developed was the next largest category, at almost 30%. This juxtaposition highlights the unique position Los Angeles County holds - while an urban center, the county is a majority natural, and holds an incredible amount of biodiversity.

SI Classification	**Percentage of LA County**
Agriculture	2.9%
Bare Soil	1.5%
Non-Native Grasses	1.1%
Non-Native Trees and Shrubs	1.0%
Natural	64.6%
Urban, Developed	28.4%
Water	0.5%

Table 1. Percent of LA County land cover classified by the Singapore Index

Rare Vegetation

Across the county-wide dataset, 11 rare vegetation alliances were identified (see Table 2). These habitats were chosen from the set of habitats in the dataset with less than 1 square kilometer total area across the county.

Vegetation Alliance	Total Area (km^2)
Alpine Grasses and Forbs	0.004
Intermittent Lake or Pond	0.051
Subalpine Conifers	0.109
California Buckeye	0.130
Tule - Cattail	0.258
Saltbush	0.306
Coastal Bluff	0.387
Perennial Lake or Pond	0.397
Wet Meadows	0.513
Dune	0.545
Pickleweed - Cordgrass	0.795

Table 2. LA County Rare Vegetation Alliances and Area

Protected Land and Habitat

Two types of protected areas in Los Angeles County were focused on in this study, Significant Ecological Areas (SEA) and the California Protected Areas Database (CPAD) (Refer to Figure 8). According to Los Angeles County Department of Regional Planning, SEA are “officially designated areas within LA County with irreplaceable biological resources” (Los Angeles County Department of Regional Planning). The program goals aim to conserve significant physical, biological, and genetic diversity. The importance of sustaining genetic diversity emphasizes this program’s aims to promote resilience of these ecosystems into the future, ensuring preservation of enough genetic diversity for populations to adapt to environmental changes. The SEA program works under three guiding principles: (1)

biodiversity, (2) resiliency, and (3) public service. These guidelines emphasize conservation of important natural areas beyond just protecting organisms in place, but putting conservation in context of long-term biotic and genetic resilience, reduction of habitat fragmentation, and regulating anthropogenic influence in these landscapes. The next dataset, CPAD, is a collection of protected land GIS data spanning the entire state of California. The types of protected areas include "national, state, or regional parks, forests, preserves, and wildlife areas, large and small urban parks that are mainly open space (as opposed to recreational facility structures), land trust preserves, special district open space lands (watershed, recreation, etc.) and other types of open space" (California Protected Areas Database). While CPAD data is presented in three spatial forms - Holdings, Units, and Super Units (from most detailed to coarsest cartographic scale respectively). Super Units are the simplest polygons making them ideal for cartographic use and spatial analysis. Including both these protected areas provides a comprehensive overview of protected land in the county.

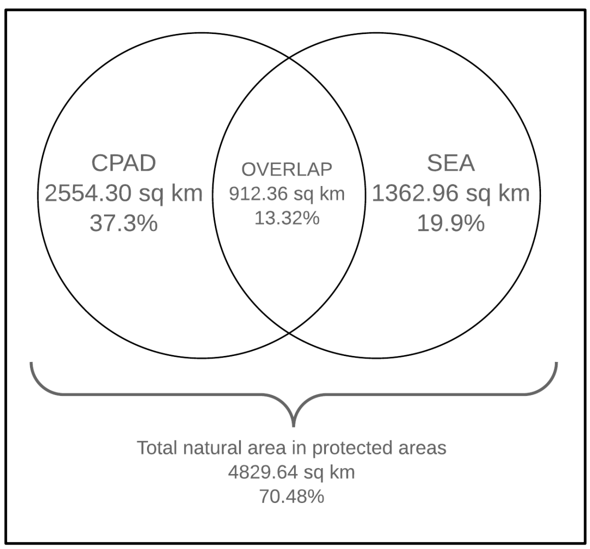


Figure 1. Percentage of Natural Land in Protected Areas, Los Angeles County

Significant Ecological Areas and California Protected Areas Database data were downloaded and used to quantify how much natural area in Los Angeles County currently falls under some form of protected area. The protected area datasets were the most recent available, created in 2018. When considered together, SEA and CPAD cover 4829.64 km^2 of natural area in Los Angeles County, or 70.5% (refer to Figure 1). CPAD exclusively covers 2554.30 km^2

(37.3%) of natural area, SEA exclusively covers 1362.96 km^2 (19.9%) of natural area, and where these two protected areas overlap, they cover 912.36 km^2 (13.3%) of natural area.

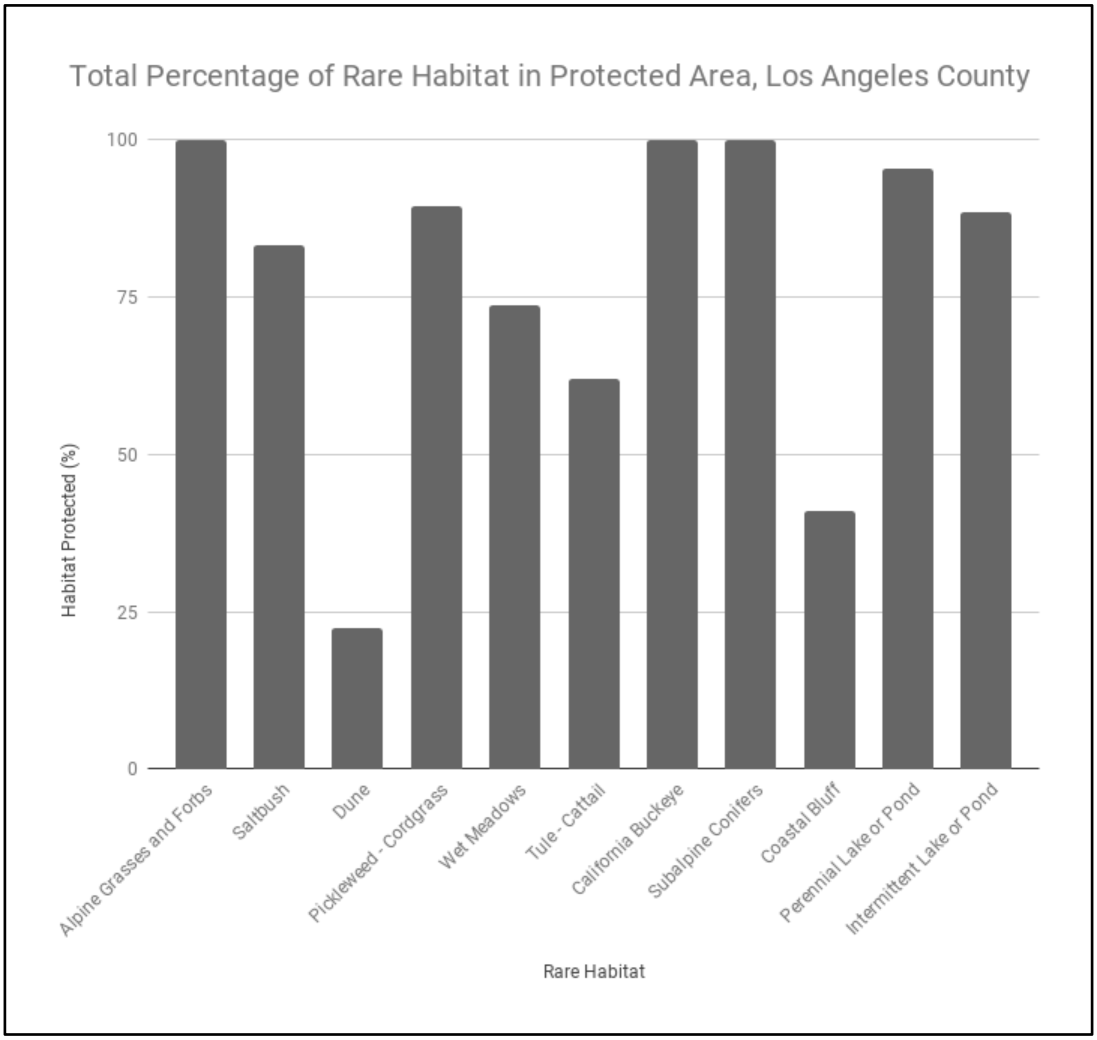


Figure 2. Percentage of Rare Habitats in Protected Area, Los Angeles County

All rare alliance types have at least some area that is within a protected area. Dunes and Coastal Bluff are the two least protected, 23% and 41% respectively (refer to Figure 2).

<u>Rare Alliance Types</u>

Alpine Grasses and Forbs

Communities designated by alpine represent those in high elevation, above the treeline. The most commonly found grasses in the alpine zone are perennials. Grasses are often temperature limited, making these vegetation alliances rare in high elevation zones (Rundel, 2011).

Intermittent Lake or Pond

Lakes, ponds, and water features that are only inundated for certain periods annually.

Perennial Lake or Pond

Lakes, ponds, and water features that inundated for the entire year, rather than holding water seasonally.

Subalpine Conifers

Often growing over 70 feet tall, these trees often represent the upper limits of the tree line. Common species in California subalpine forests include Whitebark Pine, Foxtail Pine, and Limber Pine. Warming temperatures pose a large threat for these high elevation forests, as many of these species are climate limited - and increasing temperatures reduces optimal habitat (National Park Service).

California Buckeye

California Buckeye, part of the Hippocastanaceae family, are trees less than 10 meters tall, but can also be found in shrubby life forms. Growing in shallow soils, these trees are usually found between 100 to 1,500 meters elevation. These trees are drought deciduous but resilient to fire. They are able to sprout from stumps and root crowns. Often found in the coastal ranges and the Sierra Nevada's, they grow on steeper slopes, often mixing with chaparral. These trees are toxic to livestock, and are not considered ideal vegetation by ranchers. Despite toxicity, these trees in large stands play a steady role in the overall foothill landscape of Southern California (California Native Plant Society).

Tule - Cattail

Most often found below 350 meters elevation, these alliances form an herbaceous cover. Their ground cover can intermittent or continuous, and are common in silty and clay soils. Their habitat includes brackish and freshwater marshes, which can be flooded. As parts of wetlands, these plants help play vital roles in pollutant filtering, habitat creating, and nutrient fixing (California Native Plant Society). Human disturbance to these habitats are common, given their desirable coastal locations.

Saltbush

Found up to elevations of 1200 meters, Saltbush shrub canopies are usually less than 3 meters, forming an open or intermittent cover. These plants are able to grow in well-drained soils and sands, and are common on upland slopes, or growing on alluvial fans. While not dependent on fire for reproductive processes, these shrubs are fire resistant. Increasing fire frequency may be of concern in a conservation management standpoint (California Native Plant Society).

Coastal Bluff

Common vegetation in coastal bluffs and prairies include scrub plants and grasses. These alliances occur generally within 45 kilometers of the coastline, and can be found up to 900 meters elevation. With no typical species composition, these alliances can handle a variety of soil substrates and moisture levels (de Becker).

Wet Meadows

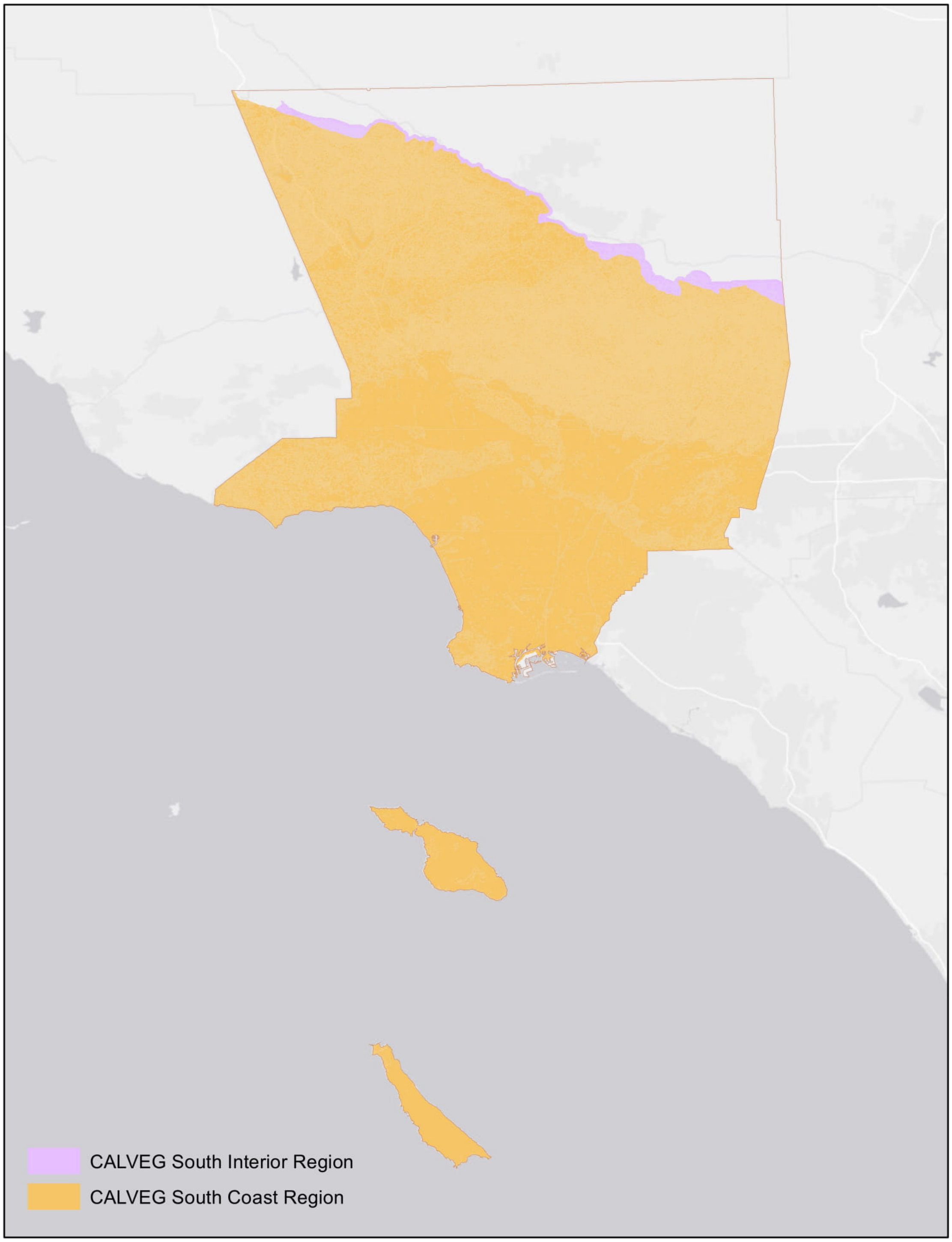
Wet meadows are wetlands with almost annually saturated soils. They often occur near riparian habitats or around lakes. However, distinct from other types of wetlands, wet meadows lack water that is pooling or standing. There may be inundation during the growing season, however these periods alternate with long periods of saturation. These habitats are important for regulating water flow into downstream rivers and creeks, which can help mitigate spring flooding and summer drought. These habitats contain high levels of plant diversity (Pacific Forest Trust).

Dune

Dune are regions of interplay between marine and terrestrial habitats. They are dynamic habitats that serve as coastal barriers, nesting grounds, and diverse habitat space for a variety of species (Schlacher, 2007).

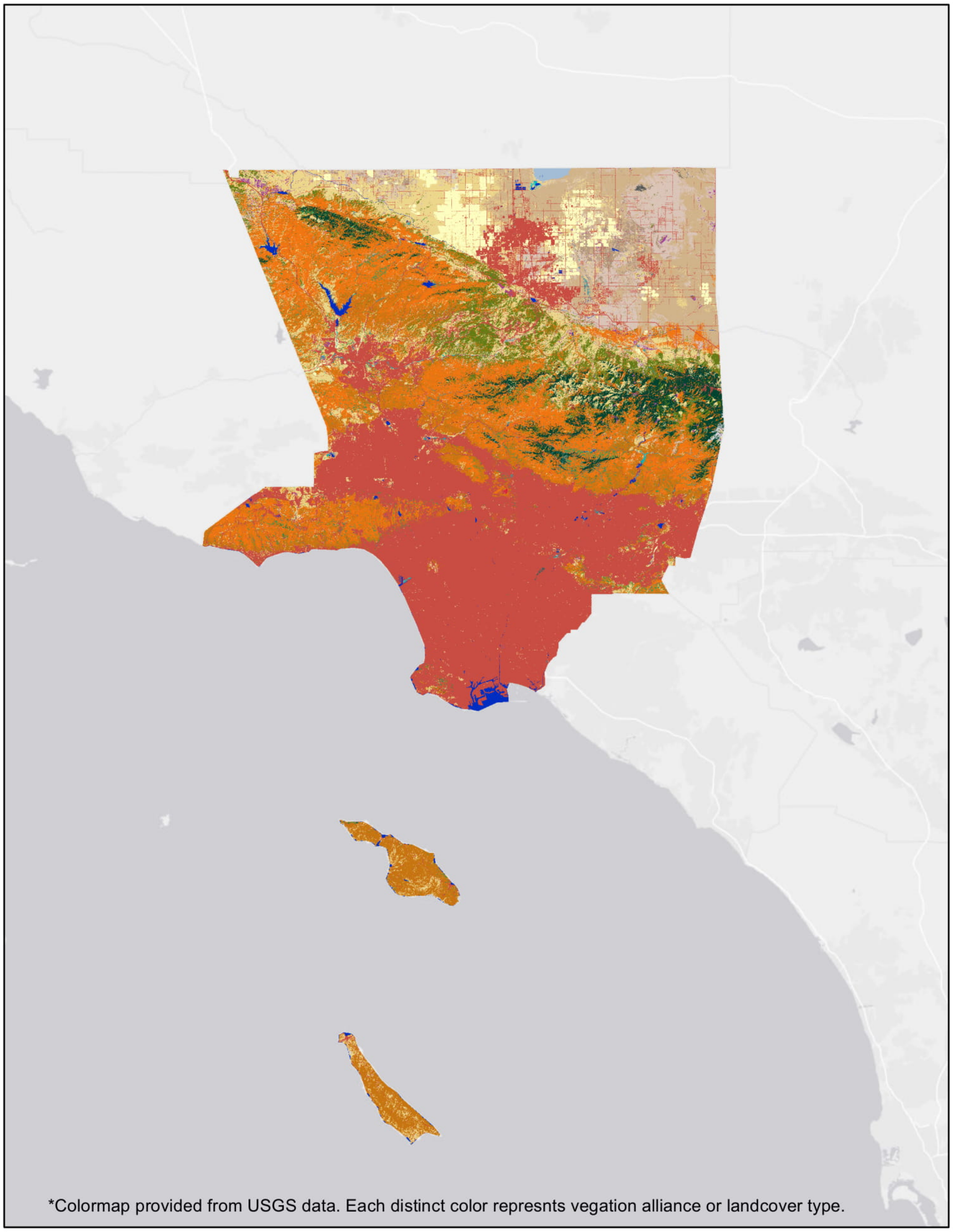
Pickleweed - Cordgrass

Commonly found in wetlands, these plants tolerate flooding disturbance and can handle saline environments. Found mainly between sea level and 1,200 feet elevation. Frequently found in salt marshes, five known species of *Salicornia* grow in California (California Native Plant Society). Most common threats to this alliance include the common threats to wetlands at large, such as human disturbance and habitat fragmentation.



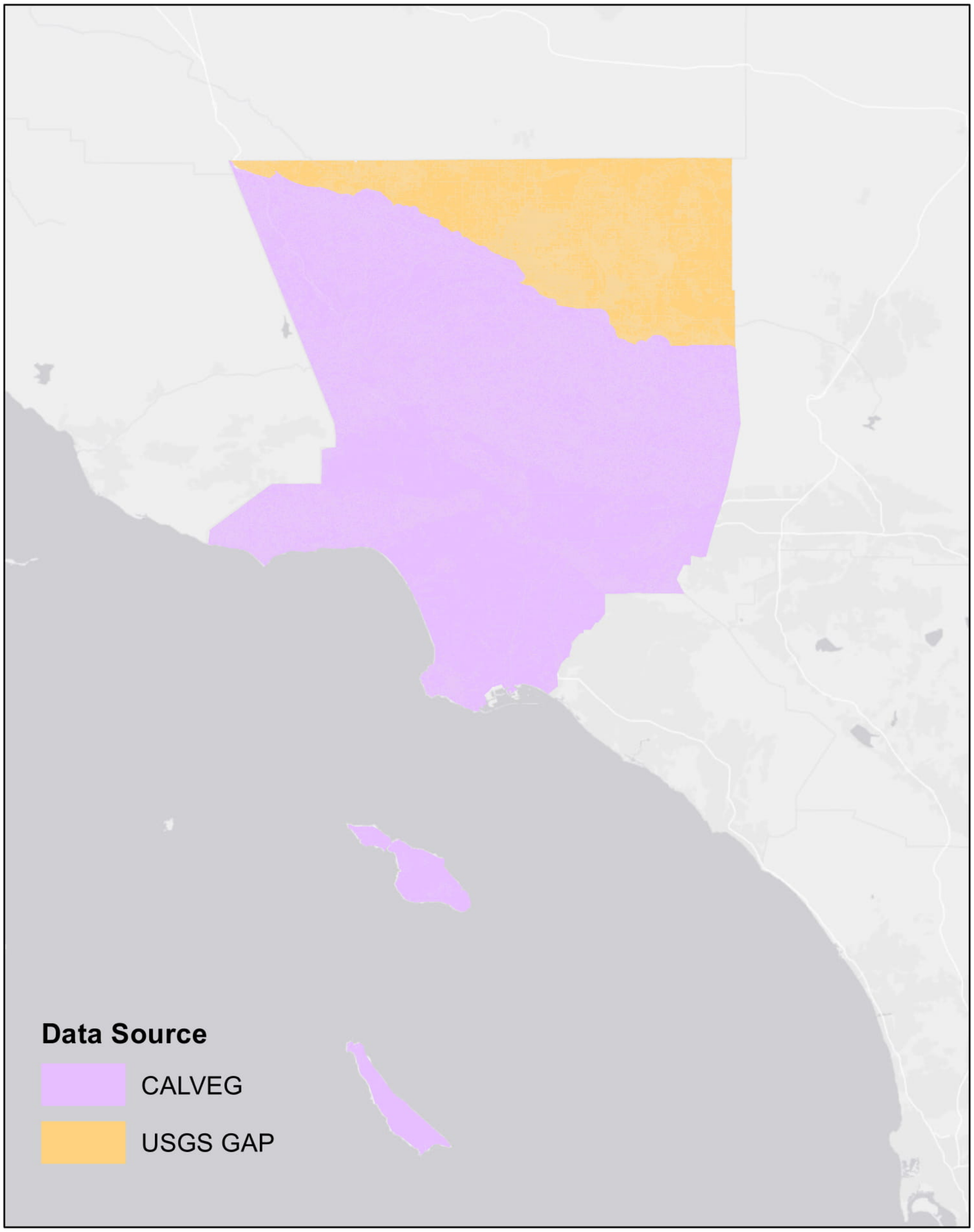
Data Sources: Existing vegetation - CALVEG, [ESRI personal geodatabase]. (2004). McClellan, CA: USDA-Forest Service, Pacific Southwest Region. [Accessed 2019].
U.S. Geological Survey Gap Analysis Project, 20160513, GAP/LANDFIRE National Terrestrial Ecosystems 2011: U.S. Geological Survey. [Accessed 2019].
Cartography by Porter Margolis, 2019

Figure 3. Extent of CALVEG databases



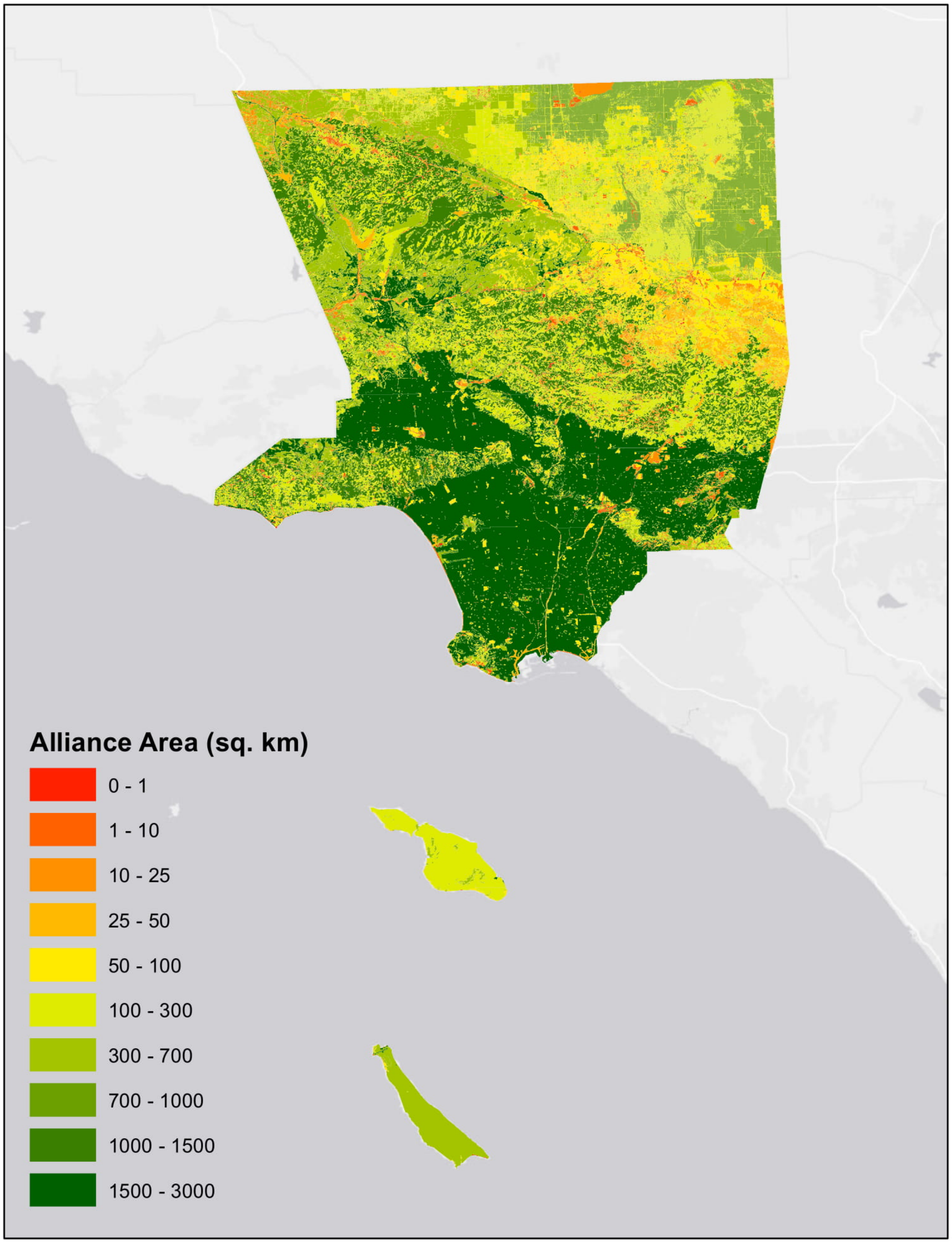
Data Source: U.S. Geological Survey Gap Analysis Project, 20160513, GAP/LANDFIRE National Terrestrial Ecosystems 2011: U.S. Geological Survey. [Accessed 2019].
Cartography by Porter Margolis, 2019

Figure 4. Extent of USGS GAP raster



Data Sources: Existing Vegetation - CALVEG, [ESRI personal geodatabase]. (2204) McClellan, CA: USDA-Forest Service, Pacific Southwest Region. [Accessed 2019].
U.S. Geological Survey Gap Analysis Project, 20160513, GAP/LANDFIRE National Terrestrial Ecosystems 2011: U.S. Geological Survey. [Accessed 2019].
Cartography by Porter Margolis, 2019

Figure 5. Fused output dataset with complete LA County coverage



Data Sources: Existing vegetation - CALVEG, [ESRI personal geodatabase]. (2004). McClellan, CA: USDA-Forest Service, Pacific Southwest Region. [Accessed 2019].
U.S. Geological Survey Gap Analysis Project, 20160513, GAP/LANDFIRE National Terrestrial Ecosystems 2011: U.S. Geological Survey. [Accessed 2019].
Cartography by Porter Margolis, 2019

Figure 6. Vegetation alliances by total area.
Note the concentration of smaller habitats in the San Gabriel Mountains

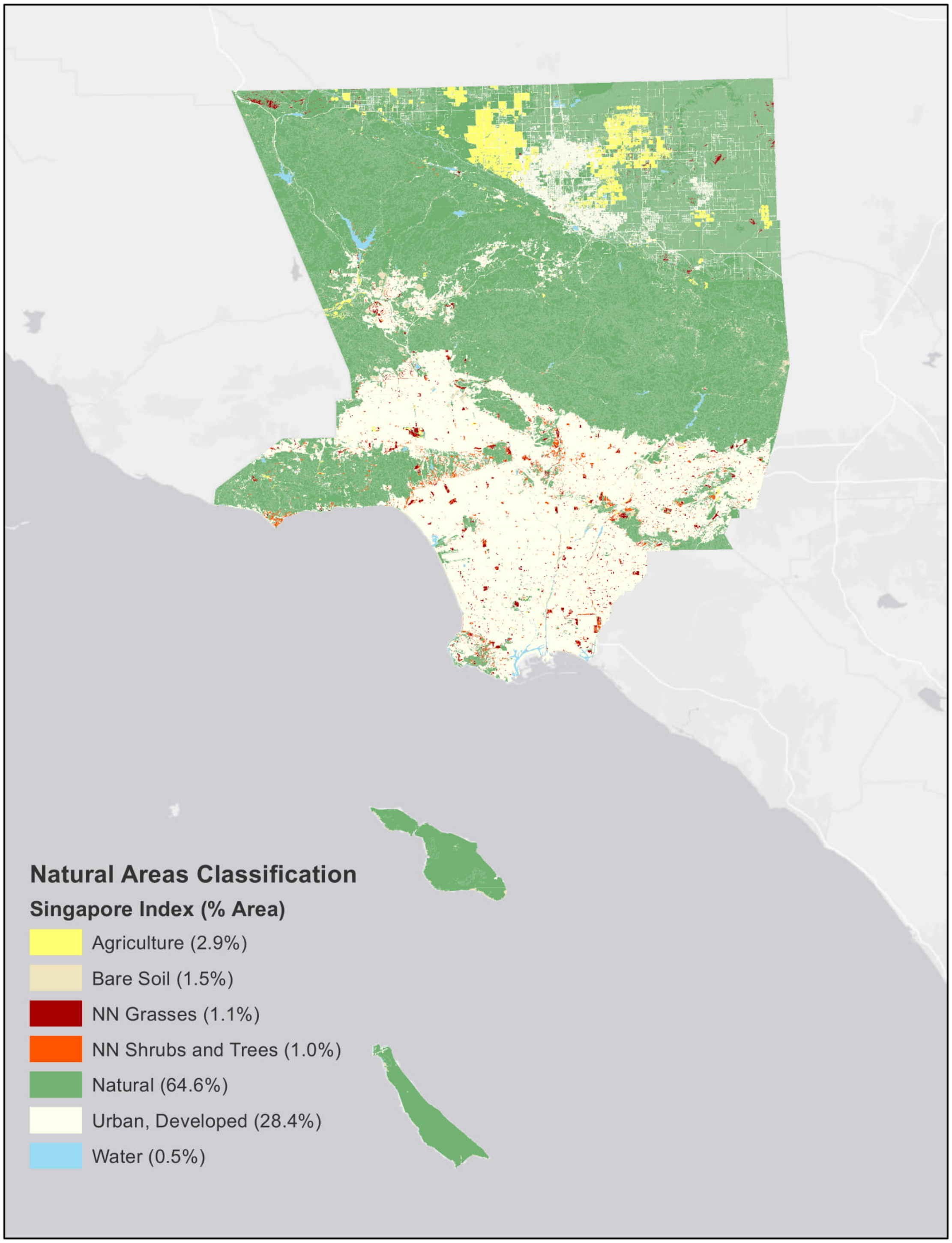


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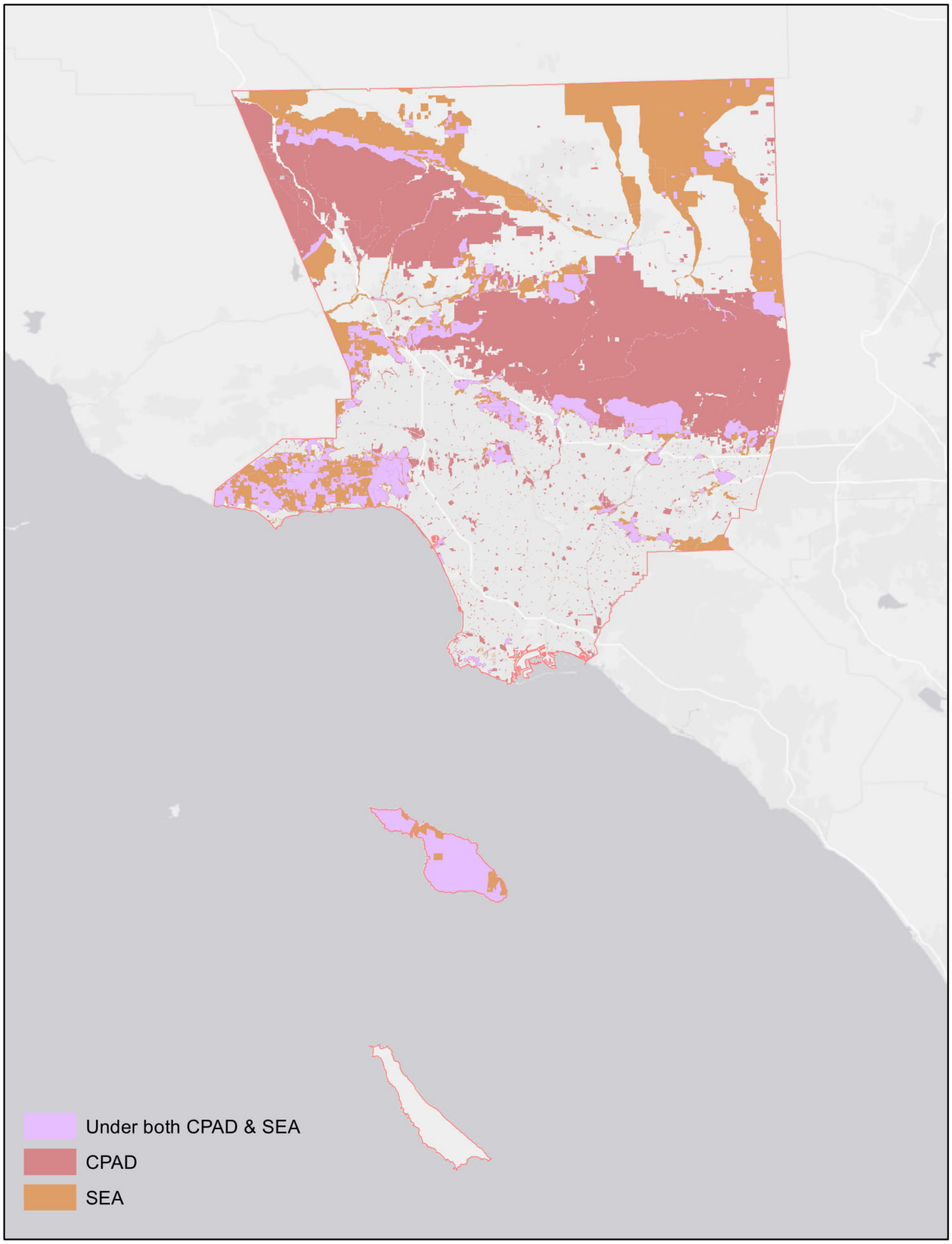
Figure 7. LA County Singapore Index land cover classification



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Cartography by Porter Margolis, 2019

Figure 8. LA County Protected Areas

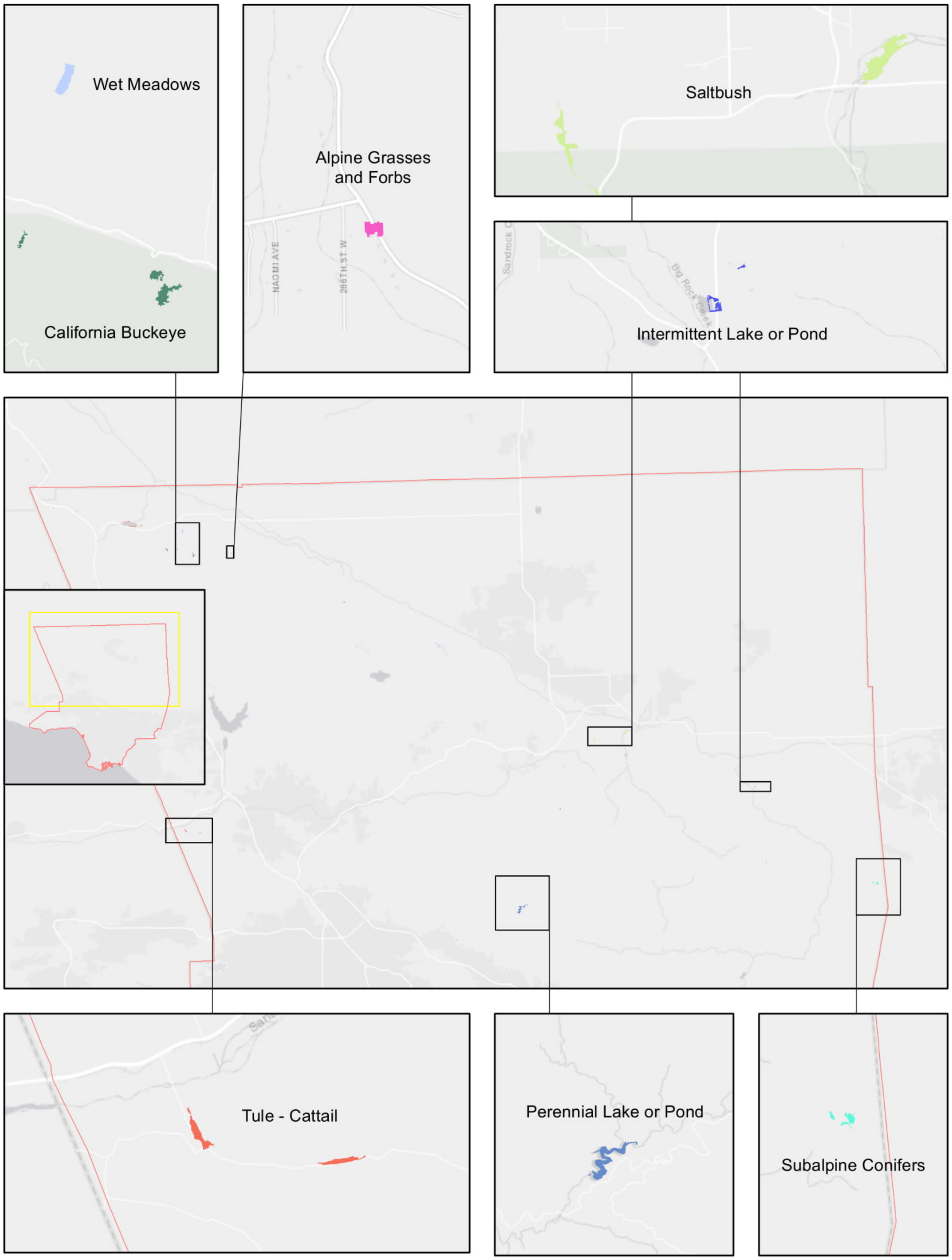

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Figure 9. Northern Los Angeles County Rare Habitat Types

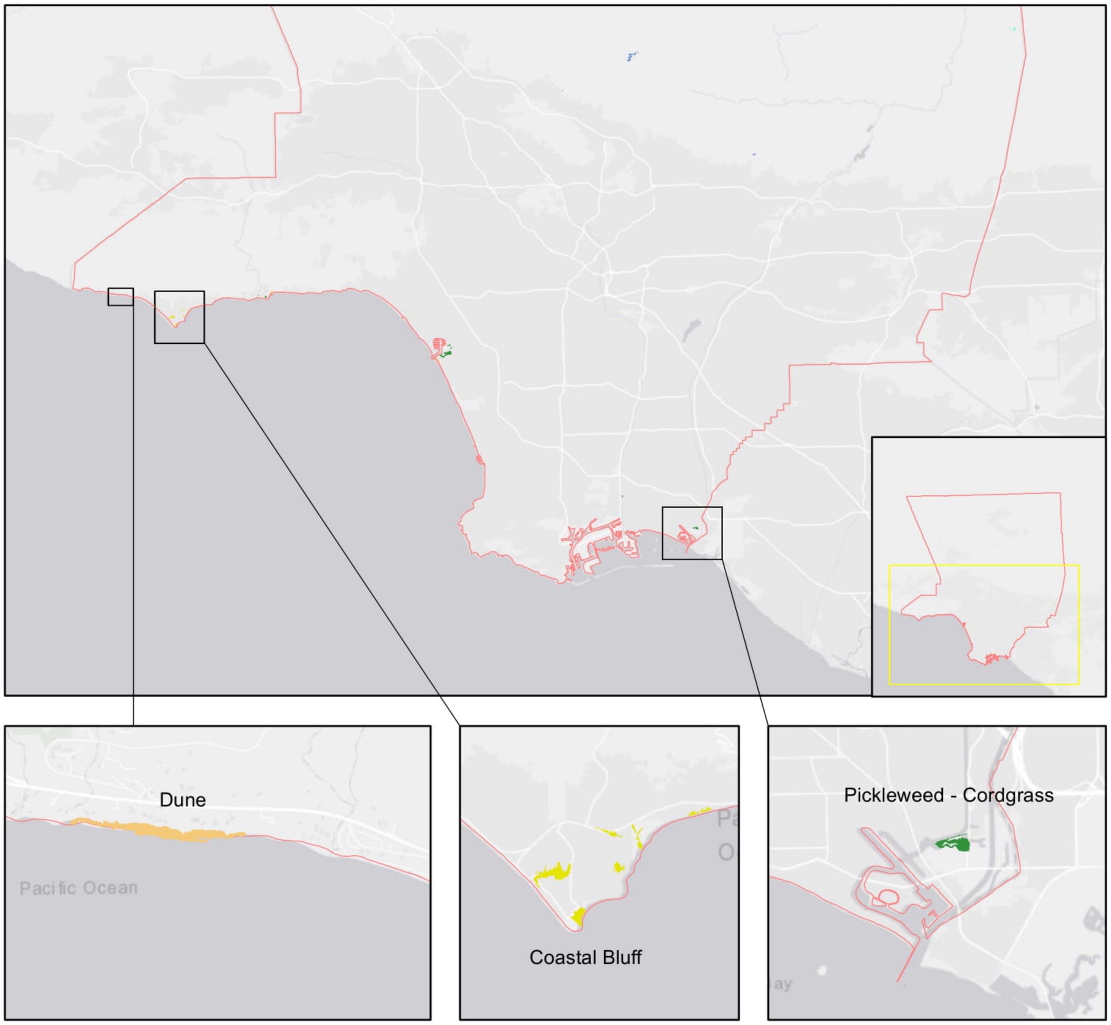

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Figure 10. Southern Los Angeles County Rare Habitat Types

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