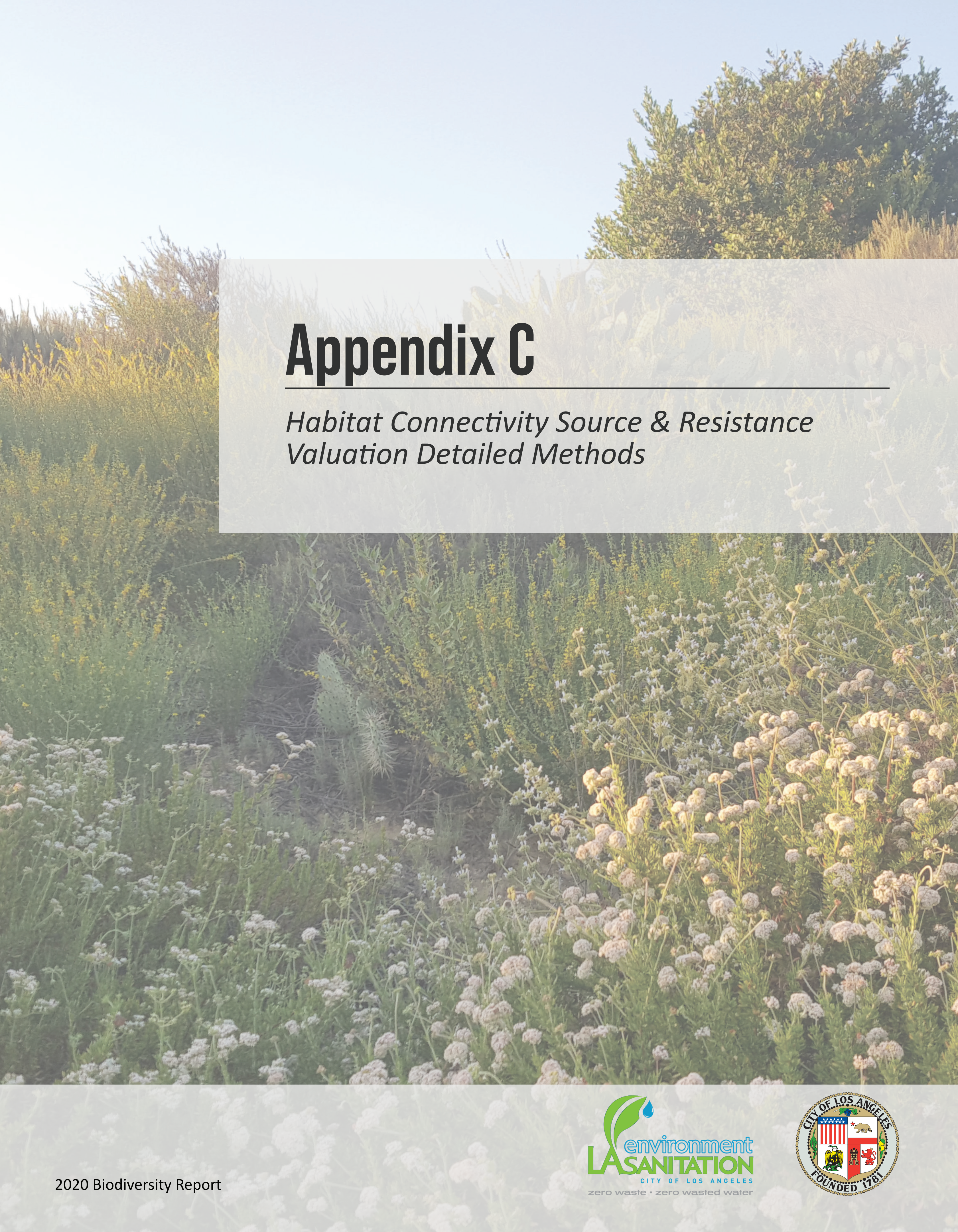

Appendix C

Habitat Connectivity Source & Resistance Valuation Detailed Methods

UNIVERSITY OF CALIFORNIA

Los Angeles

Managing Cities as Urban Ecosystems: Analysis Tools for Biodiversity Stewardship in Los Angeles

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Environmental Science & Engineering

by

Isaac Thomas Brown

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Measuring Habitat Quality (Omniscape Source Layer)

Defining a habitat quality map to serve as a "source" layer for Omniscape is the first step in measuring habitat connectivity. Such a map is also valuable in and of itself for stewardship decision making and it is a key indicator in the LA City Biodiversity Index (Indicator 1.1b). In California, habitat quality assessments are most frequently performed for individual or groups of species of conservation concern based on the State and Federal Endangered Species Act, often as a result of potential negative impacts to habitat and associated compliance with the California Environmental Quality Act (CEQA). Less common approaches address broader suites of species and ecosystems of similar conservation concern in comprehensive conservation planning projects such as California's Natural Communities Conservation Plans (NCCP's) (CDFW 2018). While more comprehensive habitat quality data, such as NCCP's, are available for various sub-areas of the study area, only datasets with complete coverage were considered in order to provide uniform results.

A newer Combined Habitat Assessment Protocol (CHAP) is also being applied by governmental agencies. CHAP assigns habitat value to different vegetation types considering species in the California Wildlife Habitat Relationships (CWHR) dataset (CDFG 2008). CHAP modeling has been performed across the entire study area (e.g. SCAG 2015); however, results are provided at a coarse-resolution and valuation strongly emphasizes native wildlife species of conservation concern typically found within high quality natural areas. The dataset accounts very low value, with little differentiation, across urban land uses that are home to mostly common native species. Connectivity or size of patches of habitat are also not considered in CHAP habitat quality valuations. The CHAP model is also proprietary and methods details for how vegetation was valued as habitat for wildlife species could not be determined. Therefore, the dataset was not incorporated into habitat valuation considerations, but could be in the future. The Green Visions Plan by Rubin, Rustigian & White (2006) also used CWHR data combined with Southern California Council of Governments Landcover Types to estimate habitat potential across the urban matrix for a set of target species of conservation concern. The full dataset could not be easily acquired and reconciled, and therefore, was not incorporated into this analysis.

This study expands upon this previous work to provide a more high-resolution, City-wide assessment of habitat quality for overall native biodiversity in both urban landscape and open space areas at a 10-foot (3.05 meter) resolution. Interpreted high-resolution, 6-inch aerial infrared remote sensing and LIDAR data resulting from the 2016 LA County Tree Canopy Assessment was resampled to a 10-foot pixel size and was used as the base layer for assigning habitat quality values (SaveATree Consulting Group 2016). This dataset also includes classification of all lands within the County classified into several types, in addition to tree canopy, and was refined and reclassified based on additional spatial data on native vegetation from several relevant, open source datasets described below. A 10-foot resolution is small enough to detect individual trees or yards in urban areas and supports a variety of local-scale stewardship objectives, including detailed biodiversity monitoring and planning at the parcel-level, prioritizing locations for protection and enhancement in both natural and developed landscapes, or for planning public access to biodiversity.

Like the CNS study, estimation of habitat quality is based on a measure of naturalness of landscapes across the study area, rather than suitability for individual species. When applied at broad scales, each of these approaches rely on remotely sensed landcover data and some level of expert judgement about the relationship between landcover and the presence of species (CDFG 2008, McRae et al. 2016). I combine considerations of two factors, vertical structural quality of vegetation ("vegetation type quality") and landscape patch size ("patch size"), into an overall habitat quality score for each pixel. Individual pixel scores for vegetation type quality and patch size were then added together and weighted for a maximum potential habitat quality score of 10 points per pixel. The detailed measurement methods, including GIS analysis steps, for habitat quality are described in Appendix F.

Detailed methods for measuring vegetation type quality, including GIS-application steps, are provided in Appendix F, Section 3.2, and are summarized as follows. Vegetation type scores are reported on a 5-point scale, with 5 representing the most natural (i.e. natural areas) and 1 being the least (i.e. typically monocultures lawns or similar). The 2016 LA County Urban Forest Canopy Assessment classified vegetated pixels into relevant types that provided the initial basis for scoring most pixels. Additionally, the CALVEG dataset was further used to classify vegetated pixels in natural areas (CALVEG 2004). Data on streams was also used to ensure that these important habitats were fully accounted for, including locations of large culverts under roadways that provide some habitat connectivity value. Finally, iNaturalist observations of native plant species were used to account for small urban natural areas and native plant landscapes, especially in highly urban areas. Scoring assumptions for each of the above datasets are presented in Appendix F, Section 3.2.2, Tables 1-3. Mapped scores for vegetation type quality for the full study area are provided in Figure 3-5 below.

Detailed methods for measuring habitat patch size, including GIS-application steps, are provided in Appendix F, Section 3.3, and are summarized as follows. All vegetated pixels were isolated into contiguous regions (patches) that were then scored 1 to 5 based on patch size. The correlation between patch size and habitat quality is a well established principle of conservation biology and landscape ecology (Dramstad, Olson & Foreman 1996). Scoring assumptions for patch size thresholds are provided in Appendix F, Section 3.3.2.4, Table 1. Mapped scores for patch size are provided in Figure 3-5 below.

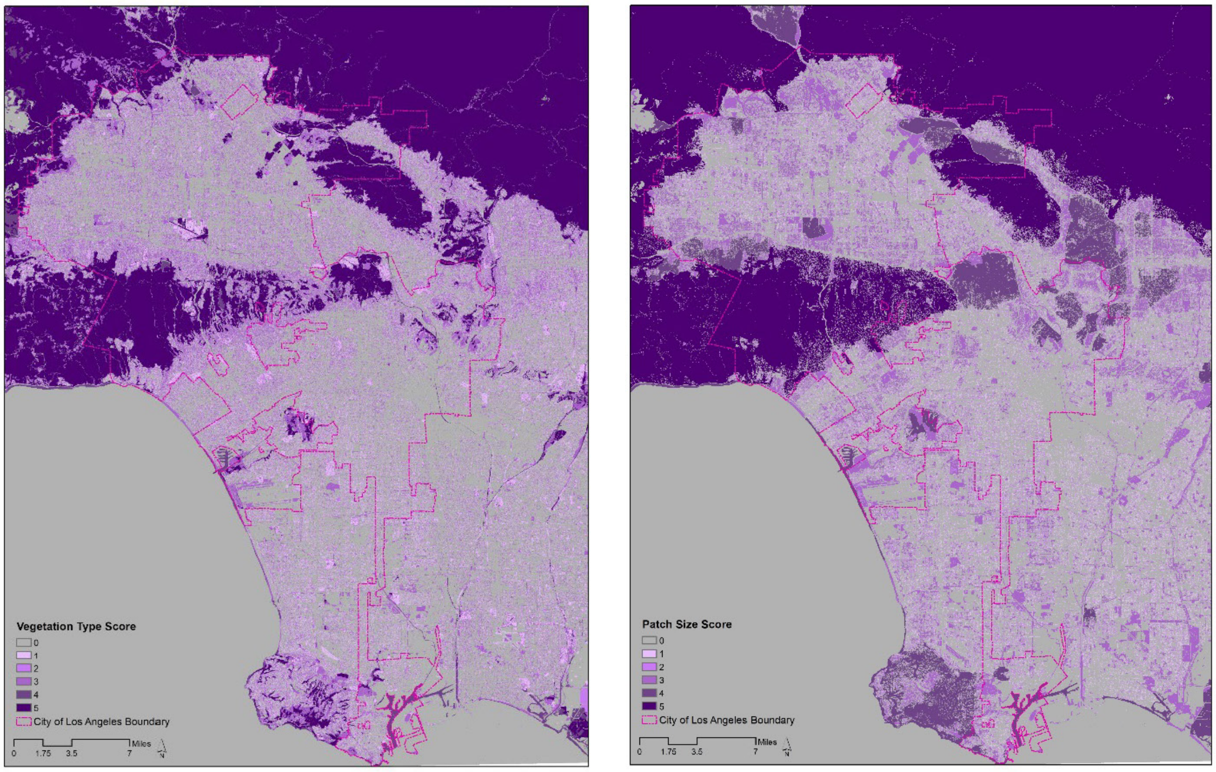

Figure 3-5: Scores for vegetation type quality (left) and patch size (right). These scores were weighted and combined to produce a total habitat quality score based on a 10-point scale.

Detailed methods for combining vegetation type quality and habitat patch size scores, including GIS-application steps, are provided in Appendix F, Section 3.4, and are summarized as follows. Individual pixel scores for vegetation type quality and patch size were added together for a maximum habitat quality score of 10 points per pixel. All pixels scoring 5 for vegetation type quality (i.e. native vegetation) were weighted so that no pixel containing native vegetation could score less than 7 total points, regardless of patch size, according to the rules described in Appendix F, Section 3.3.2.4, Table 1 (i.e. native vegetation types are weighted higher in importance for native biodiversity than all other vegetation types or patch size criteria). The resulting dataset also serves as the measurement of LA City Biodiversity Index Indicator 1.1b. Habitat quality scores were used as the basis for Omniscape "source" layer described in the following section. Total cumulative scores for the study area are mapped in Figure 3-6, and a detailed view for the Elysian Valley test area is provided in Figure 3-7.

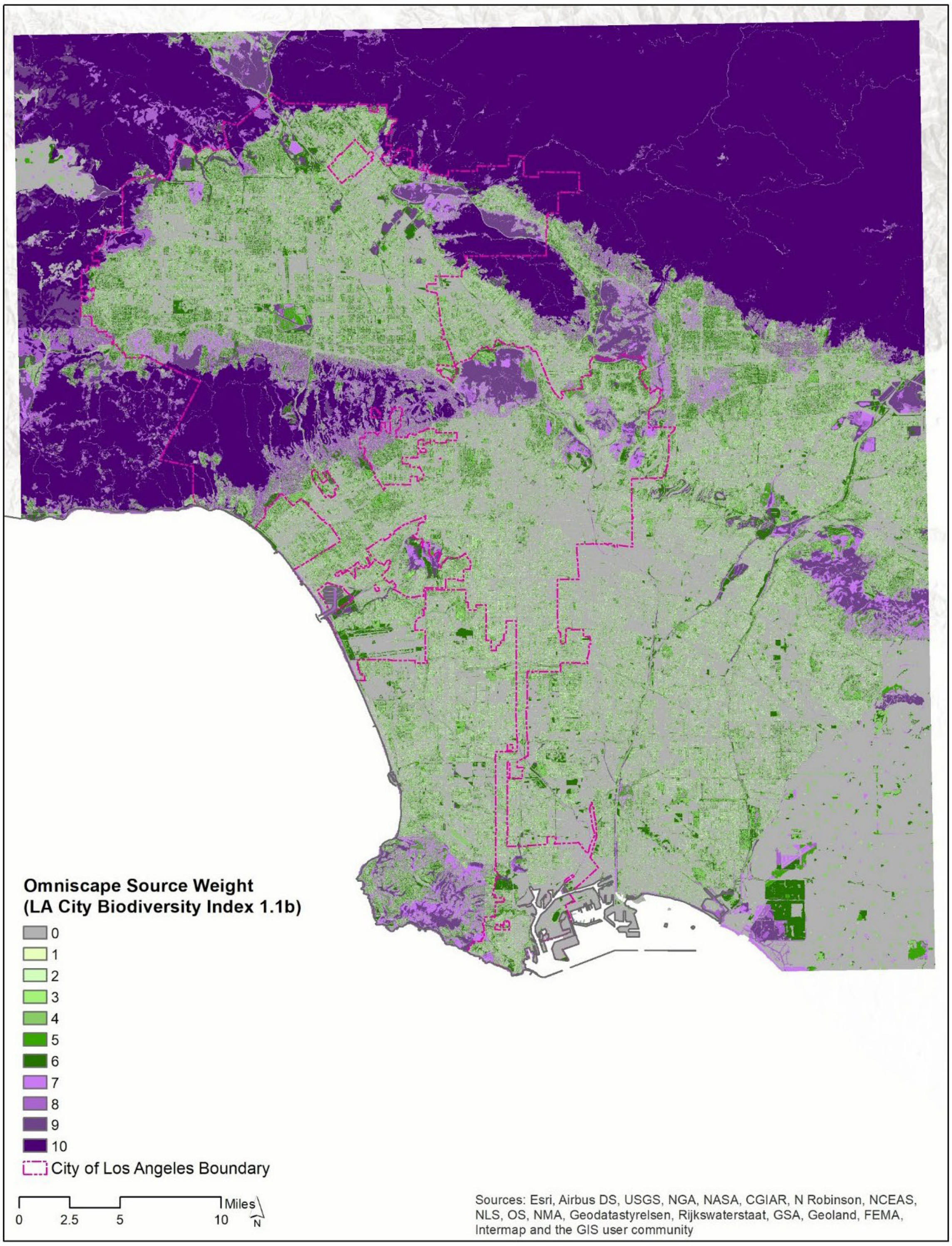

Figure 3-6: Habitat Quality scores/Omniscape source values for the study area.

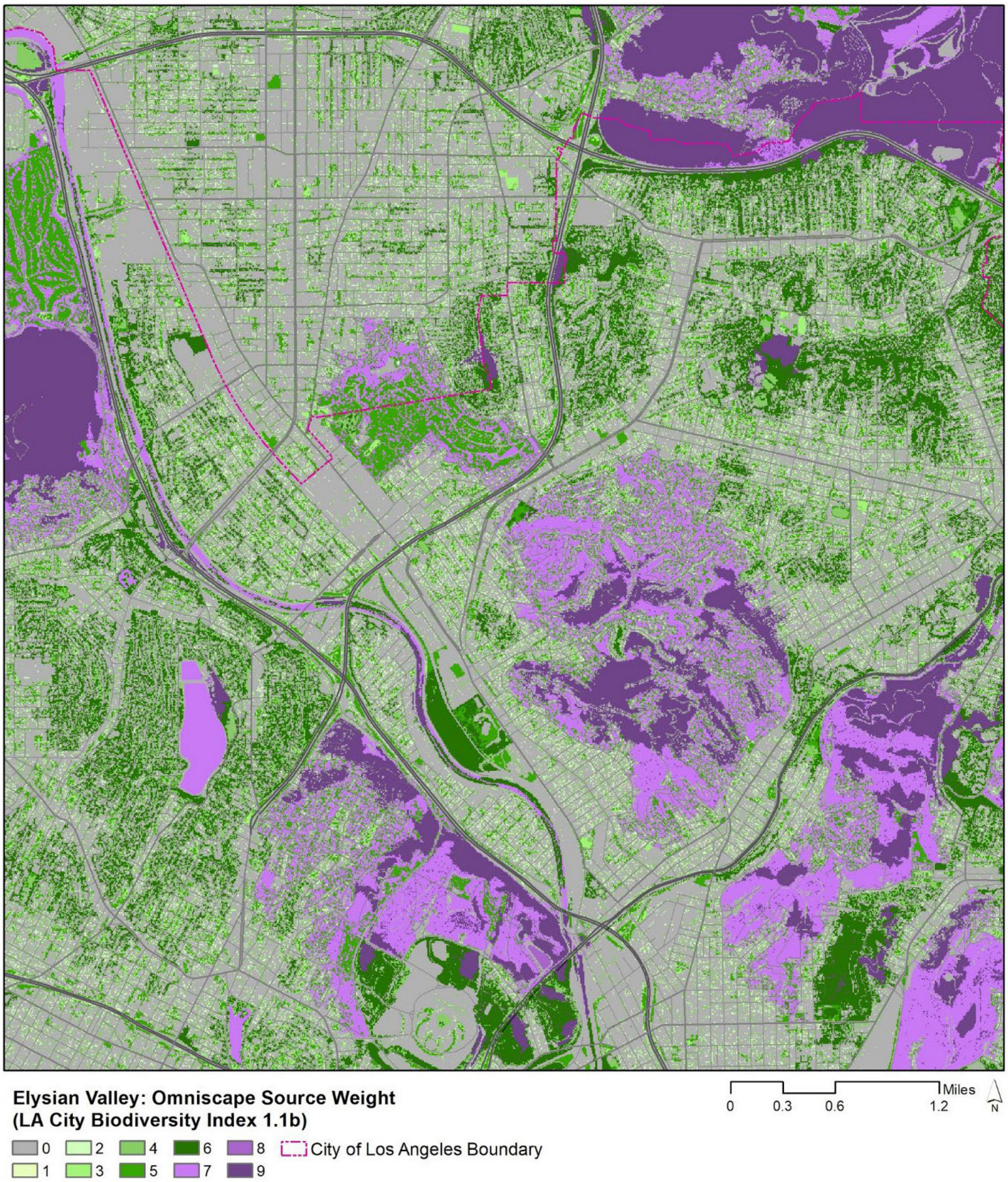

Figure 3-7: Habitat quality scores/Omniscape source weights for the Elysian Valley test area.

Estimating Resistance to Species Movement (Omniscape Resistance Layer)

The Source Layer was combined with the Southern California Council of Governments (SCAG) 2008 Land Use layer to produce the resistance layer for species movement in Omniscape. This regional land use map aggregates local municipal land use maps from the numerous local planning agencies within the study area. The specificity of each of the 100 land use types in the resulting dataset, and the precise polygon delineations, provides a detailed estimate of land use intensity and boundaries suitable for converting to the relatively high 10' pixel resolution of this study. Many of the 100 land use types provided were relatively duplicative because they represented different local naming and classification conventions for the same general land use. I reviewed the descriptions of each type and reclassified them into 15 general types based on assumed land use intensity and potential resistance to species movement (see Table 3-1). Refining resistance values considering road traffic volumes, more detailed land use for the City of Los Angeles, building footprints, and other mapped barriers is a planned next step for application.

While Rubin, Rustigian & White (2006) did not address habitat connectivity, they estimated potential habitat suitability in urban Los Angeles based on an earlier version of SCAG land use and land cover types and considering literature review combined with expert judgement for multiple target species. McRae et al. (2016) based resistance on land cover type assigned in the National Landcover Dataset (NLCD), and they selected resistance values based on expert judgement of the relationship of intensity of land uses to the potential for species movement. NLCD land cover is somewhat different than land use types from SCAG in that land cover types reflect dominant physical surface characteristics detected using remotely sensed imagery at a 30-meter pixel resolution, whereas SCAG land use is based on uses allowed under local zoning law and are spatially defined by more precise legal parcel delineations. In addition to the relatively coarse spatial resolution of NLCD, another drawback is that there are significantly fewer classes of urban landcover than SCAG land use types, and they do not consider different types of activities within land covers that may reflect the same general physical surface characteristics when sensed remotely using satellites. SCAG land use types provide additional information relative to types of activities occurring within them, such as commercial activities which may have stronger impacts on movement than other land uses of similar surface characteristics. Additionally, since NLCD also assigns land cover type based on dominant characteristics within the pixel, pixels with lower amounts of vegetation may be classified as an urban land cover type and pixels slightly dominated by vegetation may be classified as a vegetated type, but may still include some urban land uses.

The approach presented here is somewhat of a hybrid between purely landcover and land use-based approaches. First, I consider remotely sensed surface cover for differentiating vegetated vs. non-vegetated pixels using the 2016 LA County Urban Forest Canopy Assessment dataset and CALVEG. I assigned vegetated pixels, regardless of the underlying SCAG land use type they fall within, with relatively low resistance scores based on their source values, but reversed (i.e. source scores of 10 receive a resistance score of 1, 9 = 2, 8 = 3, etc.). Adjusting vegetated pixel resistance based on underlying land use context may be appropriate in this more urbanized area and should be explored as a next step in application. Next, I assigned resistance values to non-vegetated pixels based on the underlying SCAG land use type. Values of 23 to 300 were given for non-vegetated pixels, which reflects similar values to McRae et al (2016). Land uses, such as commercial and high rise residential, were assumed to produce higher "edge effects", such as light, noise, traffic, or litter, or other land use impacts that may reduce native species movement and were given the highest resistance values. Non-vegetated pixels within land uses such as low density residential and open space were given the lowest resistance values since they were assumed to produce less edge effects. Campus, office, and industrial land uses were given moderate resistance values. The ocean was given a "no data" value because this study is intended to assess terrestrial permeability only (including small water bodies).

A crosswalk of resistance values by SCAG land use type and habitat quality (source value) are provided in Appendix G, Section 3.2.4, Table 1. The 15 resulting land use types and associated resistance values used in the modeling are presented in Table 3-1 below. The overall study area resistance map is shown in Figure 3-8 and the Elysian Valley test area is shown in Figure 3-9.

Table 3-1: Resistance value calibration of the omniscape model for the Elysian Valley test area. Source values were used as resistance values for vegetated pixels regardless of land use context. Non-vegetated pixels were given higher resistance values based on a reclassified version of SCAG's 2008 land use types.

Vegetated Pixels	
Pixel Type	Resistance Value
Source Values 1-10	Reverse of Source Value (10=1, 9=2, etc.)

Non-Vegetated Pixels (Source Values 0)	
Pixel Type	Resistance Value
General Open Space	23
Vacant	25
Low Density Residential	30
Campus	30
Water Infrastructure	30
General Agriculture	30
General Water	30
Medium Density Residential	40
Under Construction	45
High Density Residential	50
Office	60
Insustrial	75
Transportation	75
High Rise Residential	150
Commercial	300

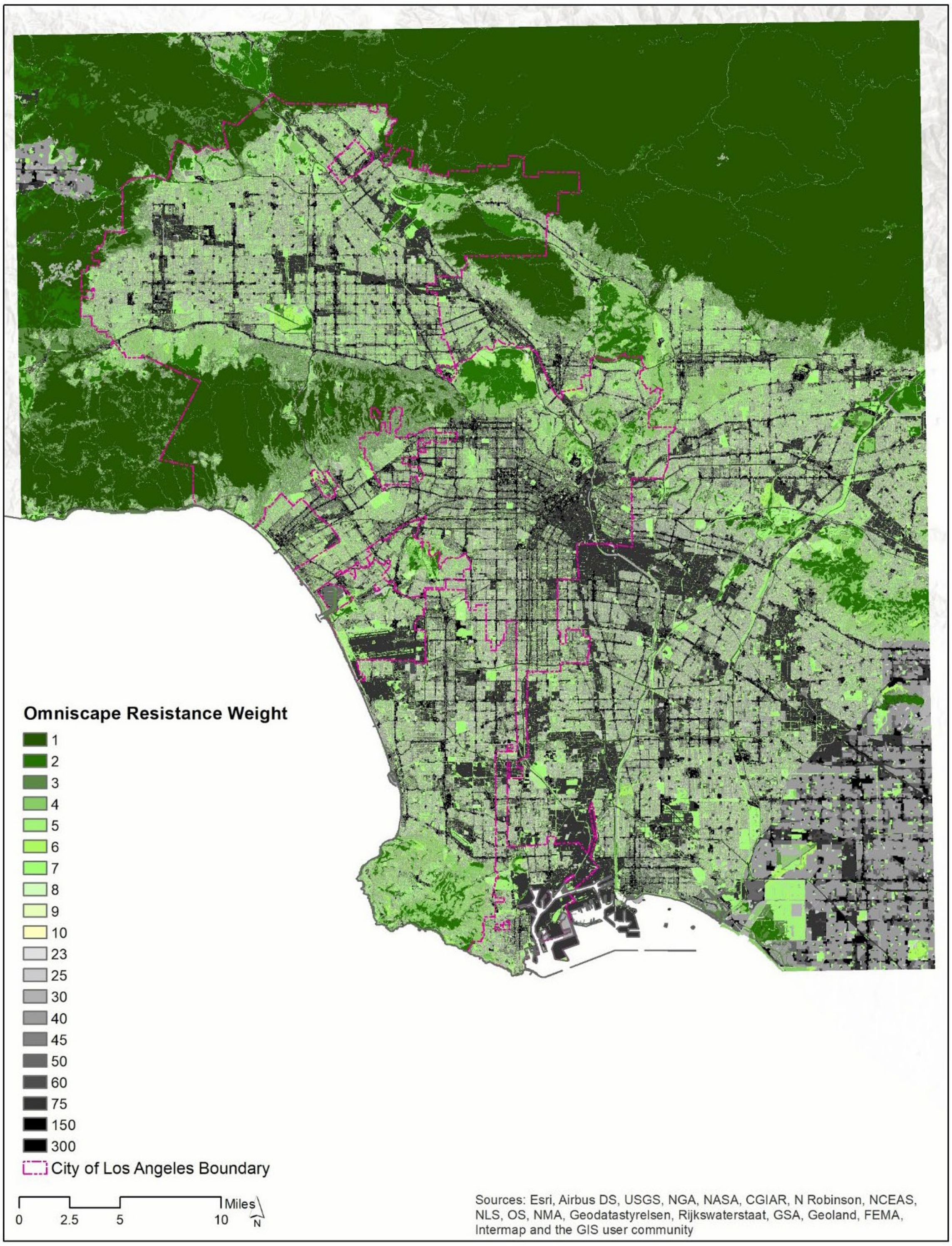

Figure 3-8: Resistance weights for land use and land cover for the overall study area.

Figure 3-9: Resistance weights for the Elysian Valley test area.

Omniscape uses a moving window process to test connectivity of each individual pixel to pixels surrounding it to a certain specified distance (i.e., the window). It combines measurements for each pixel into an overall "current flow" map for the area of interest suggesting levels of potential species movement. In this way, Omniscape creates a "wall-to-wall" connectivity map, as opposed to mapping connectivity between pairs of core habitat areas, which is often done when mapping specific, individual corridors using older Circuitscape software. The size of the moving window determines how far to evaluate potential connectivity, and a small moving window would test only local connectivity, while a larger window tests longer distance connectivity. Both local and long distance movement of species is seen as necessary for species and ecosystems to adapt to climate change, and my assumption is that local and long-distance movement is also necessary for urban ecosystems and biodiversity within fragmented urban habitats to adapt to urban or climate change stressors (Anderson et al 2012).

I used Omniscape version 1.2 through the Julia operating platform to run this analysis (https://circuitscape.github.io/Omniscape.jl/stable/, https://julialang.org/downloads/). The results presented here are for a local connectivity within a ½ mile (0.8 km) window of each pixel across the 1.4 million, 30' resolution pixel Elysian Valley test area. 10' pixel resolution provided for the source and resistance maps was resampled to 30' in order to reduce computing power requirements but still provide relatively high-resolution results. The ½ mile window is assumed to represent a measure of local connectivity of habitat pixels. Modeling a long-distance moving window, planned as 5 miles (8 km), was computationally prohibitive using my currently available systems.

Julia requires a specific set of file formats and code steps to run Omniscape and the code used for the Elysian Valley test area is provided in Appendix G, Section 3.3. Underlying computational details of Omniscape are described in Anantharaman et al. (2019). While the underlying computations in Omniscape are complex, the run codes are relatively simple and require just a few basic calibration steps. The only calibrations with significant underlying ecological measurement implications are the moving window size, resistance, and source weights. Other omniscape calibrations within this code are designed to optimize model run time based on computing power constraints and model output formats (e.g., block size, # of parallel processes, normalized current map, etc.) and are described in the Omniscape websites provided above.

Results

The basic Omniscape output is a "current flow" map within the area of interest (see Figure 3-10). As was mentioned previously, results are presented for the 1.4 million pixel sub-area, the Elysian Valley test area. Results demonstrate local-scale connectivity using a ½ mile moving window. A larger analysis extent and higher computing power is necessary to measure long-distance connectivity using the 5-mile window; however, local-scale connectivity mapping also partially reflects these longer-distance connections.

APPENDIX F: Habitat Quality of Landscapes and Open Space GIS Methods

1. Datasets Used:

1.1. Dataset 1 Name: LA County Tree Canopy Assessment 2016 (Based on LARIAC 2014?) (Propriatery)

1.1.1. Dataset Filename: landcover_2016_losangeles.tif

1.1.2. Dataset Location: D:\TreeCanopy_LosAngeles_2016.gdb\landcover_2016_losangeles_countywide_mosaic\landcover_2016_losangeles_countywide_mosaic

1.1.3. Reference: https://www.treepeople.org/sites/default/files/pdf/tree-canopy-data/Tree%20Canopy%20LA%202016%20Report_FINAL%2020190425.pdf

1.1.4. Original Source: https://egis3.lacounty.gov/dataportal/lariac/lariac-archives/lariac4-archive/

1.1.5. Original Source Metadata:

1.1.6. Dataset Discussion: Includes landcover classified into 8 classes by University of Vermont team for LA County. Original dataset has 0.75 foot resolution.

1.1.7. Citation: SavATree Consulting Group, University of Vermont Spatial Analysis Laboratory, TreePeople, & Loyola Marymount University Center for Urban Resilience. (2016) *Los Angeles County Tree Canopy Assessment,* 2016.

1.2. Dataset 2 Name: CALVEG Southern Coast Section

1.2.1. Dataset Filename: ExistingVegSouthCoast2002_2010_v2.gdb

1.2.2. Dataset Location:

1.2.3. Original Source: https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

1.2.4. Original Source Metadata:

https://www.fs.fed.us/r5/rsl/projects/gis/data/vegcovs/scoast/ExistingVegSouthCoast2002_2010_v2.html

1.2.5. Dataset Discussion: Only complete and uniform dataset of natural vegetation available for the entire City. Some level of error due to statewide extent and resolution. This dataset does not identify small natural, naturalized, or restoration areas well. Also, data was collected over 10 years starting approximately 1998 which will result in some error due to landcover change.

1.3. Dataset 3 Name: LA County Department of Parks and Recreation Parks and Open Space

1.3.1. Dataset Filename: DPR_COUNTYWIDE_PARKS_AND_OPENSPACE

1.3.2. Dataset Location:

1.3.3. Original Source: https://egis3.lacounty.gov/dataportal/2016/10/25/department-of-parks-and-recreation-county-parks-and-open-space/

1.3.4. Dataset Discussion: Includes all City and County parks and open space including park program elements. National forests aren't included.

1.4. Dataset 4 Name: LA County CAMS Streets & Addresses 2014

1.4.1. Dataset Filename: CAMS.gdb

1.4.2. Dataset Location: \\htpgis3\General_Users\RAD

1.4.3. Original Source: http://egis3.lacounty.gov/dataportal/2014/06/16/2011-la-county-street-centerline-street-address-file/

1.4.4. Dataset Discussion: Includes streets, roadways, rail, trails, etc., and related information for Los Angeles County.

1.5. Dataset 5 Name: SCAG Los Angeles Countywide Zoning 2008

1.5.1. Dataset Filename: zoning_countywide.shp

1.5.2. Dataset Location: \\htpgis3\General_Users\RAD

1.5.3. Original Source: https://egis3.lacounty.gov/dataportal/2012/04/10/countywide-zoning/

1.5.4. Dataset Discussion: Includes detailed zoning normalized by SCAG for all Cities in the County. "Zone_Code" field is most detailed and includes densities. "SCAG_GP_CO" field includes less detailed descriptions used in the County general plan. This field was referenced in this analysis to identify schools.

1.6. Dataset 6 Name: LA County Department of Public Works Storm Drain Network

1.6.1. Dataset Filename: SDN_Public.gdb

1.6.2. Dataset Location: \\htpgis3\General_Users\RAD

1.6.3. Original Source: http://egis3.lacounty.gov/dataportal/2013/08/08/los-angeles-county-storm-drain-system/

1.6.4. Dataset Discussion: Used to identify open channels and streams. Includes some additional information/different information than the NHD dataset (below) but includes few natural streams. Many natural streams within LA (especially Hollywood Hills) are missing from both datasets.

1.7. Dataset 7 Name: National Hydrography Dataset

1.7.1. Dataset Filename: nhd_flowline_withcodes.shp

1.7.2. Dataset Location: \\htpgis3\General_Users\RAD

1.7.3. Original Source: http://egis3.lacounty.gov/dataportal/2013/08/08/los-angeles-county-storm-drain-system/

1.8. Dataset Discussion: Mainly used to identify streams. Includes many more natural streams that the DPW "Stream/River" dataset. However, many known natural streams within LA (especially Hollywood Hills) are missing from both datasets.

2. Other Datasets Considered

2.1. NWF Certified Habitat gardens/schools. This dataset could be used in a similar way to iNaturalist data by assigning addresses that are certified a score of 5 for the parcel. However, NWF addresses are not to be shared with the public and would need to be modified, possibly by assigning scores based on broader-scale pixels instead of parcels.

3. Methods

3.1. Extract and resample UVT LARIAC (2016 Canopy Assessment per above) Landcover raster

3.1.1. Extract pixels for study area extent boundary (extract by mask using a 10ft pixel rasterized County boundary clipped to the square version of the ecotopes extent boundary ("Charbdry1…20km").

3.1.2. Extraction will result in resampling of the 0.75' pixel UVT LARIAC raster to a 10' pixel size (extracting "nearest" pixel value to determine pixel value of the 10' pixel. Maximum is preferred but couldn't figure out how to get it to work.

3.1.3. Expand extent of UVT LARIAC raster file to analysis extent because it doesn't include areas of Orange or Ventura County (See Chapter 2, Ecotopes for discussion of analysis extent). The habitat quality layer will ultimately be used to model habitat connectivity indicators using Citcuitscape/Omniscape, and connectivity analysis requires an extent broader than the City boundary to improve connectivity modeling accuracy within the focus area.

3.1.3.1. Convert Ecotopes extent rectangular boundary file to a 10ft raster. (filename: CharBdry1_5kmNSW_wshdNE_20kmE).

3.1.3.2. Use "Cell Statistics" tool in ArcGIS. Spatial Analyst>Local>Cell Statistics. Add boundary file and UVT LARIAC File, overlay statistic="Maximum", check box to ignore no data cells. Edit no data cells to have value 999.

3.1.3.3. Do the same for other data layers including streams, iNaturalist and CALVEG. There were issues with the extent of the output and it was necessary to open the Environments dialog box in the Cell Statistics tool and select **Processing Extent> Extent** item to "Union of Inputs".

3.2. Score Vegetation Type Quality of Landscapes.

3.2.1. For areas within or outside LA County, score the pixels of the UVT LARIAC raster based on the following rules by combining UVT LARIAC raster, Classified CALVEG raster, streams

(NHD and DWP datsets), and “barefix” raster, which scores bare soil that is ballfields from the UVT LARIAC per rules below. File name is 1.1bhabqual#

3.2.2. All files need to be converted to raster files per metehods in 3.1 and combined into a master raster with all relevant fields and scored in a “Max” field according to the following rules. Note that CALVEG needs to be made into a wall to wall raster for the study area. The ocean is excluded, so union with boundary and give ocean a unique value to address in raster combining.

1.1b Vegetation Type (Habitat Quality) Scoring Rules

Table 1: Within LA County						
LARIAC Landcover Type	**Score 0**	**Score 1**	**Score 2**	**Score 3**	**Score 4**	**Score 5**
Buildings	All pixels					
Roads/Railroads	All pixels					
Other Paved	All pixels					
Grass/Shrubs		All other pixels		in CALVEG Degraded natural areas		in CALVEG Natural Areas, iNat research grade native plant observation
Tree Canopy				All other pixels		in CALVEG Natural Areas, iNat research grade native plant observation
Bare Soil			in CPAD 2019 Local Parks with Baseball Fields or SCAG 2005 Land Use Elem, Jr, and High Schools (most of this appears to be ball fields so score of 2 is a compromise since some degraded natural areas	All other pixels (includes smaller degraded natural areas and some dry natural areas not detected in CALVEG, but also a lot of urban bare soil too)		in CALVEG Natural Areas, iNat research grade native plant observation

			might be in this class too)			
Water				All other pixels		in CALVEG Natural Areas, iNat research grade native plant observation
Tall Shrubs						All pixels

Table 2: Within LA County (Other Datasets)						
Dataset	**Score 0**	**Score 1**	**Score 2**	**Score 3**	**Score 4**	**Score 5**
LA County Department of Public Works Stormdrain Network				“Open Channel” and LARIAC score of 0	Other “Open Channel” (Except CALVEG or LARIAC score of 5 overrides)	“Natural Drainage”
National Hydrography Dataset				“Artificial Path”, “Canal/Ditch”, “Connector” and LARIAC score is 0	Other “Artificial Path”, “Canal/Ditch”, “Connector” (Except CALVEG or LARIAC score of 5 overrides)	Description Field: “Stream/River” of any type (three types)

Table 3: Outside of LA County						
Dataset	**Score 0**	**Score 1**	**Score 2**	**Score 3**	**Score 4**	**Score 5**

CALVEG Dataset	CALVEG Urban or Developed (classifications per 2018 Biodiversity Report Appendix B Indicator 1)	CALVEG Non-Native ornamental grasses or Agriculture (classifications per 2018 Biodiversity Report Appendix B Indicator 1)		All other non-native vegetation (including Urban Agricutlture, remaining classifications per 2018 Biodiversity Report Appendix B Indicator 1)	Degraded Natural Areas (includes CALVEG "Water" and remaining classifications per 2018 Biodiversity Report Appendix B Indicator 1)	CALVEG Natural Areas, Known Restored/Constructed Habitat Areas

Notes: There are various levels of error in these datasets and assumptions on the above scores represent effort to accommodate this error. On gound-field truthing at sites of interest should be performed if/when this dataset is used to evaluate site conditions. Some error may be corrected with further data processing. Key sources of error include:

- The UVT LARIAC dataset combines grass and shrubs into one class. Isolating grass and giving that a value of 1, and giving shurbs a 2 or a 3, would improve detection of native and non-native shrub areas.
- Some native chapparal classified as “tree canopy” in UVT LARIAC. Much of this is corrected by through integration of CALVEG natural areas which result in score of 5 for these areas of canopy.
- Some annual grasslands and native shrubs classified as “bare soil” or “grass and shrubs” in UVT LARIAC.
- Some Annual Grasslands (Degraded Natural Areas) in CALVEG are misclassified areas of urban development or urban bare soil. Therefore, these classes have not been included within LA County except to bump up scores of grass/shrubs due to potential for native species.
- Not all perennial or ephemeral streams are mapped within the study area, especially those on private property including the Hollwood Hills.

3.3. Score Patches of Landscape/Canopy based on Patch Size

3.3.1. Note: Considered using streets as breaks in patches, however, decided against it since UVT LARIAC is so detailed large street with no overhanging tree canopy are detected as breaks. Overhanging tree canopy or vegetated bridges/tunnel overpasses detected in UVT LARIAC are assumed to constitute connectivity. I tested using CAMS Streets to break paches, however this reduced accounting of connectivity benefits of overhanging tree canopy, it also resultd in removing any vegetated tunnel overpasses (e.g. Elysian Park over the 110 and likely future habitat bridges). Singapore Index requires considering 15 meter or wider streets as breaks. Again this wasn't necessary since LARIAC will account for breaks from streets as small as 10' (pixel size). Additionally, few streets over 15 meters have contiguous canopy, so most are considered breaks in paches in LARIAC as well. Canopied streets over 15 meters (if they exist) are assumed to be beneficial for connectivity and not counted as breaks in this measurement.

3.3.2. Differentiate and score patchs based on size

3.3.2.1. Use UVT LARIAC for LA County and CALVEG for outside of LA County to identify patches of habitat. Any landscape/canopy or water detected by satellite is considered part of a patch. Combine LARIAC and CALVEG. Add "Field Name" and edit scores for all landscape/canopy as score 2 and all built, streets, streets, etc as score 1

3.3.2.2. Use "Lookup" tool to create new raster from "Field Name" field with values of 1 or 2. Spatial Analyst>Reclass>Lookup

3.3.2.3. Use "Regional group" tool to group pixels from Lookup file into patches. Spatial Analyst>Generalization>Region group. Set "score 1 (or whatever value used for developed lands" values as "no value". Set "number of neighbors to use" to "4" (default, most conservative).

3.3.2.4. Score patches (region value 2 in "Field Name" field) based on region size (i.e. "count" field for # of 100 square foot pixels) based on following rules.

Table 1: Habiat Patch Scoring Rules

Patch Size Range	Score	Justification for Score Threshold
500 sf or less, except when Vegetation Type score is 5, then those pixels 3	0	
>500 sf to <0.5 acres (count 5 to <218), except when Vegetation Type scores 5, then those pixels 3	1	500' is project threshold in LID ordinance, typical mature tree canopy.
0.5 acres to <3 acres (count 218 to <1,307), except when Vegetation Type scores 5 then those pixels in paches score 4	2	0.5 acres was used for SFPUC Triple Bottom Line
3 acres to <300 acres (count 1,307 to <130,680), except when Vegetation Type scores of 5 then those pixels score 4	3	3 acres is near the lower range of home territories/ranges for small upland and riparian birds of conservation concern targeted in the at Green Visions project. Including yellow-breasted chat, lark sparrow, and rufous crowned sparrow.

300 acres to <10,000 acres (count 130,680 to <4,356,000), except when Vegetation Type scores of 5 then those pixels in paches score 4	4	300 acres is size of Deb's Park which has bobcat population.
10,000 acres+ (count 4,356,000+)	5	10,000 acres is threshold used in California Essential Habitat Linkages project.

3.4. Combine Patch Score and Vegetation Type Score (files call this Habitat Quality or Value) into Overall Habitat Quality Score of 1-10 points.

3.4.1. Combine final output tables, latest versions are called "Lookup_Regio6_PTCHSCRMaster" and "1_1b_habql11". Final combined Habitat Quality Score File is called: 1_1b_qalptch6. Spatial analyst>Local>Combine.

3.4.2. Add field called "QULPTCH_REP". Add both scores for veg type and patch size together. Adjust scorring for patches that score 5 for veg type per rules in table 3.3.2.4. above and…

3.4.2.1. Correct final score for streams that fall within LARIAC pixels classified as developed/roads/built (these score 999 for patch sze in current file). Assume patch score is 4 for pixels with habitat quality of 5, 3 for habitat quality of 4 or 3, 2 for habitat quality 2 or 1.

3.4.2.2. Weighted and unweighted scoring was tested. Unweighted scoring is used for all but natural areas that score 5 for vegetation type (habitat quality/value). This is to ensure that all natural areas, large or small, in the City are valued at a very high level, regardless of size.

3.4.3. Final output file for Omniscape is called source_fin3. It is the same as the final habitat quality score.

APPENDIX G: Habitat Connectivity of Landscapes and Open Space GIS Methods

1. Datasets Used:

1.1. Results of Indicator 1.1b Habitat Quality of Landscapes and Open Space (and all associated datasets)

1.2. Dataset 5 Name: SCAG Los Angeles Countywide Zoning 2008

1.2.1. Dataset Filename: zoning_countywide.shp

1.2.2. Dataset Location: \\htpgis3\General_Users\RAD

1.2.3. Original Source: https://egis3.lacounty.gov/dataportal/2012/04/10/countywide-zoning/

1.2.4. Dataset Discussion: Includes detailed zoning normalized by SCAG for all Cities in the County. "Zone_Code" field is most detailed and includes densities. "SCAG_GP_CO" field includes less detailed descriptions used in the County general plan. This field was referenced in this analysis to identify schools.

2. Other Datasets Considered

2.1. NASA landcover TBD.

3. Method

3.1. Convert Habitat Quality raster file into "source weight" file to run in Omniscape.

3.1.1. Using Lookup. Current version called "source_fin3". Note: Ocean should have no data (-9999 in current Omniscape version) to reduce processing time.

3.1.2. Resample to 30' pixels. Data Management Tools>Raster>Raster Process>Resample.

3.2. Prepare "resistance" file for Omniscape

3.2.1. Convert SCAG Land Use to 30' raster grid from polygon. Remove or reclassify ocean polygons classified as "GenWater" around the Port so they can be given same -9999 no data resistance score as rest of ocean.

3.2.2. Expand grid to study area using boundary file (must be resampled to 30').

3.2.3. Vegetated areas from the Source Weight file receive the reverse value for resistance (i.e. 10=1, 9-2, etc).

3.2.4. All pixels scoring zero (i.e. developed/built) are scored for resistance values of 20 or greater. Reclassify the 100 SCAG LU05 types to 15 categories and assign scores based on the following rules in the table below. Each of the 100 land use type descriptions were reviewed during the reclassification process – many are duplicative and represent the various conventions of planning agiencies who's codes were aggregated to produce the

SCAG regional land use map LU05. LU05 was the most recent comprehensive compilation by SCAG that covered the entire study area. The SCAG landcover dataset used for Green Visions also looked good but SCAG folks couldn not find it. Resistance values are based on resistance values used in McCrae et. al 2016 (Connecting Natures Stage).

Table 1: Resistance Weight – Land Use Crosswalk			
Source Weight	Southern California Council of Governments LU05 Code	ReClassified Land Use	Resistance Weight
10	Varies	Varies	1
9	Varies	Varies	2
8	Varies	Varies	3
7	Varies	Varies	4
6	Varies	Varies	5
5	Varies	Varies	6
4	Varies	Varies	7
3	Varies	Varies	8
2	Varies	Varies	9
1	Varies	Varies	10
0	1111	Medium Density Residential	40
0	1112	Low Density Residential	30
0	1121	High Density Residential	50
0	1122	High Density Residential	50
0	1123	High Density Residential	50
0	1124	High Rise Residential	150
0	1125	High Rise Residential	150
0	1131	High Density Residential	50
0	1140	High Density Residential	50
0	1151	Low Density Residential	30
0	1152	Low Density Residential	30
0	1211	Office	60
0	1212	High Rise Residential	150
0	1213	High Rise Residential	150
0	1221	Commercial	300
0	1222	Commercial	300
0	1223	Commercial	300
0	1224	Commercial	300
0	1231	Commercial	300
0	1232	Commercial	300
0	1233	Office	60
0	1241	Office	60
0	1242	Office	60
0	1243	Office	60
0	1244	Office	60
0	1245	Office	60
0	1246	Office	60
0	1247	Commercial	300
0	1251	Commercial	300

0	1252	Office	60
0	1253	Office	60
0	1261	Office	60
0	1262	Office	60
0	1263	Office	60
0	1264	Office	60
0	1265	Campus	30
0	1266	Office	60
0	1271	Campus	30
0	1272	Vacant	25
0	1273	Campus	30
0	1311	Industrial	75
0	1312	Office	60
0	1313	Industrial	75
0	1314	Office	60
0	1321	Industrial	75
0	1323	Industrial	75
0	1324	Industrial	75
0	1325	Industrial	75
0	1331	Industrial	75
0	1332	Industrial	75
0	1340	Industrial	75
0	1411	Transportation	75
0	1412	Transportation	75
0	1413	Transportation	75
0	1414	Transportation	75
0	1415	Industrial	75
0	1416	Industrial	75
0	1417	Industrial	75
0	1418	Transportation	75
0	1420	Industrial	75
0	1431	Industrial	75
0	1432	Industrial	75
0	1433	Industrial	75
0	1434	Water Infrastructure	30
0	1435	Industrial	75
0	1436	Water Infrastructure	30
0	1437	Water Infrastructure	30
0	1438	Water Infrastructure	30
0	1440	Industrial	75
0	1450	Transportation	75
0	1460	Transportation	75
0	1500	Industrial	75

0	1600	Commercial	300
0	1700	Under Construction	45
0	1810	General Open Space	23
0	1821	General Open Space	23
0	1822	General Open Space	23
0	1831	General Open Space	23
0	1832	General Open Space	23
0	1840	General Open Space	23
0	1850	General Open Space	23
0	1860	General Open Space	23
0	1870	General Open Space	23
0	1880	General Open Space	23
0	2110	General Agriculture	30
0	2120	General Agriculture	30
0	2200	General Agriculture	30
0	2300	General Agriculture	30
0	2400	General Agriculture	30
0	2600	General Agriculture	30
0	2700	General Agriculture	30
0	3100	Vacant	25
0	3200	General Agriculture	30
0	3300	Vacant	25
0	3400	General Open Space	23
0	4100	General Water	30
0	4200	General Water	30
0	4300	General Water	30
0	4400	General Water	30

3.3. Run Omniscape using Julia 1.2.0

3.3.1. Had a lot of help from Vincent Land to get Omniscape installed and to run. There seemed to be some bugs running it through Windows (they use Linux)

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Conservation Science Partners, Inc.
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Fort Collins, CO 80524
www.csp-inc.org | 970 484-2898

3.3.2. Extract subsets of study are as needed (improved computing power will be necessary to model the entire study area in Omniscape). Extract by Rectangle is best (GIS often doesn't like irregular boundaries)

3.3.2.1. However, for some reason some relationship to the full extent remains after extract by rectangle. You can tell because the Omniscape results include the full study area but with a zero value (or maybe no data). I don't think it is being incorporated into the model (or else run times would be a lot longer). However, this might be the reason that the normalized and potential current flow maps are failing. Need to figure out how to completely get rid of areas outside of the rectangle.

3.3.3. Convert resistance and source raster files to ASCII file for Omniscape and Julia. Convversion Tools>From Raster> Raster to ASCII. (There is a bug in ArcMap 10.5, select second "file" for file type. First "file" is a .txt file second is a .asc file. Julia only reads .asc)

3.3.4. Install atest version of Julia and then Omniscape. https://julialang.org/downloads/, https://github.com/Circuitscape/Omniscape.jl, https://circuitscape.github.io/Omniscape.jl/stable/,

3.3.5. Create .ini file of Omniscape parameters using notepad (.ini file is the one that says "configuration file" for file type). You have to save as .ini in the actual file name, otherwise it saves as a "text file" file type from notebook. Start with beta test file here (D:\Ecotopes\HabitatValuation\Connectivity\OmniGPTest) and adjust as needed based on computing power and whether local or long distance connectivity is desired (i.e. moving window size). .ini files are created in notebook (or similar), but when you save you MUST put .ini at the end of the file name. Note that the computers I tested this on were not able to run parallel processes (thus "false" for that perameter) which made this very slow. MacArthur Park beta test of ~450K pixels and ¼ mile moving window took 21 hours. Example .ini file for MacArthur Park is here: D:\Ecotopes\HabitatValuation\Connectivity\OmniscapeMPTest\MPtest25.ini (configuration file, not text file with same name)

3.3.5.1.1. Block size should be no more than 5% or so of the moving window size

3.3.5.1.2. # of parallel processes = the number of cores and/or CPU's that the computer has.

3.3.5.1.3. Full analysis extent will require a very large computer via Microsoft Azure Cloud Service or similar. Looking at using the following: M64ls: 64 vCPU's, 512 GB Ram, with 2048 GB or Temp Storage for $5.415/hr .

3.3.5.1.4. Use Linux operating system is best. See "Docker" read me files on the omniscape github site from Vincent. https://github.com/Circuitscape/Omniscape.jl

3.3.5.2. Run Julia 1.2.0 for Test Area

3.3.5.2.1. Run Code Location for Elysian Valey: D:\Ecotopes\HabitatValuation\Connectivity\OmniGPTest

Julia_Omni_runCODE_GP - Notepad

File Edit Format View Help

```
cd("d:\\Ecotopes\\HabitatValuation\\Connectivity\\OmniGPTest")

julia> using Omniscape

julia> run_omniscape("GPTest1.ini")
```

3.3.5.2.2. .ini file setup is below (there might be an extra set of row spaces in here??) Note that I couldn't run parallel processes. Might be an issue with running Omniscape through Windows. Vincent uses Linux. (normalized flow fails, possibly for reasons above)

GPtest1 - Notepad

File Edit Format View Help

```
[Input files]

resistance_file = resgp12.asc

source_file = srcgp12.asc


[Options]

block_size = 11

radius = 86

buffer = 0

source_threshold = 0

project_name = GPtest1

calc_flow_potential = true

correct_artifacts = true

source_from_resistance = false

r_cutoff = 0.0


write_raw_currmap = true

write_normalized_currmap = true

write_flow_potential = true


parallelize = false
max_parallel = 4
```

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