ACE DATASET FACT SHEET
Terrestrial Connectivity

DS2734

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INTENT AND PURPOSE

The **Terrestrial Connectivity** dataset is one of the four key components of the California Department of Fish and Wildlife's (CDFW) Areas of Conservation Emphasis (ACE) suite of terrestrial conservation information along with terrestrial Biodiversity, Significant Habitats, and Climate Resilience. The Terrestrial Connectivity dataset summarizes information on terrestrial connectivity by ACE hexagon including the presence of mapped corridors or linkages and the juxtaposition to large, contiguous, natural areas. This dataset was developed to support conservation planning efforts by allowing users to spatially evaluate the relative contribution of an area to terrestrial connectivity based on the results of statewide, regional, and other connectivity analyses.

This map builds on the 2010 California Essential Habitat Connectivity (CEHC) map, based on guidance given in the 2010 CEHC report. The data are summarized by ACE hexagons (hexagon area = 2.5 square miles). The purpose of this map is to:

1) **Provide a broad overview of statewide connectivity based on the most up-to-date information.** The map incorporates species-specific, fine-scale linkage information that has been developed at a regional scale. In some areas, these fine-scale linkages refine or replace the coarser statewide linkages. In some areas, if more than one connectivity analysis was available, study authors or CDFW regional staff provided input on which version(s) to incorporate into the statewide map. Information on large mammal movement corridors that are currently being developed by CDFW staff using GPS collar data will be incorporated when they become available.

2) **Assess potential connectivity importance in every hexagon across the state.** Information was gathered from the most current statewide structural connectivity and habitat intactness datasets

Areas of Conservation Emphasis

across every ACE hexagon in the state, including areas not evaluated in the 2010 CEHC (i.e., areas that did not fall between two neighboring landscape blocks), and areas not yet evaluated by fine-scale regional studies. This provides information on potential connectivity importance outside modeled habitat linkages. In addition, it provides complementary information identifying connectivity importance using different model algorithms.

3) **Serve as a spatial library of existing connectivity studies**, to point users to connectivity information available for regional planning. Users can query by hexagon to obtain a list of connectivity studies available for that area, and how each contributes to our understanding of the area's connectivity importance.

This dataset is not meant to supersede or replace individual regional studies or other input datasets.

DATA SOURCES AND MODELS USED

For ACE version 3, several types of connectivity information at different spatial scales were brought together to develop ACE connectivity ranks by hexagon.

Source Data

1. <u>Large, Unfragmented Habitat Areas</u>: Large, intact natural areas in California were defined and mapped as Natural Landscape Blocks (NLBs) by the CEHC (ds621; Spencer et al. 2010). The NLBs represent areas of intact natural habitat >2000 acres in size, defined by ecological condition (e.g., areas with low fragmentation and high ecological integrity) and independent of ownership. Areas defined as NLBs are expected to have high connectivity value because they are large, unfragmented, natural areas. Each hexagon was attributed with the proportion of the hexagon mapped as NLB.
2. <u>Linkages and Corridors</u>: areas identified as linkages or corridors in statewide or regional connectivity analyses. These analyses identify least-cost path corridors between landscape blocks, where cost is defined as landscape permeability. In other words, the corridor analysis identifies the optimal path to connect two natural areas, to allow for ecological connectivity and/or wildlife movement. Alternatively, corridors were based on fine-scale GPS collar tracking data for migrating ungulates.

   If there was a mapped linkage or corridor within an ACE hexagon, that hexagon was attributed with the BIOS dataset number (dsXXXX) of the corridor dataset. Some hexagons may include mapped corridors from multiple datasets, because there was some overlap of study areas. In this case, the hexagon was ranked based on the total amount of mapped linkage area within the hexagon when looking across all studies. Note that there is also overlap between NLBs and corridors.

Three main types of linkage and corridor data were included:

a. Statewide CEHC Essential Connectivity Areas [ds620]. The CEHC Essential Connectivity Areas (ECAs) were identified at a coarse scale, to "focus attention on large areas important to maintaining ecological integrity at the broadest scale" (Spencer et al. 2010). The ECAs connect neighboring NLBs >10,000 acres in size. Landscape permeability was defined by ecological condition, including level of habitat fragmentation, but did not include species-specific movement information. ECAs are available statewide.

b. Regional Linkages and Corridors. These finer-scale analyses have been completed for individual ecoregions or regional planning areas in the state and are based on habitats and focal species within each study region. These analyses generally define landscape permeability based on species-specific habitat and movement needs, using finer-scale and region-specific information to identify corridors and linkages at a regional scale (Krause and Gogol-Prokurat 2014). Regional linkage analyses have been completed for about 66% of the state to date. See the list of BIOS datasets and associated reports, below.

c. Ungulate Migration Corridors. In 2020, efforts began to analyze GPS collar datasets that provide accurate location information for ungulate individuals over time. Using these collar data from historical and ongoing projects across the state, ungulate population-level migration corridors, migration stopovers, and winter range habitats are being mapped and prioritized for conservation. Where appropriate, migration corridors are further classified as high use (≥ 20% of collared animals used the corridor) or moderate use (≥ 10% of collared animals used the corridor). Currently, migration corridors for mule deer, elk, and pronghorn have been integrated; bighorn sheep migration corridors are not represented in this layer.

3. Landscape Intactness: Terrestrial landscape intactness analysis for California developed by CBI (Degagne et al. 2016; https://databasin.org/datasets/e3ee00e8d94a4de58082fdbc91248a65). This dataset represents relative landscape intactness, or ecological condition, for California by estimating existing human impacts such as agriculture, urban development, natural resource extraction, and invasive species.

   The ecological condition index used as the basis of the CEHC was published in 2003 and was based on datasets developed prior to that date (Davis et al. 2003). This CBI landscape intactness model is based on more recent datasets and reflects changes that have occurred in the environment since the CEHC was published. The CBI 2016 Landscape Intactness model was used as a weighting factor in the ACE connectivity ranking to capture recent changes in landscape condition in areas previously identified as NLBs or Linkages by the CEHC.

4. Omniscape: A statewide connectivity model for California developed by The Nature Conservancy (TNC) and Conservation Science Partners. This analysis represents a wall-to-wall picture of regional habitat connectivity for plant and animal species whose movement is inhibited by developed or agricultural land uses. The approach uses a modified version of Circuitscape (http://www.circuitscape.org/) with a moving-window algorithm to quantify ecological flow (potential connectivity) among all pixels within a 50km radius. Circuitscape treats landscapes as resistive surfaces, where high-quality movement habitat has low resistance and barriers have high resistance. The algorithm incorporates all possible pathways between movement sources and destinations and identifies areas of high flow via low-resistance routes, i.e., routes presenting relatively low movement difficulty because of lower human modification, and thus mortality risk.

Ranking Criteria

The ACE connectivity ranks were developed to provide a broad overview of connectivity across the state using the best available connectivity information for each region of the state. The scoring system was designed to bring together connectivity information at multiple scales, giving each hexagon an ACE Connectivity Rank of 1-5 based on the conservation importance of connectivity based on the best-available data.

Ranking criteria were based on the following assumptions:

1. Large, contiguous natural areas have high connectivity value.
2. Linkages or corridors serve to connect existing habitat core areas and have high connectivity value.
3. Areas with high landscape intactness have higher connectivity value than areas with low landscape intactness.
4. Regional connectivity analyses provide information that supplements, but does not replace, the CEHC statewide linkages. Some statewide linkages identified by the CEHC were not identified in regional connectivity analyses covering the same footprint. This may be because of differences in the location of (i.e., differences in definitions for) landscape blocks between studies.
5. Areas mapped as both NLB and linkage may be of particularly high connectivity value, functioning both as unfragmented habitat and as part of a pathway connecting two blocks. In some cases high connectivity values in areas of overlap may be an artifact of modeling rules, but further work is required to assess this on a case-by-case basis.
6. Connectivity studies generally do not rank linkages by level of importance or conservation priority, so all linkages were treated equally for the purpose of this analysis.
7. Connectivity analysis maps show NLBs and linkages as distinct areas with “hard” boundaries. However, in reality, connectivity value is likely variable within a linkage or NLB, with higher connectivity value toward the core and decreasing connectivity value toward the edge. There is

likely also variability in value across the area of an NLB, or across the width of a linkage (most connectivity studies establish a minimum corridor width of 2 km or greater). The ranking criteria addressed this by a) scoring the core of a linkage or NLB higher than the edge, and b) weighting the NLB and/or linkage score with a landscape intactness score.

8. Connectivity values may appear higher in areas of the state where more landscape block and linkages have been mapped (e.g., in areas where regional connectivity analyses have been conducted), or where there is overlap among studies.

Connectivity ranks were defined as follows:

ACE Rank 5: **Irreplaceable and Essential Corridors**: This includes channelized areas as identified in The Nature Conservancy's (TNC) Omniscape model, and priority species movement corridors. Information on priority wildlife movement corridors is currently very limited and is not comprehensive across the state. Identifying priority wildlife movement corridors is an active area of research and information will be added as it becomes available. TNC mapped channelized areas are those areas where surrounding land use and barriers are expected to funnel, or concentrate, animal movement. Channelized areas may represent the last available connection(s) between two areas, making them high priority for conservation.

ACE Rank 4: **Conservation Planning Linkages**: These are the habitat connectivity linkages mapped in the CEHC and fine-scale regional connectivity studies. Habitat connectivity linkages are often based on species-specific models, and represent the best connections between core natural areas to maintain habitat connectivity. Linkages have more implementation flexibility than irreplaceable and essential corridors. Any linkage areas not included in the category above was included here.

ACE Rank 3: **Connections with implementation flexibility**: These are other areas that have been identified as having connectivity importance, but have not been identified as channelized areas, species corridors, or habitat linkages at this time. This may change with future changes in surrounding land use or regional specific information. Hexagons included in this category include areas mapped as "intensified" in the TNC Omniscape study, core habitat areas, and hexagons on the periphery of mapped habitat linkages when not included in the categories above.

ACE Rank 2: **Large natural habitat areas**: These are large blocks of natural habitat (>2000 acres) where connectivity is generally intact. This includes natural landscape blocks from the 2010 CEHC and updated with the 2016 Statewide Intactness dataset. Any area mapped as a CEHC NLB and not included in the categories above was included in this rank.

ACE Rank 1: **Limited connectivity opportunity**: Areas where land use may limit options for providing connectivity (e.g., agriculture, urban) or no connectivity importance has been identified in models. Includes lakes. Some DOD lands are also in this category because they have been excluded from models due to lack of conservation opportunity, although they may provide important connectivity habitat.

<u>Ruleset for connectivity ranks</u>:

Rank 5:

1. Hexagon contains a known priority species movement corridor. This may include known road crossing locations based on gps collar or roadkill data. -OR-
2. Greater than 25% of the hexagon is mapped as channelized by Omniscape (TNC 2018) -OR-
3. Greater than 5% of a hexagon is mapped as channelized by Omniscape (TNC 2018) AND is identified as a statewide or regional habitat linkage. -OR-
4. Greater than 5% of a hexagon is mapped as channelized by Omniscape (TNC 2018) AND no species-specific regional habitat connectivity data is available for the area. -OR-
5. Hexagon intersects one or more high use ungulate migration corridor polygons.

Rank 4:

1. Greater than 25% of a hexagon is mapped as a statewide or regional habitat linkage AND hex is not assigned Rank 5 by above rules. -OR-
2. Hexagon intersects one or more moderate use ungulate migration corridor centerlines AND hex is not assigned Rank 5 by above rules.

Rank 3:

1. Greater than 5% of a hexagon is mapped as a statewide or regional habitat linkage AND hex is not assigned Rank 4 or 5 by above rules. -OR-
2. Greater than 5% of a hexagon is mapped as channelized or intensified by Omniscape (TNC 2018) AND hex is not assigned Rank 4 or 5 by above rules. -OR-
3. Greater than 5% of a hexagon is mapped as a core habitat by a regional habitat connectivity study AND hex is not assigned Rank 4 or 5 by above rules. -OR-
4. Hexagon intersects one or more ungulate migration corridor centerlines AND hex is not assigned Rank 4 or 5 by above rules.

Rank 2:

1. Greater than 25% of a hexagon is mapped as a CEHC Natural Landscape Block AND no more than 50% of the hexagon is mapped at urbanized based on recent landcover maps AND hex is not assigned Rank 3, 4, or 5 by above rules. -OR-
2. Greater than 5% of a hexagon is mapped as a CEHC Natural Landscape Block AND mean CBI Intactness score is moderate or high AND hex is not assigned Rank 3, 4, or 5 by above rules.

Rank 1:

1. Greater than 50% of a hexagon is mapped as urbanized based on recent landcover maps AND hex is not assigned Rank 2, 3, 4, or 5 by above rules. -OR-
2. Mean CBI Intactness score is low AND hex is not assigned Rank 2, 3, 4, or 5 by above rules. -OR-
3. Hex is not assigned Rank 2, 3, 4, or 5 by above rules (e.g., lakes).

List of Connectivity GIS data sources:

<u>Statewide datasets:</u>

Natural Landscape Blocks – California Essential Habitat Connectivity Analysis [ds621] (Spencer et al. 2010)

Essential Connectivity Areas - California Essential Habitat Connectivity Analysis [ds620] (Spencer et al. 2010)

Terrestrial Landscape Intactness (1km) - 2016 [ds2670], https://databasin.org/datasets/e3ee00e8d94a4de58082fdbc91248a65

Omniscape (TNC 2018) https://www.scienceforconservation.org/science-in-action/connectivity-roadmap) [ds2887]

<u>Regional datasets:</u>

South Coast Missing Linkages [ds419] (South Coast Wildlands 2008)

Wildlife Linkages – San Joaquin Valley [ds417] (Endangered Species Recovery Program 1996; USFWS 1998, Table 11)

Habitat Connectivity – Ventura County [ds565] (subset of South Coast Missing Linkages, ds419; South Coast Wildlands 2008)

Linkage Design for the California Desert Linkage Network [ds822] (Penrod et al. 2012)

Linkage Design for the California Bay Area Linkage Network [ds852] (Penrod et al. 2013)

Northern Sierra Nevada Foothills Wildlife Linkages [ds1005] (Krause et al. 2015)

Northern Sierra Nevada Foothills Riparian Corridors [ds1018] (Krause et al. 2015)

Core Linkages – Region 5 – Connectivity Monitoring Strategic Plan [ds2698] (SDMMP and TNC 2017, Volume 2B, Section 8)

Core Habitat Areas – Region 5 – Connectivity Monitoring Strategic Plan [ds2697] (SDMMP and TNC 2017, Volume 2B, Section 8)

Central Valley Core Reserved and Corridors [ds2693] (Huber et al, UC Davis)

Focused Planning Areas – Northwestern San Diego County [ds2770]

Orange County Reserves [ds2699] (County of Orange 1996, Section 4.4)

Mayacamas to Berryessa [ds2819]

Coyote Valley and Santa Clara Valley [ds2823]

Modoc Habitat Connectivity (Gallo et al., Conservation Biology Institute, 2019)

Connectivity Least Cost Corridors (top 10 percent) – Modoc – CBI [ds3133]

Connectivity Cores – Modoc – CBI [ds3134]

<u>Ungulate migration corridors (CDFW):</u>

Elk Migration Corridors - West Goose Lake - 1999-2002, 2018-2020 [ds2901]

Elk Migration Corridors - East Shasta Valley - 1999-2001, 2016-2020 [ds2903]

Elk Migration Corridors - Egg Lake - 2001-2002, 2017-2020 [ds2908]

Mule Deer Migration Corridors - Upper San Joaquin River Watershed - 2013-2016 [ds2878]

Mule Deer Migration Corridors - Carson River - 2012-2019 [ds2888]

Mule Deer Migration Corridors - Modoc Interstate CA and OR - 1999-2001, 2017-2020 [ds2894]

Mule Deer Migration Corridors - Jawbone Ridge - 2009-2015 [ds2896]
Mule Deer Migration Corridors - Doyle - 2016-2019 [ds2909]
Mule Deer Migration Corridors - Loyalton - 2006-2017 [ds2914]
Mule Deer Migration Corridors - Verdi-Truckee - 2009-2010, 2012-2017 [ds2915]
Mule Deer Migration Corridors - East Tehama - 2010-2017 [ds2931]
Mule Deer Migration Corridors - Butte - 2010-2016 [ds2969]
Mule Deer Migration Corridors - Blue Canyon - 2018-2020 [ds2971]
Mule Deer Migration Corridors - Bucks Mountain-Mooretown - 2018-2020 [ds2972]
Mule Deer Migration Corridors - Downieville-Nevada City - 2018-2020 [ds2973]
Mule Deer Migration Corridors - Grizzly Flat - 2018-2021 [ds2974]
Mule Deer Migration Corridors - Salt Springs - 2018-2020 [ds2975]
Mule Deer Migration Corridors - Siskiyou - 2015-2020 [ds2976]
Mule Deer Migration Corridors - Kern River - 2020-2021 [ds2977]
Mule Deer Migration Corridors - Manache - 2020-2021 [ds2978]
Mule Deer Migration Corridors - Mendocino - 2004-2013, 2017-2021 [ds3014]
Pronghorn Migration Corridors - Lassen - 2014-2016 [ds2933]
Pronghorn Migration Corridors - Clear Lake - 2015-2020 [ds2932]
Pronghorn Migration Corridors - Likely Tables - 2014-2020 [ds2934]
Pronghorn Migration Corridors - Bodie-Wassuk - 2014-2016 [ds3100]

HOW TO USE THE DATA LAYER

The ACE Connectivity dataset provides a single snapshot of connectivity information across the state. The scoring indicates the relative connectivity importance in the hexagon. A score of 5 indicates high connectivity importance because the area is a known species movement path or represents the last remaining habitat connections in an area. A score of 1 indicates that the area has low connectivity opportunity, although there may be important connectivity areas present.

Common uses of the dataset include:

1. Select a hexagon and view the attribute table to determine whether there is a mapped linkage or corridor within the hexagon. The BIOS dataset number of any corridor dataset that intersects the hexagon will be given in the ACE attribute table, and the user can then use that information to overlay the BIOS source dataset to see exactly where the corridor was mapped.
2. Select a hexagon to determine whether the area falls within or adjacent to a CEHC NLB. Overlay the NLB BIOS dataset [ds621] to see where exactly the NLB boundaries are.
3. Select a hexagon to view its overall connectivity rank (1-5), and how it compares with the connectivity rank of other hexagons.

Field Definitions

Using the *Identify Features* or *Select* tool in the ACE viewer, users can obtain a table of information (i.e., attribute table) for a hexagon or area of interest. The ACE viewer allows the user to print the table or save as a spreadsheet (.csv) file. The definitions below describe the attribute table fields for this dataset.

Field	Definition
Connectivity Rank	Final connectivity score of 1-5, where 5 is highest connectivity importance. See Connectivity Rank ruleset above.
Connectivity datasets	List of connectivity datasets that overlap each hexagon.
Natural Landscape Block Proportion	Proportion of hexagon that is covered by natural landscape blocks.
Sq miles	Square miles
Eco_Sect	Code for the USDA ecoregion that the majority of the hex falls in.
Eco_Name	The Name of the USDA ecoregion that the majority of the hex falls in.
Jepson_Eco	Name of the Jepson ecoregion that the majority of the hex falls in.
County	Name of the county that the majority of the hex falls in.
Regional_dataset	Yes (1) or No (0): The hexagon falls within the study area of a fine-scale connectivity analysis. Connectivity ranks for hexagons within fine-scale connectivity studies are expected to have higher certainty.
Pct_channelized_Omniscape	Percent of hexagon mapped as channelized by Omniscape model (TNC 2018)
Species movement	List of species for which priority wildlife movement data are available within the hexagon, such as corridors or road crossing locations based on GPS collars and roadkill hotspot information.

DATA PRECISION AND LIMITATIONS

Connectivity models are landscape-level GIS analyses that are subject to the limitations of the source datasets (e.g., landcover data) as well as to the limitations of the connectivity modeling methods. For the purposes of this analysis, data precision in areas addressed by fine-scale regional connectivity analyses would be expected to have higher certainty than those where only CEHC data is available. The individual project reports should be referred to for a full description of the source data used and limitations for a given area. See the Terrestrial Significant Habitats Factsheet for a full discussion of data limitations and accuracy of landcover/vegetation datasets.

Least-cost path analysis requires a set start- and end point be set for each corridor and is therefore sensitive to the choice of landscape blocks used in each analysis. An area that is important for connectivity but does not fall between two landscape blocks may fail to be identified as a linkage or corridor. Rules used to define landscape blocks vary across regional connectivity analyses in California, which can lead to different sets of assumptions that define what the corridors represent between regions.

There is overlap between study areas of the connectivity analyses, and also between linkages and landscape blocks. For example, some regional studies have defined corridors that fall completely within CEHC NLBs. Areas identified both as landscape block and linkage/corridor would receive a high ACE connectivity rank. These areas may be particularly important for connectivity, but in some cases the high score could be an artifact of the modeling. Most linkage analyses do not rank linkages by level of importance or conservation priority, so all linkages were treated equally for the purpose of this analysis.

DATA ACCESS

The ACE Connectivity dataset is available for viewing and download in BIOS. For assistance with interpretation contact Michael Hardy, Spatial Ecologist: Michael.Hardy@wildlife.ca.gov

The statewide and regional connectivity analysis datasets are available as individual datasets in BIOS, including the ungulate migration corridor, migration stopover, and winter range products, and can be easily accessed in the BIOS Habitat Connectivity Viewer.

The terrestrial intactness dataset is available from CBI in Databasin: https://databasin.org/datasets/e3ee00e8d94a4de58082fdbc91248a65.

BACKGROUND INFORMATION

2024: The ACE Terrestrial Connectivity dataset received a second update in January 2024. Fine-scale regional habitat connectivity datasets in the Modoc Plateau were added to the ACE Terrestrial Connectivity dataset. Additionally, ungulate migration datasets were explicitly included in ACE for the first time.

2019: The ACE Terrestrial Connectivity dataset was updated in June, 2019. New statewide and fine-scale regional habitat connectivity datasets were compiled and added to the ACE Terrestrial Connectivity dataset.

2017: Terrestrial Connectivity was added as an ACE layer in 2017. The ACE Connectivity dataset summarizes connectivity information by hexagon, whereas the previous version (ACE-II) included statewide datasets from the CEHC project as ancillary maps that could be overlaid within the ACE viewer but were not summarized by hexagon.

Further work developing the ACE Connectivity dataset will continue in 2024 and into the future. This includes continuing to compile and incorporate new habitat connectivity information, and adding wildlife migration corridor data, based on state-of-the-art wildlife GIS tracking technology, as it becomes available.

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County of Orange. 1996. Central and Coastal Subregion Natural Community Conservation Plan/Habitat Conservation Plan. Prepared by R.J. Meade Consulting, Inc. Prepared for: County of Orange, Environmental Management Agency and US Fish and Wildlife Service/California Department of Fish and Game. Santa Ana, California. Available online at: https://occonservation.org/about-ncc/

Davis, F. W., D. M. Stoms, C. Costello, E. Machado, J. Metz, R. Gerrard, S. Andelman, H. Regan, and R. Church. 2003. A framework for setting land conservation priorities using multi-criteria scoring and an optimal fund allocation strategy. National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, California, USA.

Degagne, R., J. Brice, M. Gough, T. Sheehan, and J. Strittholt. Terrestrial Landscape Intactness 1 km, California. Conservation Biology Institute, December 2016. From DataBasin.org: https://databasin.org/datasets/e3ee00e8d94a4de58082fdbc91248a65

Gallo, JA, J. Strittholt, G. Joseph, H. Rustigian-Romsos, R. Degagne, J. Brice, and A. Prisbrey.2019. Mapping Habitat Connectivity Priority Areas that are Climate-wise and Multi-scale, for Three Regions of California. Conservation Biology Institute. March 2019. https://doi.org/10.6084/m9.figshare.7477532

Krause, C., S. Bisrat, and M. Gogol-Prokurat. 2015. Technical report to the Wildlife Conservation Board on the northern Sierra Nevada foothills fine-scale connectivity analysis. California Department of Fish and Wildlife, Sacramento, California. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=85358

Krause, C. and M. Gogol-Prokurat. 2014. Guidance Document for Fine-Scale Wildlife Connectivity Analysis. California Department of Fish and Wildlife, Sacramento, California. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=93018

Penrod, K., P. Beier, E. Garding, and C. Cabañero. 2012. A Linkage Network for the California Deserts. Produced for the Bureau of Land Management and The Wildlands Conservancy. Produced by Science and Collaboration for Connected Wildlands, Fair Oaks, CA www.scwildlands.org and Northern Arizona University, Flagstaff, Arizona http://oak.ucc.nau.edu/pb1/. Available online at http://www.scwildlands.org/

Penrod, K., P. E. Garding, C. Paulman, P. Beier, S. Weiss, N. Schaefer, R. Branciforte and K. Gaffney. 2013. Critical Linkages: Bay Area & Beyond. Produced by Science & Collaboration for Connected Wildlands, Fair Oaks, CA www.scwildlands.org in collaboration with the Bay Area Open Space Council's Conservation Lands Network www.BayAreaLands.org. Available online at http://www.scwildlands.org/

San Diego Management and Monitoring Program (SDMMP) and The Nature Conservancy (TNC). 2017. Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: A Strategic Habitat Conservation Roadmap. Prepared for San Diego Association of

Governments (SANDAG). San Diego, California. Available online at https://portal.sdmmp.com/msp_doc.php

South Coast Wildlands. 2008. South Coast Missing Linkages: A Wildland Network for the South Coast Ecoregion. Produced in cooperation with partners in the South Coast Missing Linkages Initiative. Available online at http://www.scwildlands.org/

Spencer, W.D., P. Beier, K. Penrod, K. Winters, C. Paulman, H. Rustigian-Romsos, J. Strittholt, M. Parisi, and A. Pettler. 2010. California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration. Available online at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18366

The Nature Conservancy (TNC), California Chapter. 2018. Landscape Connectivity using Omniscape.

U.S. Fish and Wildlife Service (USFWS). 1998. Recovery plan for upland species of the San Joaquin Valley, California . Region 1, Portland, OR. 319 pp.