ACE DATASET FACT SHEET
Terrestrial Biodiversity

DS2739

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INTENT AND PURPOSE

The **Terrestrial Biodiversity Summary** is a compilation of the best available information on terrestrial species biodiversity in California, including amphibians, birds, mammals, plants, and reptiles, for the California Department of Fish and Wildlife's (CDFW) Areas of Conservation Emphasis Project (ACE). It is one component, together with Aquatic Biodiversity, **of overall species biodiversity in California.** The terrestrial biodiversity summary combines the three measures of biodiversity developed for ACE into a single metric: 1) terrestrial native species richness, which represents overall native diversity of all species in the state, both common and rare; 2) terrestrial rare species richness, which represents diversity of rare species; and, 3) terrestrial irreplaceability, which is a weighted measure of endemism. The data can be used to **view patterns of overall species diversity**, and **identify areas of highest biodiversity** across the state and in each ecoregion, taking into account common, rare, and rare endemic species. Users can **view a list of species** that contribute to the biodiversity measures for each hexagon.

The **terrestrial biodiversity summary** displays relative biodiversity values for each ecoregion of the state, so that the areas of highest diversity within each ecoregion are highlighted. The data is normalized so that areas of highest diversity for each taxonomic group contribute equally to the final map (see Data Sources and Models Used section).

BACKGROUND INFORMATION

The differences between this biodiversity dataset and the previous version, formerly called "Biological Richness" in ACE (ACE-II) are: 1) this dataset only includes terrestrial species; fish are now included in a separate aquatic biodiversity dataset; 2) the native species richness component of this dataset used

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species predicted habitat distribution maps to identify the hexagons in which a species may potentially occur, while ACE-II had used species range maps; 3) the irreplaceability component of this dataset was based only on rare endemic species, while the previous version had been based on a rarity-weighted richness index that included all rare species; and, 4) this dataset includes information only on the distribution of species diversity throughout the state, while previous version in ACE-II also factored in the presence of significant habitats when ranking biological richness.

The previous version of ACE (ACE-II) included two different maps: statewide biodiversity and biodiversity by ecoregion. The new viewer displays only biodiveristy normalized by ecoregion, since this dataset is the scale most relevant for most planning processes in California. The statewide biodiversity summary not normalized by ecoregion (showing relative biodiversity on a statewide basis, not by ecoregion) is not shown in the ACE viewer but is still available as a separate layer in BIOS (ds1331), and the statewide values are available in the ACE biodiversity summary GIS attribute table.

DATA SOURCES AND MODELS USED

The Terrestrial Biodiversity Summary is a combination of three ACE datasets that were developed to capture different components of biodiversity: 1) terrestrial native species richness, which represents overall native diversity of all species in the state, both common and rare; 2) terrestrial rare species richness, which represents diversity of rare species; and, 3) terrestrial irreplaceability, which is a weighted measure of endemism. See the ACE Fact Sheets for each of those datasets for a detailed description of the data sources and models used to develop each component. A summary is provided below.

For ACE version 3, native species richness was based on distribution data for all native, regularly-occurring species in California, including amphibians (n=59), birds (n=360), mammals (n=167), and reptiles (n=78). Information was summarized at the taxonomic level of the full species. Distribution data for plants (n=4960) was summarized statewide, but due to data resolution was not included the summary (see below).

Rare species included in this ACE version 3 analysis included State and Federally-listed species, Species of Special Concern (SSC), fully-protected species, and California Rare Plant Rank (CRPR) 1B and 2 rare plants. This list includes all species that were defined as Species of Greatest Conservation Need (SGCN) in the State Wildlife Action Plan (SWAP; CDFW 2015) based on their rarity status. Rare species richness counts were conducted for amphibians (n=34), birds (n=100), mammals (n=94), plants (n=1672), and reptiles (n=36) at the taxonomic level treated as special status (e.g., species, subspecies, ecologically significant unit). Rare endemic species included in this ACE version 3 analysis included amphibians (n=38), birds (n=43), mammals (n=99), plants (n=1178), and reptiles (n=28) identified as endemic or near-endemic in the California Species of Special Concern reports, and California Rare Plant Rank (CRPR) 1B plants, most of which are rare endemics.

Data Sources

Terrestrial vertebrate distribution data was based on California Wildlife Habitat Relationships (CWHR) Predicted Habitat Suitability models for amphibians, birds, mammals, and reptiles. These models represent potential suitable habitat within the range of each species based the CWHR species range, CWHR species habitat relationship table (CDFW 2014), and the best available habitat/landcover map, FVEG15_1 (Calfire 2015). All native terrestrial vertebrate species for which a CWHR Predicted Habitat Suitability Model was available were included in the counts. If any potentially suitable habitat for a species was mapped within a hexagon, the species was counted as potentially present in the hexagon. Terrestrial vertebrate counts were based on full species only; counts did not consider subspecies or varieties because range maps were generally not available at the subspecific level. The CWHR Predicted Habitat Suitability Models for each species are available in BIOS.

Plant distribution data was based on Jepson ecoregion designations as published in the Jepson Manual and provided by the Jepson Herbarium, UC Berkeley. All native plants in the Jepson manual were included. Although plant information was available at the subspecies level, we merged these to full species during processing to be consistent with terrestrial vertebrate distribution data. The Jepson ecoregion designations are equivalent to plant ranges, where the range is defined by the boundaries of the Jepson ecoregions in which the species occurs. This results in every hexagon within a given ecoregion having the same native plant count (every plant species that occurs in the ecoregion is counted across the entire ecoregion), and therefore the native plant richness data could not be normalized to identify the highest richness areas within each ecoregion. Because of this, the plant data was not included in the ecoregional native richness summary. However, rare and endemic plant data is available at a finer resolution and was included in the overall ecoregional terrestrial species biodiversity summary.

Terrestrial climate vulnerable species was a count of species indicated as climate vulnerable in the State Wildlife Action Plan (SWAP; CDFW 2015) Species of Greatest Conservation Need (SGCN) list, based on the same distribution data as the full native species richness dataset.

Terrestrial native game species was a count of large game, upland game, and waterfowl managed for hunting by the CDFW Wildlife Branch's Game Management Program, based on the same distribution data as the full native species richness dataset.

Terrestrial rare species location data were derived from available documented, mapped species occurrences. Sources included "presumed extant" California Natural Diversity Database (CDFW 2017) records (excluding extirpated and possibly extirpated records); additional museum records from the California Academy of Sciences, the Museum of Vertebrate Zoology at UC Berkeley, and the Consortium of California Herbaria (from years 1999-2009); and additional datasets from the CDFW BIOS online map viewer (https://www.wildlife.ca.gov/Data/BIOS), used with permission from the contributors. All documented occurrences with accuracy ±1 mile or better were included in order to incorporate as many known occurrences as possible. No cut-off date of observation was used, based on the assumption that occurrences still may be present if the habitat has not been modified and the

occurrences have not been documented as extirpated. A one mile buffer was added to all occurrence points and polygons to standardize accuracy.

Data Processing Steps and Ranking Criteria

Data normalization by taxonomic group corrected for any bias caused by differences in the number of taxa per taxonomic group. Due to large differences in total numbers of species between taxonomic groups, the raw sum of total species richness based on counts of species resulted in richness maps highly skewed toward the taxonomic group(s) with the largest numbers of species. In order to give each taxonomic group equal weight in the final model output, the species counts were normalized (scaled from zero to one): The count in each hexagon for a given taxonomic group was divided by the maximum value for that taxonomic group. To identify and highlight areas of greatest richness within each ecoregion, the count for each taxonomic group was divided by the maximum value for that taxonomic group within each ecoregion (ecoregional normalization). The ecoregionally normalized values identify the areas of greatest species richness within each ecoregion, and were summed to create the Rare Species Richness Summary. Statewide normalized values (the count for each taxonomic group was divided by the maximum value for that taxonomic group across the state), which give a picture of relative diversity on a statewide basis, were also produced and are available in the GIS attribute table for reference.

Data processing steps:

See the ACE Fact Sheets for data processing steps used to develop the three components of biodiversity: terrestrial native species richness, terrestrial rare species richness, and, terrestrial irreplaceability.

To develop the overall biodiversity summary:

1. The final ecoregional rank for each dataset, which represents its relative contribution to that component of biodiversity in each ecoregion, was summed.
2. This sum was then **normalized** (scaled from zero to one) by ecoregion to allow comparison between hexagons on a standardized scale. This was done by dividing the biodiversity sum for each hexagon by the maximum biodiversity sum value within the ecoregion in which the hexagon is found.
3. **Final ranking**: To display the relative biodiversity values, the biodiversity summary was ranked from 1-5 using 5 quantiles by ecoregion. The 20% of hexagons with the highest scores in each ecoregion were given a 5 (highest score), the 20% of hexagons with the lowest scores in each ecoregion were given a 1, etc. Note that due to differences in size between ecoregions, and differences in the number of species potentially occurring in each ecoregion, the number of hexagons ranked in each category (1-5) differs across ecoregions, and the number of species present in a hexagon with a given score also varies across ecoregions.

HOW TO USE THE DATA LAYER

The biodiversity summary maps can be used to view and explore how biodiversity is distributed across the state and within each ecoregion. The user can view patterns of overall biodiversity by ecoregion summarized in this dataset, as well as patterns of diversity shown in all of the component layers used to build this dataset, which are nested below this dataset in the viewer. By selecting a hexagon in the viewer, the user can see the number of species in each category (all native species, rare species, and rare endemic species) counted in the hexagon, the relative rank of the hexagon compared to the rest of the ecoregion and the rest of the state, and view a list of species potentially present.

Frequent uses of this dataset include:

- Identify the areas of highest biodiversity within each ecoregion (Rank 5 hexagons in Biodiversity Summary)
- View the information in the attribute table for each hexagon, or contained in the component data layers, to understand what contributes to the biodiversity value in a given area.
- Identify the number of native, rare, and rare endemic species potentially present within a hexagon based on species distribution information (using identify tool or GIS attribute table)
- Obtain a list of those potential species (using 'Identify Features' on the Species List dataset in ACE viewer)
- Overlay Predicted Habitat Distribution model BIOS layers for individual species based on the species list, to obtain a finer-grain view of species distributions in the landscape
- View relative native, rare, or rare endemic richness across the state for a given taxonomic group
- Identify the highest native, rare, or rare endemic richness areas in an ecoregion for a given taxonomic group (using identify tool or GIS attribute table to obtain ecoregionally normalized values and ranks for each taxonomic group)
- Compare the ecoregional rank with the statewide rank (using identify tool or GIS attribute table), to understand the relative importance of the hexagon for the biodiversity within the ecoregion as well as the relative importance on a statewide basis.
- Identify where data may be lacking (viewing 'No Data' hexes).

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 it as a spreadsheet (.csv file). The definitions below describe the attribute table fields for this dataset.

Field	Definition
NativeCount	Count of native species (not including plants) with potential habitat in each hexagon.
Game Species Count	Count of game species with potential habitat in each hexagon.

Field	Definition
Climate Vulnerable Species Count	Count of climate vulnerable species (not including plants) with potential habitat in each hexagon.
Native Amphibian Count	Count of native amphibian potential habitat models that intersect the hexagon.
Native Reptile Count	Count of native reptile potential habitat models that intersect the hexagon.
Native Bird Count	Count of native bird potential habitat models that intersect the hexagon.
Native Mammal Count	Count of native mammal potential habitat models that intersect the hexagon.
Native Plant Count	Count of native plant ranges that intersect the hexagon.
Rare Amphibian Count	Count of rare amphibian taxa per hexagon based on documented occurrences. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Rare Reptile Count	Count of rare reptile taxa per hexagon based on documented occurrences. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Rare Bird Count	Count of rare bird taxa per hexagon based on documented occurrences. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Rare Mammal Count	Count of rare mammal taxa per hexagon based on documented occurrences. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Rare Plant Count	Count of California Rare Plant Rank (CRPR) 1B and 2 rare plant taxa per hexagon based on documented occurrences. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.

Field	Definition
Endemic Amphibian Count	Count of endemic and near endemic amphibian taxa, as defined by the CDFW Amphibian and Reptile Species of Special Concern Report, in each hexagon. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Endemic Reptile Count	Count of endemic and near endemic reptile taxa, as defined by the CDFW Amphibian and Reptile Species of Special Concern Report, in each hexagon. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Endemic Bird Count	Count of endemic and near endemic bird taxa, as defined by the CDFW Bird Species of Special Concern Report, in each hexagon. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Endemic Mammal Count	Count of endemic and near endemic mammal taxa, as defined by the CDFW Mammal Species of Special Concern Report, in each hexagon. Taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, subspecies, distinct population segment (DPS), or evolutionarily significant unit (ESU). Taxa are not double counted within the hexagon.
Endemic Plant Count	Count of plant taxa with a California plant rank of 1B in each hexagon. Plants with a California Rare Plant Rank of 1B are rare throughout their range with the majority of them endemic to California. Plant taxa are defined and aggregated at the taxonomic unit at which they are listed and tracked by the California Natural Diversity Database (CNDDB), which may be by species, or subspecies level.
AllTaxaEndem	Count of all endemic and near endemic plants and animal taxa in each hexagon.
Statewide Native Species Weight	Aggregated statewide normalized values for all native taxa for each hexagon, re-normalized statewide.
RareCount	Count of rare species with occurrences that intersect the hexagon.
Ecoregion Native Species Weight	Total of aggregated ecoregionally normalized values for all native taxa for each hexagon, re-normalized ecoregionally.
Statewide Native Species Rank	Ranks of 1-5 assigned to the statewide normalized native species richness values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.

Field	Definition
Ecoregion Native Species Rank	Ranks of 1-5 assigned to the ecoregionally normalized native species richness values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Statewide Rare Species Weight	Sum of aggregated statewide normalized rare species richness values across all taxonomic groups for each hexagon. Final sum is scaled from zero to one statewide for ease of interpretation.
Ecoregion Rare Species Weight	Sum of aggregated ecoregionally normalized rare species richness values across all taxonomic groups for each hexagon. Final sum is scaled from zero to one ecoregionally for ease of interpretation.
Statewide Rare Species Rank	Ranks of 1-5 assigned to the statewide normalized rare species richness values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Ecoregion Rare Species Rank	Ranks of 1-5 assigned to the ecoregionally normalized rare species richness values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Statewide Irreplaceability	Maximum statewide normalized rare weighted index value for any taxonomic group in each hexagon.
Ecoregion Irreplaceability	Maximum ecoregionally normalized rare weighted index value for any taxonomic group in each hexagon.
Statewide Irreplaceability Rank	Ranks of 1-5 assigned to the statewide normalized rarity weighted index values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Ecoregion Irreplaceability Rank	Ranks of 1-5 assigned to the ecoregionally normalized rarity weighted index values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Statewide Biodiversity Weight	Sum or aggregated statewide normalized native species richness values, rare species richness values, and rarity weighted index values, scaled from zero to one statewide for ease of interpretation.
Ecoregion Biodiversity Weight	Sum of aggregated ecoregionally normalized native species richness values, rare species richness values, and rarity weighted index values, scaled from zero to one ecoregionally for ease of interpretation.
Statewide Biodiversity Rank	Ranks of 1-5 assigned to the statewide normalized biological values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.
Ecoregion Biodiversity Rank	Ranks of 1-5 assigned to the ecoregionally normalized biological values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of hexagons.

DATA PRECISION AND LIMITATIONS

ACE provides data to help guide and inform conservation priorities in California. All ACE data layers are limited by the accuracy, scale, extent of coverage, and completeness of the input data at the time they were run. We highly recommend reviewing available metadata and ACE Factsheets prior to interpreting these data. The ACE maps do not replace the need for site-specific evaluation of biological resources and should not be used for regulatory purposes.

The Terrestrial Biodiversity dataset is meant to represent broadscale patterns of species richness and diversity in the landscape, and is limited by the accuracy and scale of the input data.

Because the range and distribution data used are coarse-scale and have been designed to prioritize commission error (predicting presence when the species is absent) over omission error (predicting absence when the species is present), we expect the native richness component of this dataset will tend to *overestimate* species richness. The native richness values are best interpreted as a general representation of the distribution of diversity throughout the state, but the values for any individual hexagon should be interpreted with caution. For further information, see the terrestrial native species richness fact sheet. The list of potential species in each hexagon includes those species that, based on our best-available information, could potentially occur within the hexagon, but it is unlikely that all of those species would be found in the hexagon at a given point in time.

The rare species occurrence datasets compiled for use in ACE rely on voluntary submission of data to the Department. Surveys for rare species have not been conducted comprehensively across the entire landscape. Therefore, current maps of verified rare species occurrences are expected to be biased by level of survey effort and have **high rates of omission error** (locations where species exist but are not documented). For this reason, counts of rare species richness would be expected to be *underestimates* in some hexagons, particularly those for which no survey data are available. Verified species occurrences mapped by CNDDB and museum data tend to be spatially biased toward areas with high levels of survey effort, which may result in particularly high rare species richness values in well-surveyed areas. RWI scores used to develop the irreplaceability ranks are sensitive to level of survey effort, because both the species-level RWI score and the total hexagon score are influenced by the level of omission error.

Irreplaceability measures the uniqueness of an area, and best represents areas important for *narrow-ranging species and habitats*, but does not necessarily capture areas important for wide-ranging species that are rare within their range and may also be of high conservation concern. A separate metric should be developed to identify the areas of greatest importance for wide-ranging species.

DATA ACCESS

All datasets are available for viewing and download in BIOS.

For assistance with interpretation contact Melanie Gogol-Prokurat.

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Factsheet: Melanie Gogol-Prokurat

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For additional information and a full list of ACE 3 Factsheets, see the ACE3 Technical Report.

Areas of Conservation Emphasis, CA Dept of Fish and Wildlife, www.wildlife.ca.gov/Data/Analysis/Ace