ACE DATASET FACT SHEET
Species Biodiversity

DS2769

UPDATED 2/21/2018

INTENT AND PURPOSE

The California Department of Fish and Wildlife's (CDFW) Areas of Conservation Emphasis (ACE) **Species Biodiversity** dataset is a summary of the best available information on species biodiversity in California, and is based on species occurrence and distribution information for amphibians, aquatic macroinvertebrates, birds, fish, mammals, plants, and reptiles. It synthesizes information from the ACE Terrestrial Biodiversity Summary, which is compiled by hexagon, and the Aquatic Biodiversity Summary, which is compiled by watershed. The biodiversity summary combines three measures of biodiversity: 1) native species richness, which represents overall native diversity of all species in the state, both common and rare; 2) rare species richness, which represents diversity of rare species; and, 3) 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**, taking into account common, rare, and rare endemic species.

This dataset 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). The attribute table for this dataset includes the final ranks for all ACE datasets, providing an overview of all ACE scores for an area.

BACKGROUND INFORMATION

The Species Biodiversity dataset was a new addition to ACE in 2017. The previous version of ACE (ACE-II) combined aquatic information, including fish distribution data, in the terrestrial hexagons, and did

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

ACE
Areas of Conservation Emphasis

not include aquatic invertebrate data. Ace version 3 models aquatic data by watershed (National Hydrography Dataset at the HUC 12 level (HUC 12) rather than by hexagon. The Species Biodiversity

dataset combines the terrestrial hexagons and aquatic watersheds, preserving the boundaries of each dataset. Therefore, the combined dataset can be viewed by hexagon, where the watershed-based aquatic information is accounted for in the hexagon scores. Or, the dataset can be viewed by watershed, where the finer-scale terrestrial scores are shown as a gradient within the larger watershed.

DATA SOURCES AND MODELS USED

The Species Biodiversity dataset is a combination of the ACE Terrestrial Biodiversity Summary, which is compiled by 2.5 square mile hexagon, and the Aquatic Biodiversity Summary, which is compiled by HUC 12 watershed. Each of those biodiversity summary datasets are based on: 1) native species richness, which represents overall native diversity of all species in the state, both common and rare; 2) rare species richness, which represents diversity of rare species; and, 3) irreplaceability, which is a weighted measure of endemism. See the ACE Fact Sheets for those datasets for a detailed description of the data sources and models used to develop each component. Note that aquatic reptile and aquatic amphibian species were included in both the terrestrial biodiversity and the aquatic biodiversity datasets, but these species were only counted once in the combined Species Biodiversity dataset.

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), fish (n=127), aquatic invertebrates (n=183 by Family), 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 ecoregion-based summary.

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), fish (n=90), 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. Aquatic invertebrates were included in the overall native richness counts but not in the aquatic rarity or irreplaceability counts because much of the aquatic invertebrate occurrence data was only available at the taxonomic level of family, while rarity is usually designated at the level of species or subspecies.

Data Sources

Amphibian, bird, mammal, and reptile 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.

Fish distribution data was based on native fish ranges as mapped in Pisces (Santos et al. 2014, https://pisces.ucdavis.edu/). The CDFW is in the process of updating these range maps. If the species range intersected a watershed, the species was counted as potentially present in the watershed. Fish species counts were based on full species only; if separate ranges were available for subspecies, these were combined at the full species level before running the analysis. The Pisces range map for each species is available in BIOS.

Invertebrate distribution data was based on observation point data. Freshwater macroinvertebrate data were extracted from the California Environmental Data Exchange Network database (CEDEN, accessed September 15, 2017). Records were queried from four CEDEN "Projects" (NLA, SWAMP, DFW-ABL, and EMAP). Records primarily consist of data collected under the State Water Board's Surface Water Ambient Monitoring Program (SWAMP) using the SWAMP Bioassessment Protocols (Ode et al. 2016). A small percentage of samples (i.e., less than 10%) were collected by other programs, but almost all of these followed the same sampling protocols. The vast majority of invertebrate identifications were performed by taxonomists at the DFW-Aquatic Bioassessment Laboratory following the procedures documented by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). The extracted records were screened to remove non-freshwater invertebrate taxa and non-native taxa.

Counts for invertebrates were done by family, due to the taxonomic level to which many of the invertebrate specimens were identified. If a data point was present in a watershed, the family was counted for that watershed.

Rare species location data were derived from available documented, mapped species occurrences. Sources included "presumed extant" California Natural Diversity Database (CNDDB; 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 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. Terrestrial rare species occurrences were buffered by one mile, while aquatic rare species occurrence data was not. 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. Each

species was counted for the hexagons (terrestrial species) or HUC12 watersheds (aquatic species) with which its occurrence locations intersected.

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) by ecoregion. The ecoregional normalized values show relative biodiversity within the ecoregion, identifying the highest and lowest biodiversity areas within each ecoregion.

The **irreplaceability weight** is based on the **rarity-weighted index (RWI) calculation,** which weights each species by the extent of its distribution. Whereas for the count of endemic species every species was given the same weight (1 species = 1), for RWI every species was given a weight between zero and one that is proportional to the extent of its distribution. The RWI was calculated by taking the inverse of the number of watersheds or hexagons occupied by each taxon [**RWI = Σ 1/(# occupied watersheds or hexagons per taxon)**], so that taxa with the smallest distributions have the largest values. The values for each species were then summed by taxonomic group per watershed or hexagon. The final rank was assigned by taking the maximum RWI value across taxonomic groups, so that areas of high irreplaceability for any single taxonomic group would be ranked highly in the final map.

Data processing steps:

See the ACE Fact Sheets for data processing steps used to develop the components of biodiversity: Terrestrial Native Species Richness, Terrestrial Rare Species Richness, Terrestrial Irreplaceability, Aquatic Native Species Richness, Aquatic Rare Species Richness, and Aquatic Irreplaceability.

To develop the combined Species Biodiversity dataset:

1. The HUC 12 watersheds were segmented by the 2.5 square mile hexagon grid, so that the boundaries of both were preserved. All segments were attributed with both the original HexID and HUC 12 ID.
2. The aquatic species data was applied to the segments by HUC 12 ID, and the terrestrial species data was applied to the segments by HexID. When data for the same species was available both by hexagon and by HUC 12 watershed (i.e., aquatic reptiles and aquatic amphibians), the data was applied to the segments by hexagon to maintain the finer-scale information.
3. Overall combined Native Species Richness, Rare Species Richness, and Irreplaceability scores were calculated for each segment using the same rules as the terrestrial and aquatic scores for

each (described in the fact sheets listed above). All scores were normalized by ecoregion, to depict relative biodiversity values within each ecoregion.

4. The three component scores (Native Species Richness, Rare Species Richness, and Irreplaceability) were summed by segment.
5. The sum was then normalized (scaled from zero to one) by ecoregion to depict the range of biodiversity values within each ecoregion. This was done by dividing the biodiversity sum for each segment by the maximum biodiversity sum value in the ecoregion.
6. **Final ranking**: To display the relative biodiversity values, the biodiversity summary was ranked from 1-5 using 5 quantiles by ecoregion. The 20% of segments with the highest scores in each ecoregion were given a 5 (highest score), the 20% of segments with the lowest scores in each ecoregion were given a 1, etc.

HOW TO USE THE DATA LAYER

The biodiversity summary maps can be used to view and explore how biodiversity is distributed 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 an area in the viewer, the user can see the final ranks for all ACE datasets, providing an overview of all ACE scores for an area, and the relative rank of the hex/HUC12 segment compared to the rest of the ecoregion.

Frequent uses of this dataset include:

- Identify the areas of highest biodiversity within each ecoregion (Rank 5 hex/HUC12 segments in Biodiversity Summary)
- View the information in the attribute table for each hex/HUC12 to understand what contributes to the biodiversity value in a given area.

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
Ecoreg Biodiversity Rank	Ranks of 1-5 assigned to the ecoregionally normalized biodiversity values, with all zero values removed and remaining values broken into 5 quantiles.

Field	Definition
Ecoreg Biodiversity Weight	Aggregated total of ecoregionally normalized biodiversity values including native species richness, rare species richness, and rarity weighted index. Final sum is re-normalized to 0-1 statewide for ease of interpretation.
State Biodiversity Rank	Ranks of 1-5 assigned to the statewide normalized biodiversity values, with all zero values removed and remaining values broken into 5 quantiles.
Ecoreg Terr Biodiversity Rank	Ranks of 1-5 assigned to the ecoregionally normalized terrestrial biodiversity values, with all zero values removed and remaining values broken into 5 quantiles.
State Terr Biodiversity Rank	Ranks of 1-5 assigned to the statewide normalized terrestrial biodiversity values, with all zero values removed and remaining values broken into 5 quantiles.
State Aqua Biodiversity Rank	Ranks of 1-5 assigned to the statewide normalized aquatic biodiversity values, with all zero values removed and remaining values broken into 5 quantiles.
Ecoreg Native Sp 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.
State Native Sp 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.
Ecoreg Terr Native Sp Rank	Ranks of 1-5 assigned to the ecoregionally normalized terrestrial native species richness values, with all zero values removed and remaining values broken into 5 quantiles.
State Terr Native Sp Rank	Ranks of 1-5 assigned to the statewide normalized terrestrial native species richness values, with all zero values removed and remaining values broken into 5 quantiles.
State Aqua Native Sp Rank	Ranks of 1-5 assigned to the statewide normalized aquatic native species richness values, with all zero values removed and remaining values broken into 5 quantiles.
Ecoreg Rarity 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.
State Rarity 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.
Ecoreg Terr Rarity Rank	Ranks of 1-5 assigned to the ecoregionally normalized rare terrestrial species richness values, with all zero values removed and remaining values broken into 5 quantiles.
State Terr Rarity Rank	Ranks of 1-5 assigned to the statewide normalized terrestrial rare species richness values, with all zero values removed and remaining values broken into 5 quantiles.

Field	Definition
State Aqua Rarity Rank	Ranks of 1-5 assigned to the statewide normalized rare aquatic species richness values, with all zero values removed and remaining values broken into 5 quantiles.
Ecoreg Irreplaceability Rank	Ranks of 1-5 assigned to the ecoregionally normalized irreplaceability values, with all zero values removed and remaining values broken into 5 quantiles.
State Irreplaceability Rank	Ranks of 1-5 assigned to the statewide normalized irreplaceability values, with all zero values removed and remaining values broken into 5 quantiles.
Ecoreg Terr Irreplaceability Rank	Ranks of 1-5 assigned to the ecoregionally normalized terrestrial irreplaceability values, with all zero values removed and remaining values broken into 5 quantiles.
State Terr Irreplaceability Rank	Ranks of 1-5 assigned to the statewide normalized terrestrial irreplaceability values, with all zero values removed and remaining values broken into 5 quantiles.
State Aqua Irreplaceability Rank	Ranks of 1-5 assigned to the statewide normalized aquatic irreplaceability values, with all zero values removed and remaining values broken into 5 quantiles.
Terr Connectivity Rank SUPP	Final connectivity score of 1-5. This is a sum of the NLB_rank and the Linkage_rank, further weighted by the mean CBI Intactness score. This information is supplemental to the dataset. It was not included in the ecoregional or statewide species biodiversity ranks calculated for this dataset. For more information about this field, please refer to Terrestrial Connectivity - ACE [ds2734].
Terr Climate Resilience Rank SUPP	Rank 1-5 based on area-weighted refugia value using equal interval classes Rank 0 = No data (0% of unit assessed). This information is supplemental to the dataset. It was not included in the ecoregional or statewide species biodiversity ranks calculated for this dataset. For more information about this field, please refer to Terrestrial Climate Change Resilience - ACE [ds2738].
Terr Significant Habitat Rank SUPP	Ranks of 1-5 assigned to the statewide normalized terrestrial significant habitat values, with all zero values removed and remaining values broken into 5 quantiles. This information is supplemental to the dataset. It was not included in the ecoregional or statewide species biodiversity ranks calculated for this dataset. For more information about this field, please refer to Terrestrial Significant Habitats Summary - ACE [ds2721].

Field	Definition
Aqua Significant Habitat Rank SUPP	Ranks of 1-5 assigned to the statewide normalized terrestrial significant habitat values, with all zero values removed and remaining values broken into 5 quantiles. This information is supplemental to the dataset. It was not included in the ecoregional or statewide species biodiversity ranks calculated for this dataset. For more information about this field, please refer to Aquatic Significant Habitats Summary - ACE [ds2756].

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 combined Species 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 or watershed should be interpreted with caution. For further information, see the terrestrial native species richness fact sheet. The number of potential species per hexagon or watershed includes those species that, based on our best-available information, could potentially occur within the area, but it is unlikely that all of those species would be found in the area at a given point in time. The aquatic species data used in this analysis is summarized by watershed. However, the species are not expected to be found across the entire watershed; their actual distributions are limited to the locations of suitable habitat within the watershed.

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:

melanie.gogol-prokurat@wildlife.ca.gov

ACKNOWLEDGEMENTS

Combined aquatic and terrestrial biodiversity conceptual model: Ryan Hill, Sandra Hill, Karen Miner, Melanie Gogol-Prokurat.

Native Species Richness Index, Rare Species Richness Index, and Rarity-weighted Index model development: ACE-II technical team, 2009. Melanie Gogol-Prokurat, Monica Parisi, Adrienne Truex, Eric Haney, Dan Applebee.

CWHR Predicted Habitat Suitability Models: Sandra Hill and Melanie Gogol-Prokurat, Conservation Analysis Unit

GIS Scripting: Ryan Hill and Sandra Hill

Thank you to the Jepson Herbarium staff, UC Berkeley, for providing the plant species list and Jepson ecoregion designation database.

Factsheet: Melanie Gogol-Prokurat

SELECTED PUBLICATIONS

Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, Editors. 2012. *The Jepson Manual: vascular plants of California, second edition.* University of California Press, Berkeley, CA.

California Department of Fish and Game (CDFG). 2010. Areas of Conservation Emphasis (ACE-II) Project Report. Sacramento, California.

California Department of Fish and Wildlife (CDFW). 2014. California Habitat Relationships Program (CWHR) version 9.0., personal computer program. California Department of Fish and Wildlife and California Interagency Wildlife Task Group, Sacramento, CA. https://www.wildlife.ca.gov/Data/CWHR/Wildlife-Habitats

California Department of Fish and Wildlife. 2015. California State Wildlife Action Plan, 2015 Update: A Conservation Legacy for Californians. Armand G. Gonzales and Junko Hoshi (editors). Prepared with assistance from Ascent Environmental, Inc., Sacramento, CA.

California Department of Fish and Wildlife (CDFW). 2017. California Natural Diversity Database (CNDDB). Accessed Sept 5, 2017. https://www.wildlife.ca.gov/Data/CNDDB

California Department of Forestry and Fire Protection (CALFIRE). 2015. FRAP Vegetation (FVEG15_1). http://frap.fire.ca.gov/data/frapgisdata-sw-fveg_download

Ode, P.R., Fetscher, A.E., and L.B. Busse. 2016. Standard Operating Procedures (SOP) for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat, SWAMP-SOP-SB-2016-0001, http://www.waterboards.ca.gov/swamp

Santos, N., J. Katz, P. Moyle, J. Viers. 2014. A programmable information system for management and analysis of aquatic species range data in California. Environmental Modelling & Software: 53: 13-26.

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