ACE DATASET FACT SHEET

Aquatic Biodiversity

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INTENT AND PURPOSE

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

The **aquatic biodiversity summary** is a sum of values normalized by taxonomic group, so that areas of highest diversity for each taxonomic group contribute equally to the final map.

BACKGROUND INFORMATION

The separate Aquatic Biodiversity datasets were 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 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.

Areas of Conservation Emphasis

Further work developing the ACE Aquatic data will continue in 2018 (ACE 3, phase 2). This includes continuing to compile and incorporate new aquatic species distribution and occurrence information as it becomes available, and further refining the aquatic species list.

DATA SOURCES AND MODELS USED

The Aquatic Biodiversity Summary is a combination of three ACE datasets that were developed to capture different components of biodiversity: 1) aquatic native species richness, which represents overall native diversity of all species in the state, both common and rare; 2) aquatic rare species richness, which represents diversity of rare species; and, 3) aquatic 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, aquatic native species richness was based on distribution data for aquatic amphibians (n=36), fish (n=127), aquatic invertebrates (n=183 by Family), and aquatic reptiles (n=12). Data for aquatic members of other taxonomic groups, including plants, mammals, and birds, have not yet been included in ACE. Aquatic rare species richness was based on documented occurrence data for aquatic amphibians (n=36), fish (n=90), and aquatic reptiles (n=12). Irreplaceability was based on a subset of the rarity data. Taxa were 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). Aquatic invertebrates were included in the overall native richness counts but not in the aquatic rarity 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 and Reptile distribution data was based on California Wildlife Habitat Relationships (CWHR) Predicted Habitat Suitability models. These models represent potential suitable habitat within the range of each species based the CWHR species range, CWHR species habitat relationship table, and the best available habitat/landcover map (FVEG2015). All native aquatic amphibian and reptile 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 watershed, the species was counted as potentially present in the watershed. These species 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 fish ranges as mapped in Pisces (Santos et al. 2014, https://pisces.ucdavis.edu/). The Department 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.

Aquatic 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 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. Aquatic rare species data was not buffered by 1 mile as the terrestrial rare species data was. 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 each HUC12 watershed(s) 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 sum of total species richness based on raw 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 watershed for a given taxonomic group was divided by the maximum value for that taxonomic group across the state. Aquatic data was not normalized by ecoregion as the terrestrial data was. Statewide normalized values for each taxonomic group were summed by hexagon to create the Aquatic Native Richness values.

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 occupied by each taxon [**RWI = Σ 1/(# occupied watersheds per taxon)**], so that taxa with the smallest distributions have the largest values. The values for each species occurring in a watershed were then summed per watershed by taxonomic group. 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 three components of biodiversity: aquatic native species richness, aquatic rare species richness, and aquatic irreplaceability.

To develop the overall biodiversity summary:

1. The final statewide rank for each dataset, which represents its relative contribution to that component of biodiversity in the state, was summed.
2. This sum was then **normalized** (scaled from zero to one) to allow comparison between watersheds on a standardized scale. This was done by dividing the biodiversity sum for each watershed by the maximum biodiversity sum value in the state.
3. **Final ranking**: To display the relative biodiversity values, the biodiversity summary was ranked from 1-5 using 5 quantiles by watershed. The 20% of watersheds with the highest scores across the state were given a 5 (highest score), the 20% of watersheds with the lowest scores 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 by watershed across the state. The user can view patterns of overall biodiversity 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 watershed 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 a watershed, the relative rank of the watershed compared to 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 in the state (Rank 5 watersheds in Biodiversity Summary)
- View the information in the attribute table for each watershed, 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 in a watershed based on species distribution information (using the Identify Features tool or GIS attribute table)
- Obtain a list of those potentially present species (using theIdentify Features tool on the Species List dataset in the 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 the state for a given taxonomic group (using the Identify Features tool or GIS attribute table to obtain the normalized weights and ranks for each taxonomic group)

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 watershed 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**
Native Fish Count	Count of native fish ranges that intersect each HUC 12 watershed. Fish taxa are aggregated to full species level before counting.
Native Aquatic Invertebrate Count	Count of native aquatic invertebrate taxa that occur within the HUC 12 watershed based on stream survey data.
Native Aquatic Amphibian Count	Count of native aquatic amphibian potential habitat models that intersect the HUC 12 watershed.
Native Aquatic Reptile Count	Count of native aquatic reptile potential habitat models that intersect the HUC 12 watershed.
Native Aquatic Species Weight	Sum of aggregated statewide normalized values for all native aquatic taxonomic groups for each HUC 12 watershed, scaled from zero to one statewide for ease of interpretation.
Native Aquatic Species 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, each containing the same number HUC 12 watersheds.
Rare Fish Count	Count of rare fish taxa within the HUC 12 watershed 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 HUC 12 watershed.

Field	Definition
Rare Aquatic Amphibian Count	Count of rare aquatic amphibian taxa within the HUC 12 watershed 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 HUC 12 watershed.
Rare Aquatic Reptile Count	Count of rare aquatic reptile taxa within the HUC 12 watershed 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 HUC 12 watershed.
Rare Aquatic Species Weight	Sum of aggregated statewide normalized values for all rare aquatic taxa within each HUC 12 watershed. Final sum is scaled from zero to one statewide for ease of interpretation.
Rare Aquatic Species Rank	Ranks of 1-5 assigned to the statewide normalized aquatic rare species richness values, with all zero values removed and remaining values broken into 5 quantiles, each containing the same number of HUC 12 watersheds.
Aquatic Irreplaceability	Maximum statewide normalized rarity weighted index value for any taxonomic group in each HUC12 watershed.
Aquatic 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 HUC 12 watersheds.
Aquatic Biodiversity Weight	Aggregated total of statewide 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.
Aquatic 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 HUC 12 watersheds.
Fish Irreplaceability	Statewide normalized sum of rarity weighted fish values.
Aquatic Amphibian Irreplaceability	Statewide normalized sum of rarity weighted amphibian values.
Aquatic Reptile Irreplaceability	Statewide normalized sum of rarity weighted reptile values.

DATA PRECISION AND LIMITATIONS

This 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. The final maps show biodiversity by watershed. Although species distribution data is summarized by watershed, 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.

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 that native species richness results were generally *overestimates* of species richness. Therefore, the native richness values per watershed represent generalizations of the distribution of diversity throughout the state, but are not meant to represent actual number of species present per watershed at a given point in time. The list of potential species in each watershed includes all species that could potentially occur within the area, but it is unlikely that all of those species would be found in an area at a given point in time. The distribution data for aquatic macroinvertebrates is based on field sampling data, and is therefore limited to those watershed where samples have been collected. The number of species identified as present per watershed may be influenced by the level of survey effort within a 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 the species exists but is not documented). For this reason, counts of rare species richness would be expected to be *underestimates* in some watersheds, 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 are sensitive to level of survey effort, because both the species-level RWI score and the total watershed score are influenced by 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.

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