ACE DATASET FACT SHEET
Terrestrial Climate Change Resilience

DS2738

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INTENT AND PURPOSE

The **Terrestrial Climate Change Resilience** 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, Connectivity, and Significant Habitats. Here, the Terrestrial Climate Change Resilience dataset displays the probability that a given location within California may function as refugia from climate change, summarized by ACE hexagon. These are areas relatively buffered from the effects of climate change, where conditions will likely remain suitable for the current array of plants and wildlife that reside within a hexagon, and where ecological functions are more likely to remain intact. Conserving refugia is an important part of adaptation planning and a means of building resilience to climate change. The Terrestrial Climate Resilience data set is expected to be used along with other ACE datasets to provide a robust spatial assessment of the presence and relative importance of elements important for biodiversity conservation.

BACKGROUND INFORMATION

Terrestrial Climate Change Resilience was added as an ACE layer in 2017. In previous versions of ACE (ACE-II), climate change datasets were not summarized by ACE hexagons. In this version of ACE (version 3), data that represents climate change resilience is summarized by hexagon.

In previous versions of ACE (ACE-II), sea level rise datasets were included as ancillary maps that could be overlaid within the ACE viewer. In this version of ACE (version 3), sea level rise datasets continue to be provided as ancillary maps because 1) sea level rise represents a climate stressor while the ACE dataset represents climate resilience, and 2) sea level rise information has the most utility when viewed at its original scale (i.e., sea level increase in millimeters).

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Further work developing the ACE Climate Change Resilience dataset will continue in 2018 (ACE 3, phase 2). This includes continuing to identify and incorporate new climate change resilience datasets as they become available.

DATA SOURCES AND MODELS USED

The ACE Climate Change Resilience dataset summarizes information on areas in the state expected to be relatively buffered from the impacts of climate change. Currently, the ACE Climate Change Resilience dataset represents areas of possible climate change refugia, based on modeled exposure of natural habitat (vegetation) to climate change.

Source Data

For ACE version 3, areas of low climate change exposure (i.e., climate change refugia) identified in the California Vegetation Climate Vulnerability Assessment (Thorne et al. 2016, Thorne et al. 2017) were summarized by ACE hexagon.

The Thorne et al. (2016) models identified climate refugia based on results of spatially-explicit models of exposure, or expected impact, of climate change on vegetation across California using a 270 m pixel grid. For each pixel across the state, the vegetation type present in the pixel, the climate envelope of that vegetation type in California, and the projected future climate conditions in the pixel were assessed. Low climate exposure was predicted when climate conditions in the pixel remained within the core climate envelope of the vegetation type, while climate stress was expected to increase as climate conditions moved toward outer edge of the climate envelope. The ACE model combines climate refugia model results for 8 future climate scenarios, based on different combinations of global climate models, emissions scenarios, and time horizons:

- Two Global Climate Models (GCMs) representing two ends of the spectrum of potential future climate trajectories in California:
    - MIROC ESM: a hotter and drier future
    - CNRM CM5: a warmer and wetter future
- Two representative concentration pathways (rcp) representing potential future CO_2 emissions scenarios (van Vuuren et al. 2011)
    - Rcp 8.5: business-as-usual; no reduction in emissions
    - Rrcp 4.5: ambitious emissions reductions; emissions peak in 2040 and then decline significantly
- Two time horizons:
    - 2040-2069, mid-century
    - 2070-2099, end-of-century

Data Processing Steps and Ranking Criteria

The ACE Climate Change Resilience ranks were developed to provide a broad overview of expected climate resilience across the state. Data was summarized by hexagon with the following steps:

1. Each 270 m grid cell across the state was attributed with the number of times it was identified as potential climate refugia in the eight vegetation climate refugia models. Results ranged from 0 to 8, where cells never identified as refugia were scored as 0 and cells identified as refugia in every model were scored 8. This number was then converted to a percentage [refugia percentage], representing the percentage of models that identified the area as refugia. Cells that were not assessed (urban, agriculture, and open water) were attributed with 'no data'.

2. The refugia percentage was summarized by hexagon (each hexagon contained approximately 96 270 m grid cells), and weighted by area:
   [Area-weighted climate refugia score] = Σ [refugia percentage] x [percent hexagon]

   Hexagons in which every cell was identified as refugia in every model would receive a score of 1, while hexagons with fewer cells identified as refugia or less agreement among models would receive a lower score. Hexagons in which no cells were identified as refugia in any model would receive a score of zero.

3. The area-weighted climate refugia score applies only to natural areas within the hexagon that were included in the assessment. The calculations weight by area based only on the area actually assessed within the hexagon. For example, if 50% of a hexagon was assessed (50% not assessed because mapped as urban, agriculture, or open water), and all models predicted refugia in the entire 50% of the hexagon assessed, that hexagon would receive a score of 1. The percent of the hexagon assessed is included as field in the attribute table.

4. The Area-weighted climate refugia score was converted to ACE Climate Resilience Ranks 1-5 based on equal interval categories, where:

   1 = Area-weighted climate refugia score ≤ 0.2
   2 = Area-weighted climate refugia score > 0.2 and ≤ 0.4
   3 = Area-weighted climate refugia score > 0.4 and ≤ 0.6
   4 = Area-weighted climate refugia score > 0.6 and ≤ 0.8
   5 = Area-weighted climate refugia score > 0.8 and ≤ 1.0
   No data = no habitat within the hexagon assessed

This step was carried out to create consistency with the ranking schemes of other variables in ACE.

The scoring for this data layer indicates the probability that a hexagon contains refugia (between 0 and 1). Refugia are defined as areas with low exposure to climate change (see Thorne et al. 2016 for detailed description of the 'climatically suitable' exposure classification, p. 26-27). A score of 1 would indicate that every cell within the hexagon has been identified as potential refugia under all future climate projection (out of 8 total, based on different combinations of 2 GCMs, 2 emissions scenarios, and 2 time horizons). A score of 0 indicates that no cell within the hexagon has been identified as potential refugia under any future climate projection. The probability score reflects both the amount of area within an ACE hexagon that has been identified as refugia, and the level of model agreeance that each location/cell within the hexagon will likely serve as refugia.

List of data sources

Vegetation Climate Exposure Refugia 2040_2069 - ICE [ds2657] (Thorne et al 2016)
Vegetation Climate Exposure Refugia 2070_2099 - ICE [ds2658] (Thorne et al 2016)
Vegetation Climate Exposure CNRM CM5 RCP45 2070_2099 - ICE [ds2653] (Thorne et al 2016)
Vegetation Climate Exposure CNRM CM5 RCP85 2070_2099 - ICE [ds2654] (Thorne et al 2016)
Vegetation Climate Exposure MIROC ESM RCP45 2070_2099 - ICE [ds2655] (Thorne et al 2016)
Vegetation Climate Exposure MIROC ESM RCP85 2070_2099 - ICE [ds2656] (Thorne et al 2016)

HOW TO USE THE DATA LAYER

The Climate Resilience Rank provides an idea of where potential climate refugia are more likely to occur on the landscape.

Generally, this layer could be used to help prioritize areas within the state for protection, acquisition, or restoration activities in the broader contexts of conservation planning and adaptation to climate change. This data should be used in combination with other information provided in ACE to assist in making practical determinations about conservation value (e.g. other species or habitat-based information, land ownership, etc.). For example, the refugia layer could be examined alongside connectivity maps and protected areas to determine whether these areas are represented within California's connected landscape. Incorporating refugia into connectivity planning and implementation could ensure that important ecological functions and services are preserved and that species movement across the landscape in response to climate change has the best chance of success.

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
Climate Resilience Rank	Final climate resilience rank of 1-5, where 1 is low and 5 is high. This is based on equal interval categories of the area-weighted climate refugia score, which indicates the probability that a hexagon will contain climate refugia.
Veg Refugia Probability Score	Probability that a hexagon will contain climate refugia based on the percentage of future climate scenarios that predict low climate exposure in the future, weighted by area.
Percent of Hex Assessed	Percent of ACE hexagon assessed in the vegetation climate vulnerability analysis. Areas of with land cover classification of urban, agriculture, and open water were not assessed.

DATA PRECISION AND LIMITATIONS

The terrestrial vegetation climate exposure analysis was a landscape-level GIS analyses subject to the limitations of the source datasets (e.g., landcover data, future climate projections). The terrestrial exposure analysis used a 270m grid, assigning each grid cell the most prevalent vegetation type found in the pixel based on the best-available vegetation map. Vegetation types that occur in small patches on the landscape, such as riparian stringers or small wetlands, may be underrepresented. The analysis excluded Temperate Pacific Intertidal Shore due to its limited distribution within the study area; non-vegetated types such as snow, open water, and ice; and non-natural landcover types mapped as vineyards, tilled earth, orchards and Urban.

See the Terrestrial Significant Habitats Factsheet for a full discussion of data limitations and accuracy of landcover/vegetation datasets in California, and the vulnerability assessment report (Thorne et al 2016) for further discussion of data precision and limitations specific to that project. While any single future climate projection may have relatively high uncertainty, looking for agreement across multiple future climate projections, as was done here, can help reduce that uncertainty.

DATA ACCESS

All datasets are available for viewing and download in BIOS.

For assistance with interpretation contact Whitney Albright: whitney.albright@wildlife.ca.gov

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Factsheet: Whitney Albright and Melanie Gogol-Prokurat

SELECTED PUBLICATIONS

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, & J. Bjorkman. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. Prepared for: California Department of Fish and Wildlife (CDFW), Sacramento, CA.

Thorne, J. H., H. Choe, R. M. Boynton, J. Bjorkman, W. Albright, K. Nydick, A. L. Flint, L. E. Flint, and M. W. Schwartz. 2017. The impact of climate change uncertainty on California's vegetation and adaptation management. Ecosphere 8(12):e02021. 10.1002/ecs2.2021

van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. 2011. Climatic Change 109: 5. https://doi.org/10.1007/s10584-011-0148-z

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