

Description: Dune extent (2016) in central, southern and northern California.

Attributes:

- FID: Unique ID
- Area_km: Area in km²
- Habitat: Habitat type
- Shape_Area: Area in m²

Projected Coordinate System:

- CenCal and NoCal: NAD 1983 (2011) UTM Zone 10N
- SoCal: NAD 1983 (2011) UTM Zone 11N

Methodology:

High-resolution (0.5–1m) aerial imagery (2016 NAIP 4-Band) and oblique photographs from the California Coastal Records Project (www.californiacoastline.org) were used to conduct a general reconnaissance of the entire California coast and create an initial list of potential dune sites. At each location where dunes were identified, elevation data (2016 USGS West Coast El-Nino LiDAR DEM) were used in combination with HAML—Human Attuned Machine Learning Tool for Dune Annotation (Studer et al., 2023)—to map the location and elevation (North American Vertical Datum 1988) of foredune toe and crest features at 30 m intervals along the coastline using a 1625-km-long baseline created for the 2024 USGS National Shoreline Change project.

HAML is a custom ArcGIS plugin developed by the U.S. Naval Research Laboratory (Studer et al., 2023) that facilitates the quick and accurate identification and annotation of key dune features through the creation of elevation profiles derived from a user-provided digital elevation model (DEM). When first initialized, the tool uses algorithmic annotation to place features along shore-perpendicular profiles: the dune crest and toe are defined as the highest point of elevation and location of maximum change in downslope curvature, respectively. Users can adjust annotated features on newly generated profiles through a simple click-and-drag interface. Once the tool has accumulated a reasonable amount of training data (achieved after approximately 30 profiles), the machine-learning backend initiates, providing updated suggestions for crest and toe placement, while still allowing user edits (Studer et al., 2023).

The positional accuracy of toe and crest features mapped using HAML depends on the horizontal and vertical accuracy of the DEM used to generate the elevation profiles and the amount of human input to adjust or verify the placement of features initially located by the tool. In this study, we used HAML to help identify the location and height of nearly 20,000 dune toe and crest features using elevation data (2016 USGS West Coast El-Nino LiDAR DEM) with a horizontal accuracy of 0.21 m, vertical accuracy of 0.12 m, and resolution of 0.5 m. The position of each feature was individually reviewed on at least two occasions: once following its initial placement by HAML and again following the creation of the entire dataset for a region/ dune system. In most cases, only small adjustments (i.e., 1–2 m) were necessary. However, on occasion, more substantial changes (i.e., 10–20 m) were required when features were incorrectly placed by HAML. This includes, for example, instances where the tool incorrectly placed the dune toe at the base of a berm or crest on top of a cliff. Given the accuracy and resolution of the 2016 DEM used for selection and the two-step review processes, we believe the toe and crest features mapped in this study can be considered accurate to approximately 1 m. Toe and crest features were not mapped for isolated dune systems, including clifftop dunes and those disconnected from beaches and other coastal processes due to infrastructure.

Following the review process, toe features were connected and used to define the seaward boundary of dune systems. In contrast, the inland dune boundary was manually identified using elevation data downloaded from the NOAA Data Access Viewer website. For smaller dune systems, the inland boundary was determined using the same 2016 DEM dataset that was used to identify foredune toe and crest features (i.e., 2016 USGS West Coast El Nino LiDAR DEM). However, as the 2016 dataset only extends for approximately 500 m inland, alternative DEMs were used to determine the inland extent of larger dune systems. The horizontal and vertical accuracy of the DEMs used to map these larger systems ranged between 0.12–1.00 m and 0.05–0.20 m, respectively. However, in some locations with limited data availability, less accurate (i.e., > 2m), older DEMs were used (e.g., 2002–2003 IfSAR data for Southern California DEM).

Line vectors of the inland dune boundary were created using manual (heads-up) digitization in ArcGIS Pro (version 3.2.2; Esri, Redlands, California, USA) based on changes in slope and elevation shown in the DEMs (i.e., at the base of the lee slope of the backdune). In some cases, high-resolution aerial imagery (NAIP 4-Band Imagery) and NDVI data were also used, especially in

low-lying areas where changes in land cover and/or plant communities provided a better indication of dune and non-dune areas (i.e., dune to wetland ecosystems). The accuracy of the inland dune boundary varies by region depending on the accuracy and resolution of the DEM referenced, quality and availability of supporting datasets (i.e., aerial images), and type of boundary assessed, with those defined by clear changes in elevation and/or land-use (i.e., dune to infrastructure) generally considered more accurate (< 2 m error) than those produced for gently sloping, transitional environments (i.e., dune to wetlands, 5–15 m error). Given these uncertainties, the inland dune boundary should be considered broadly accurate to approximately 5–20 m across the State.

To create polygons of contemporary (2016) dune extent, the inland dune boundary and seaward dune boundary were connected in ArcGIS Pro. In total, over 1,400 polygons were generated. These polygons were then classified into 10 different habitat types. Most of these habitat types correspond directly to those identified in the historical inventory, including infrastructure, wetland, and transitional environments (e.g., Dune–Bluff, Dune–Wetland, and Dune–Grassland transition zones). However, due to challenges associated with accurately differentiating between active and stable (vegetated) dunes using aerial imagery, these habitats were combined into a single ‘dune’ category in the contemporary inventory. In general, habitat type was classified using aerial imagery from 2016 (i.e., 2016 NAIP 4-Band Imagery) as this year was the most comprehensive in terms of data coverage, accuracy (i.e., 6 m), and resolution (i.e., 1 m). However, in a few isolated cases, imagery from 2002 to 2022 was also used in areas not covered by the 2016 dataset, such as at Vandenberg Space Force Base.

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