Coastal Dunes, Wet Meadows, & Prairie

Climate Change Vulnerability Assessment for the Santa Cruz Mountains Climate Adaptation Project

This document represents an initial evaluation of mid-century climate change vulnerability for coastal dunes, wet meadows, and prairie in the Santa Cruz Mountains region based on expert input during an October 2019 vulnerability assessment workshop as well as information in the scientific literature.

Habitat Description

Coastal dunes range from mobile foredunes to semi- or fully-stabilized dunes dominated by dune grasses and, eventually, coastal scrub vegetation[1]. Dune morphology and ecology are strongly impacted by wind and inland sand movement from the beach, as well as land-use change and management activities that impact sand movement and vegetation development. Vegetation communities are characterized by species tolerant of low nutrient availability, high water drainage, salt spray, and wind desiccation[1–3].

Coastal prairies occur on coastal terraces influenced by summer fog, and are generally dominated by perennial grasses and annual forbs[4]. Seasonal freshwater meadows are scattered within the prairie, and these are characterized by wetland vegetation such as *Juncus* spp. and *Carex* spp., among other species[5].

Vulnerability Ranking

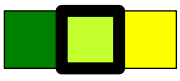
Moderate Vulnerability

Mod Confidence

Coastal dunes, wet meadows, and prairies are sensitive to climate stressors and disturbance regimes that decrease water availability (e.g., altered precipitation patterns) and reduce habitat extent (e.g., sea level rise, storms). Non-climate stressors such as invasive plants, land-use conversion, recreation, and livestock grazing can exacerbate habitat sensitivity by altering geomorphic processes, shifting species composition, and fragmenting or eliminating habitat areas. Coastal dune and coastal prairie vegetation are well-adapted to natural disturbances, however habitat degradation and altered natural geomorphic processes likely reduce the resilience of these habitats to climate change. Management strategies that focus on protection of transition zones and removal of barriers to inland dune migration, as well as removal of invasive species, may increase the resilience of these habitats to changing climate conditions.

Sensitivity and Exposure

Moderate Impact



Mod Confidence

Sensitivity is a measure of whether and how a habitat is likely to be affected by a given change in climate and climate-driven factors, changes in disturbance regimes, and non-climate stressors. **Exposure** is a measure of how much change in these factors a resource is likely to experience.

Sensitivity and future exposure to climate and climate-driven factors


Coastal dunes, wet meadows, and prairies are sensitive to climate stressors that decrease water availability (e.g., altered precipitation patterns) and reduce habitat extent (e.g., sea level rise).

Climate Stressor	Trend Direction	Projected Future Changes
Precipitation	▲▼	• Shorter winters and longer, drier summers likely, with higher interannual variability[6,7]
Sea level rise	▲	• High likelihood (67% probability) of 0.2–0.3 m (0.6–1.1 ft) sea level rise by 2050[8–10]

- **Changes in precipitation patterns** are likely to alter the amount and timing of available water for coastal vegetation. Although dune plants are adapted to periodic moisture stress associated with rapid soil drainage and evaporation[1,2,11], increases in late summer water stress are likely to reduce plant growth and recruitment[1,12]. Projected wetter winters and drier summers may also allow the expansion of invasive European beach grass (*Ammophila arenaria*), which expands during winters with above-average precipitation and is more tolerant of summer drought than most native dune species[2,13,14].

  Coastal prairies are likely less sensitive to changes in precipitation than coastal dunes, in part because many component species are able to limit summer drought stress by utilizing fog water[15]. However, water availability is closely tied to successional dynamics, and increases in precipitation would likely allow the expansion of coyote brush (*Baccharis pilularis*) into adjacent coastal prairies[4,16]. By contrast, reduced precipitation, particularly early in the growing season, could limit coyote brush recruitment[4,17,18]. Additionally, drier conditions would likely have a significant impact on wet meadows, affecting both water level and hydroperiod (i.e., timing and length of inundation)[19]. This could result in the loss of wetland vegetation, which is adapted to high soil moisture and water tables that are close to the surface[1].
- **Sea level rise** is likely to increase erosion and may inundate lower-elevation dunes, depending on factors such as elevation, sediment supply, and adjacent land use[1,10,20]. Over longer time scales, erosion and flooding are likely to result in narrower dune systems, though inland migration could occur where the movement of dynamic foredunes is unconstrained[1,20–22].

Sensitivity and future exposure to climate-driven changes in disturbance regimes


Storms are the key disturbance regime in coastal dunes within the Santa Cruz Mountains region, primarily due to their strong influence on dune morphology. By contrast, coastal prairies and wet meadows have relatively low sensitivity to climate-driven changes in disturbance regimes.

Disturbance Regimes	Trend Direction	Projected Future Changes
Storms & flooding	▲	• Increased storm intensity and duration, resulting in more frequent extreme precipitation events and flooding[6,23,24]

- **Changes in the frequency and/or severity of storms** are likely to accelerate dune erosion and inundation associated with **wave action and flooding**, particularly in conjunction with rising sea levels[1,25]. This is particularly likely during severe El Niño years such as occurred in the winter of

2015–16, when storms in the Bay Area increased wave action by 50% and resulted in extreme coastal erosion[26]. Events such as these can significantly alter dune geomorphology[27].

Although coastal prairies and wet meadows have low sensitivity to climate-driven disturbances, the shallow soils typical of these areas are prone to gullying during heavy precipitation events[19].

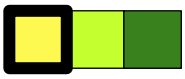
Sensitivity and current exposure to non-climate stressors

Non-climate stressors can exacerbate habitat sensitivity to changes in climate factors and disturbance regimes by altering geomorphic processes, shifting species composition, and fragmenting or eliminating habitat areas.

- **Invasive plants** have significantly altered habitat structure and functioning of both coastal dunes and coastal prairies, and projections suggest that future climate conditions will support their continued spread[1,19]. In many dunes, European beach grass has outcompeted native grasses, and its dense growth and deeper root systems anchor sand and reduce foredune mobility in response to wind and waves[1,27,28]. Coastal prairies are also susceptible to invasion by exotic annual grasses, although these habitats are more resistant to invasion than both coastal dunes and inland grasslands[29]. This is likely because the native perennial bunchgrasses that characterize coastal prairies are able to utilize fog water inputs, giving them a competitive advantage during the dry summer months[15].
- **Land-use conversion** (i.e., to **residential/commercial development** and **agriculture**) and **roads** have eliminated, fragmented, and/or degraded coastal dunes, wet meadows, and prairies across the region[1,5]. Both development and associated infrastructure (e.g., roads) also limit dune mobility and are likely to constrain inland dune migration in response to sea level rise[1,21].
- **Recreational activity** (e.g., foot traffic, off-road vehicles) contribute to vegetation loss and destabilization in coastal dunes. Off-road vehicles, in particular, reduce herbaceous and shrubby perennial vegetation in dunes[30]. Recreational activity has also been identified as a contributing factor to reduced shorebird nesting success due to direct disturbance of nesting birds as well as increased populations of nest predators (e.g., corvids) that are attracted to garbage and other food sources[31,32].
- **Livestock grazing** at appropriate intensities can be an effective strategy to prevent shrub encroachment into coastal prairies[4], and can help maintain native plant communities by reducing the abundance of invasive grasses[33]. However, results are strongly dependent on factors such as grazing timing, frequency, duration, and intensity, and inappropriately-managed grazing can have significant detrimental effects on coastal prairies[34–36]. For instance, grazing late in the season negatively impacts perennial grasses, which stay green longer and so are preferentially grazed at that time of year[19]. Grazing can also be associated with increased cover of non-native forbs and non-native grass species richness, even though the abundance of invasive grasses may decline[36].

Adaptive Capacity

Low Adaptive Capacity



Adaptive capacity is the ability of a habitat to accommodate or cope with climate change impacts with minimal disruption.

Habitat extent, integrity, continuity, and barriers to dispersal

The extent of coastal dune habitats within the Santa Cruz Mountains region is very limited, and most remaining dunes are highly degraded due to the presence of invasive species and encroaching land uses (e.g., development)[1]. However, there is a small area of relatively intact dunes at Franklin and North Points in Año Nuevo State Park[1]. Coastal prairies and wet meadows also have a highly restricted distribution within the study area due to their association with coastal terraces that are highly valued for development and agriculture[4,5]. Wet meadows are particularly rare, but a few sites remain within Año Nuevo State Park, Wilder Ranch, and Point Lobos State Natural Reserve[5]. High-quality coastal prairie sites (generally defined as having at least 20% native species) are also declining due to compositional shifts that occur with the introduction of invasive species[4,19].

Across the region, invasive species and infrastructure (e.g., development, roads) have created barriers to plant dispersal and sand movement. Over longer time scales, the presence of development or infrastructure adjacent to dunes may result in continued narrowing and possible loss of coastal dunes unable to move in response to sea level rise[1,20,21]. Patches of coastal prairie have also been fragmented by land-use conversion to development and agriculture[19].

Habitat diversity

Coastal dune systems have relatively high physical and topographical diversity due to their varied zones (e.g., foredunes to backdunes)[19], and they support many specialized plant species that are adapted to a high-disturbance environment[1]. However, many of these species are very vulnerable to climate change due to their limited distribution and high exposure to sea level rise[37]. Coastal dunes also support diverse wildlife communities[1]; shorebirds, in particular, depend on this habitat for nesting and are highly vulnerable to climate-driven habitat loss[38].

Coastal prairies include two main functional groups: perennial bunchgrasses and annual forbs[19]. They feature very high plant diversity[39], with annual forbs comprising a large proportion of the total biodiversity[39]. Coastal prairies and wet meadows are utilized by many rare and endemic species, including many threatened or endangered butterflies as well as reptiles and amphibians such as the San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) and California red-legged frog (*Rana draytonii*)[4].

Resistance and recovery

Coastal dunes are dynamic environments characterized by constant exposure to wind and waves, and recovery from disturbances is typically rapid for intact dunes[1,27,40,41]. Dune vegetation is also well-adapted to harsh conditions, including a low-nutrient substrate, airborne salt spray, strong winds and winter storms, fluctuating water tables, and erosion or burial by windblown sand[3,28]. However, climate change may bring more extreme conditions than these species have evolved to withstand[1].

Additionally, in many areas natural geomorphic processes that allow dunes to erode and reform have been altered, reducing resistance to the impacts of sea level rise[1].

Coastal prairie vegetation is well-adapted to drought, fire, and other natural disturbances. However, habitat degradation due to invasive species and land-use change is likely to reduce the resilience of this habitat, resulting in the continued loss of native species[19].

Management potential

Coastal dunes are highly valued by the public for their recreational and aesthetic value[1], and societal support for dune protection from sea level rise is also high due to the role of dunes in protecting developed communities from storm surge and flooding[19]. Coastal prairies are less well-known, but are often appreciated for their spring wildflower displays[19]. Regulatory support for these habitats comes from the Federal Coastal Zone Management Act of 1972 (16 U.S.C. § 1451) and California Coastal Act of 1976 (Division 20 of the California Public Resources Code), which limit shoreline development. The Clean Water Act (33 U.S.C. § 1251) also protects wet meadows.

Management strategies for coastal dunes could focus on protection of transition zones and removal of invasive species and barriers to inland dune migration, in order to allow natural sand transport processes to occur as sea level rises[1,19,42]. Invasive species removal has also been successful at enhancing native species populations in coastal prairies, as long as they are not already highly degraded[4]. Managers could consider the potential for mitigation banking from infrastructure development to restore coastal wet meadows, and could explore practices such as beach nourishment (e.g., in locations where inland migration is not possible) and offshore wave attenuation to limit the impacts of coastal erosion, though site-specific impacts would need to be carefully considered[19].

For coastal prairies and wet meadows, protection of remnant sites is critical, particularly for areas still dominated by native perennial vegetation[4]. Restoring historical burning through prescribed fire and cultural burns is a key tool being used to increase the resilience of coastal prairie to climate change, primarily by supporting the growth of fire-adapted native species and preventing shrub encroachment; carefully-managed livestock grazing is similarly used for conservation and restoration purposes[4,19]. As warmer temperatures and altered precipitation patterns increase shrub encroachment into coastal prairies, it will become even more important to restore frequent, low-intensity disturbances (e.g., fire, grazing) to the landscape.

Recommended Citation

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Further information on the Santa Cruz Mountains Climate Adaptation Project is available on the project page (http://ecoadapt.org/programs/awareness-to-action/santa-cruz-mountains).

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