



Coastal Scrub

Climate Change Vulnerability Assessment for the Golden Gate Biosphere Region

This document represents an evaluation of climate change vulnerability for coastal scrub in the Golden Gate Biosphere (GGB) region of California. The following information is based on stakeholder input provided during and following a winter 2022 vulnerability workshop as well as sources from the scientific literature.

Ecosystem Description

Coastal scrub within the Golden Gate Biosphere (GGB) region represents a diverse ecosystem characterized by various vegetation types (Ford & Hayes 2007; Steers et al. 2016). This system extends inland from the Golden Gate through the Coast Ranges, with species diversity diminishing as one moves inland (Ford & Hayes 2007; Wrubel & Parker 2018). Typically found in cooler and more mesic environments at elevations below 500 m (1,600 ft) (Ford & Hayes 2007; Vuln. Assessment Worksheets, pers. comm., 2022), this ecosystem's soils exhibit wide variability, ranging from clay to shallow coarse sands and dunes (Ford & Hayes 2007). The density of the shrub layer varies from continuous to more open, with an herbaceous layer consistently present (Steers et al. 2016). In the central Coast Ranges, including the GGB region, the northern coastal scrub characteristic of marine terraces in the relatively cool, moist climate of the northern California coast transitions into communities more typical of southern coastal sage scrub, characterized by lower woody plant diversity and a greater proportion of drought-deciduous species (Ford & Hayes 2007; Steers et al. 2016; Vuln. Assessment Worksheets, pers. comm., 2022). The dominant coastal scrub species in the GGB region is the evergreen shrub coyote brush (*Baccharis pilularis*; CNPS 2023). Additional characteristic species include California sagebrush (*Artemisia californica*), blue blossom (*Ceanothus thyrsiflorus*), coffeeberry (*Frangula californica*), and Pacific poison oak (*Toxicodendron diversilobum*; Ford & Hayes 2007; Reed et al. 2011; Steers et al. 2016). Coastal scrub canopies provide critical shelter for small mammals, and brush rabbits (*Sylvilagus bachmani*) significantly influence vegetation by restricting the growth of herbaceous understory species through herbivory (Bartholomew 1970; Steers et al. 2016). Coastal scrub vegetation is also essential for many special-status plant and animal species and serves as a crucial breeding habitat for songbirds (Steers et al. 2016).

Fine-scale vegetation maps for San Mateo, Marin, and Sonoma Counties were used to identify 18 vegetation classes that generally represent coastal scrub communities within the GGB region (Tukman Geospatial et al. 2018), which occupy a combined total of 112,492 acres (Figure 1, Table 1). Of that, 56% (63,486 acres) is protected, with the largest areas of protected lands managed by the National Park Service at Point Reyes National Seashore (17,344 acres) and Golden Gate National Recreation Area (10,922 acres; Table 2).

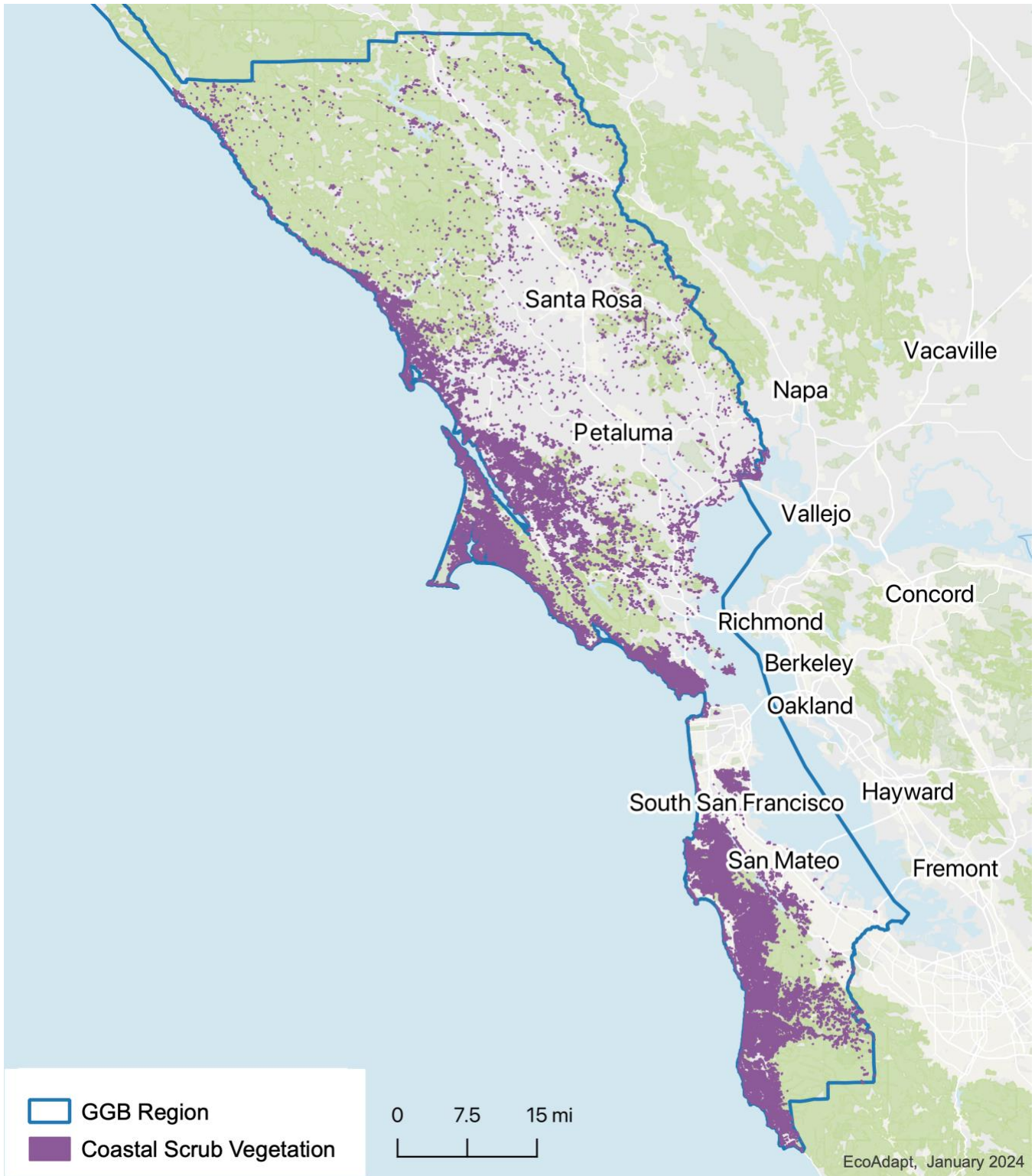


Figure 1. Distribution of vegetation map classes that likely represent coastal scrub communities within the GGB region, derived from fine scale vegetation maps for San Mateo, Marin, and Sonoma Counties (Tukman Geospatial et al. 2018).

Table 1. Vegetation map classes likely to represent coastal scrub communities within the GGB region, derived from fine scale vegetation maps for San Mateo, Marin, and Sonoma Counties (Tukman Geospatial et al. 2018).

Vegetation Map Class
<i>Artemisia californica</i> – (<i>Salvia leucophylla</i>) Alliance
<i>Baccharis pilularis</i> Alliance
California Coastal Evergreen Bluff and Dune Scrub Group
<i>Ceanothus thrysiflorus</i> Alliance
<i>Cornus sericea</i> – <i>Salix (lasiolepis, exigua)</i> Association
<i>Corylus cornuta</i> / <i>Polystichum munitum</i> Association
<i>Diplacus (aurantiacus, puniceus)</i> Association
<i>Eriodictyon californicum</i> - <i>Lupinus albifrons</i> Alliance
<i>Eriophyllum staechadifolium</i> – <i>Erigeron glaucus</i> – <i>Eriogonum latifolium</i> Alliance
<i>Frangula californica</i> ssp. <i>californica</i> – <i>Baccharis pilularis</i> / <i>Scrophularia californica</i> Association
<i>Garrya elliptica</i> Provisional Association
<i>Gaultheria shallon</i> – <i>Rubus (ursinus)</i> Alliance
<i>Hypericum canariense</i> Provisional Semi-Natural Association
<i>Lotus scoparius</i> – <i>Lupinus albifrons</i> – <i>Eriodictyon</i> spp. Alliance
Mesic Coastal Scrub Mapping Unit
<i>Rubus armeniacus</i> Semi-Natural Association
<i>Rubus spectabilis</i> – <i>Morella californica</i> Alliance
<i>Toxicodendron diversilobum</i> - (<i>Baccharis pilularis</i>) Association

Table 2. Total protected acres in the GGB region by land management agency, derived from fine scale vegetation maps for San Mateo, Marin, and Sonoma Counties (Tukman Geospatial et al. 2018).

Land Management Agency	Protected Acres
National Park Service – Point Reyes National Seashore	17,344
National Park Service – Golden Gate National Recreation Area	10,922
California Department of Parks and Recreation	9,834
San Francisco – Public Utilities Commission	6,814
Midpeninsula Regional Open Space District	5,976
Peninsula Open Space Trust	5,716
San Mateo County Parks and Recreation Department	2,589
Other protected lands	1,537
Marin Municipal Water District	670

Marin County Parks	581
Sonoma County Agricultural Preservation and Open Space District	490
United States Fish and Wildlife Service	274
Audubon Canyon Ranch	162
United States Army Corps of Engineers	129
California Department of Fish and Wildlife	113
California State Lands Commission	90
Sonoma County Regional Parks Department	82
The Conservation Fund – California	67
United States Bureau of Land Management	59
Sonoma Land Trust	37
TOTAL	63,486

Ecosystem Vulnerability → Moderate (*moderate confidence*)

Vulnerability is evaluated by considering the ecosystem’s sensitivity and exposure to various climate and non-climate stressors as well as the ecosystem’s adaptive capacity (i.e., ability to cope with these stressors), and is given a ranking of low, moderate, or high. The confidence ranking represents confidence in the accuracy of the ranking based on available scientific knowledge, and is similarly ranked on a scale from low to high.

Summary of ecosystem vulnerability

Coastal scrub ecosystems are susceptible to climate-induced stressors that impact water availability and ecological successional patterns, including changes in air temperature, precipitation, soil moisture, drought, and coastal fog dynamics. The projected increase in the frequency and intensity of wildfires can drive changes in successional dynamics and species composition, among other impacts. The expansion of non-native species also presents a challenge, as these can impede the growth of native vegetation and reduce plant diversity. Moreover, urbanization, roads, and alterations in land use patterns can result in habitat fragmentation, degradation, and barriers to species dispersal, jeopardizing the potential for species migration and threatening the continued viability of coastal scrub ecosystems.

Overall, the resilience of northern coastal scrub is supported by plant species that possess the ability to adapt quickly to changes in climate and disturbance regimes. For instance, coastal scrub species are well-adapted to arid conditions, as evidenced by traits that minimize water loss and allow them to access water stored deep in the soil. These adaptations can allow for recovery and expansion after disturbances, including fires. High species diversity and the presence of mature vegetation in many areas also support adaptive capacity within this system, although ecosystem integrity on some sites

has been degraded. Management strategies that have the potential to reduce climate change vulnerability for coastal scrub ecosystems may include controlling invasive species and ensuring suitable disturbance patterns through managed grazing, prescribed fire, and tree removal.

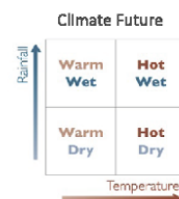
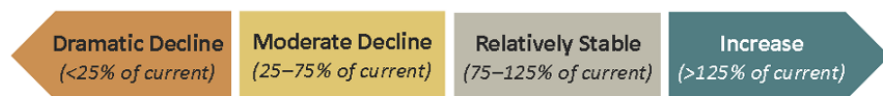
Sensitivity and Exposure → Moderate (*moderate confidence*)

Sensitivity is a measure of whether and how an ecosystem is likely to be affected by a given change in climate factors, climate-driven changes in disturbance regimes, and non-climate stressors. By contrast, **exposure** is a measure of how much change in these factors an ecosystem is likely to experience. Sensitivity and exposure are combined here into one score representing both components of vulnerability, with high scores corresponding to increased vulnerability and low scores suggesting an ecosystem is less vulnerable.

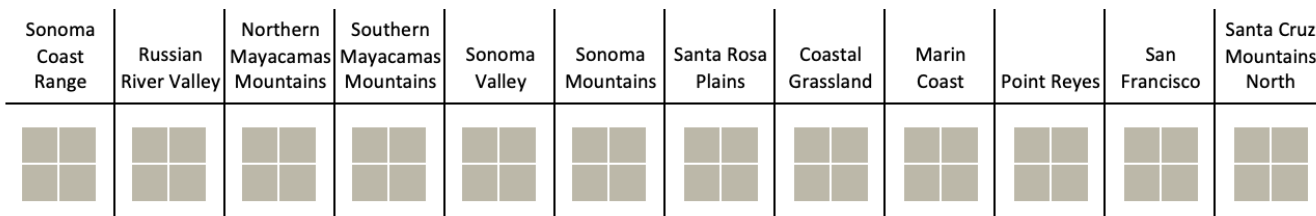
Modeling of climate-driven changes in the future distribution of California bay laurel and coast live oak by Ackerly et al. (2015a) found that these vegetation associations, which are commonly found in coastal scrub ecosystems in the GGB region, are likely to remain relatively stable under a range of potential future conditions (Figure 2). Similarly, species distribution modeling conducted by the Conservation Biology Institute found that areas within the GGB region where climatic conditions are expected to be suitable for coyote brush are expected to expand by roughly 50% by the end of the century under three global climate models (warm/high rainfall, warm/moderate rainfall, hot/low rainfall), filling in the current distribution and expanding along the inland edge (Figure 3; Syphard & Rustigian-Romsos 2024). These expansions are best predicted by changes in winter minimum temperature, which is projected to increase significantly across the region.

Modeled Changes in Vegetation Distribution

Direction and magnitude of change in vegetation cover by 2050



Coyote Brush (*Baccharis pilularis*)



California Sagebrush (*Artemisia californica*)

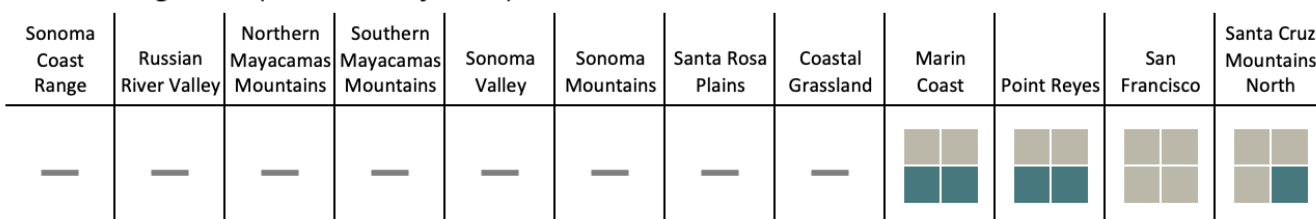


Figure 2. Projected trends in vegetation distribution by mid-century (~2050) within landscape units overlapping the GGB region, based on results from Ackerly et al. (2015a). The four squares refer to a range of possible climate futures that vary with respect to temperature and precipitation, with the top and bottom squares representing wetter and drier scenarios, respectively, and the left and right squares representing scenarios projecting average annual temperature increases of greater than and less than 4.5°C, respectively. The color of the squares indicates the direction and magnitude of change in vegetation cover by 2050, with orange representing dramatic declines (less than 25% of current cover present), yellow representing moderate declines (25–75% of current), gray representing relatively stable cover (75–125% of current), and green represents increases (more than 125% of current).

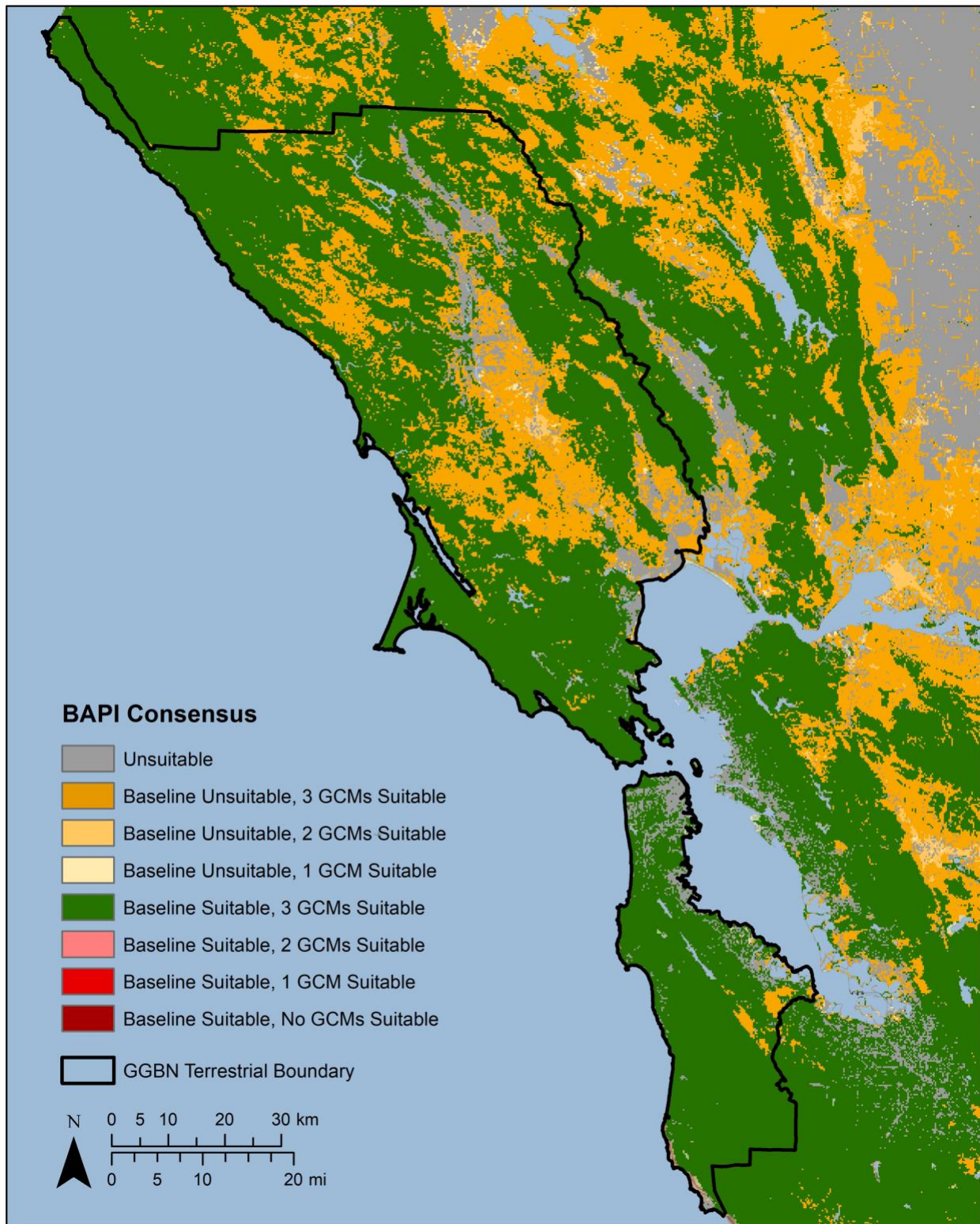


Figure 3. Future climatic suitability for coyote brush (BAPI) for an end-of-century time frame (2070–2099 compared to 1981–2010). Species distribution model compares baseline (current distribution) to three global climate models (GCMs) under the RCP 8.5 emissions scenario. GCMs included are CNRM-CM5 (warm/high rainfall), CCSM4 (warm/moderate rainfall), and MIROC-ESM (hot/low rainfall), all using the RCP 8.5 emissions scenario.

Sensitivity and future exposure to climate factors → Moderate (*moderate confidence*)

- **Increased air temperatures** could impact species composition and distribution, plant development, and pollination dynamics in coastal scrub ecosystems (Parmesan et al. 1999; Grimm et al. 2013; Hatfield & Prueger 2015). Many scrub species have traits that could help buffer them against the impacts of warming, such as smaller leaves that can dissipate excess heat (Cornwell et al. 2012; Peguero-Pina et al. 2020). Rising air temperatures could lead to the expansion of coyote brush into areas currently dominated by coastal prairie grasses, especially in conjunction with increased late-spring rainfall (Williams et al. 1987; Williams & Hobbs 1989; Cornwell et al. 2012). However, the potential expansion of coastal scrub systems might be offset by heightened moisture stress, which would likely impede shrub growth, productivity, and recruitment ability (Cornwell et al. 2012; Ackerly et al. 2015b). Temperature-driven phenological shifts that result in mismatches between flowering and insect life cycles could impact pollination processes, potentially reducing seed production and recruitment for insect-pollinated plants such as coyote brush and California sagebrush (Memmott et al. 2007; Parmesan 2007).
- **Shifts in precipitation patterns and soil moisture levels** can influence coastal scrub ecosystem function and vegetation dynamics (Goldstein & Suding 2014) and lead to shifts in distribution and species composition (Grimm et al. 2013; Goldstein & Suding 2014; Potter 2014; Vuln. Assessment Worksheets, pers. comm., 2022). The growth of coyote brush and other coastal scrub species is generally positively influenced by increased precipitation and soil moisture during the initial stages of the growth season (Williams et al. 1987; Williams & Hobbs 1989; Ford & Hayes 2007; Cornwell et al. 2012). Under wetter conditions, coastal scrub species may expand into adjacent systems such as coastal prairies (Da Silva & Bartolome 1984; Williams & Hobbs 1989; Steinberg 2002; Ford & Hayes 2007; Cornwell et al. 2012; Smither-Kopperl 2016). However, increased precipitation can also enhance the growth of exotic annuals, affecting the recruitment of coyote brush seedlings by increasing competition for resources (e.g., sunlight, nutrients; Williams & Hobbs 1989; Steinberg 2002; Ashbacher & Cleland 2015; CNPS 2023). Changes toward drier conditions, particularly if due to lower levels of precipitation during spring months, can repress coyote brush seedling growth and heighten competition from annual grasses, potentially causing the conversion of coastal scrub into grass-dominated communities (Williams & Hobbs 1989; Ford & Hayes 2007).
- **Future increases in drought severity and duration** could decrease productivity, species richness, and herbaceous cover of coastal scrub vegetation (Cornwell et al. 2012; Kimball et al. 2016; Copeland et al. 2016). During the summer dry season, some drought-tolerant scrub species, such as coyote brush, can grow a deep taproot that provides access to moisture from deep soil layers (Da Silva & Bartolome 1984; Ford & Hayes 2007; Smither-Kopperl 2016). This access to water can allow the plants to maintain their average rate of physiological processes (e.g., transpiration), which aids in the species' survival during periods of drought (Cleland et al.

2016). However, prolonged drought conditions can constrain growth and productivity as well as nutrient dynamics (uptake, transport, release) in scrub species, particularly for young plants, due to reduced mobility and absorbance of nutrients as a result of low soil moisture (da Silva et al. 2011; Cleland et al. 2016). Where seedlings can successfully establish and grow into mature adults, they are generally less moisture-limited because of their deep root system (Ford & Hayes 2007).

- **Changes in coastal fog dynamics** may affect coastal scrub ecosystems, which include many species that utilize fog water inputs to reduce seasonal drought stress (Kidder 2015; Emery 2016; Emery et al. 2018). The presence of coastal fog is known to boost vegetation productivity and growth, particularly during the dry summer months (Rastogi et al. 2016; Potter 2016; Langridge 2018). As drought and other stressors (e.g., temperature) increase, fog can aid in the overall survival of scrub species by decreasing temperatures and potential evapotranspiration (Corbin et al. 2005; Baguskas et al. 2016; Rastogi et al. 2016). Potential future decreases in the occurrence of coastal fog and low clouds would exacerbate seasonal drought stress and intensify evaporative water loss as a result of increased leaf sun exposure, threatening scrub species survival (Johnstone & Dawson 2010; Kidder 2015; Emery et al. 2018).

Sensitivity and future exposure to climate-driven changes in disturbances → High (*moderate confidence*)

- **Climate-driven shifts in wildfire regimes** are likely to influence plant growth, species composition, and nutrient availability in coastal scrub ecosystems (Chase et al. 2005; Kimball et al. 2016; Nolan et al. 2021; CNPS 2023). For obligate-seeding shrub species (i.e., shrubs that are unable to resprout and so reproduce only by seed), increases in wildfire frequency can inhibit regeneration by killing sprouts and seedlings before they mature and reproduce, decreasing abundance of these species within the ecosystem and potentially resulting in shifts in relative dominance towards shrubs that are able to resprout following topkill (e.g., coyote brush, coffeeberry, California sagebrush; Zedler et al. 1983; Enright et al. 2015). Coyote brush also has the ability to rapidly recolonize burned areas because of their wind-dispersed seeds (Smither-Kopperl 2016; CNPS 2023). Generally, wildfires also increase nitrogen deposition, which may impact plant growth, nutrient cycling, soil chemistry, and vital functions like photosynthesis across species (Kimball et al. 2016). The presence of fog can play a role in mitigating wildfires within coastal habitats by reducing the severity of summer drought stress and minimizing the loss of fuel moisture for shrub species (Emery et al. 2018). However, decreased fog as a result of climate change could limit these benefits (Kidder 2015; Emery et al. 2018). Additionally, increased extreme wildfire events due to climate changes may increase the abundance of non-native grass species (Giessow & Zedler 1996). Non-native species in scrub habitats have been found to germinate more rapidly and become established before native species, giving them the advantage of outperforming native species during early lifecycle stages and possibly slowing

the rate of post-fire coastal scrub recovery (Giessow & Zedler 1996; Wainwright & Cleland 2013). These changes in succession resulting from altered fire regimes can impact bird species such as wrentits (*Chamaea fasciata*) and Nuttall's white-crowned sparrows (*Zonotrichia leucophrys nuttalli*) by damaging or inhibiting the growth of coastal scrub vegetation on which they depend (Chase et al. 2005).

Sensitivity and current exposure to non-climate stressors → High (*high confidence*)

Non-climate stressors can exacerbate ecosystem sensitivity to changes in climate factors and disturbance regimes, and/or can be exacerbated by these changes.

- **Residential/commercial development** brings a range of consequences to coastal scrub ecosystems, such as habitat loss, fragmentation, and isolation of plant and animal populations (Ford & Hayes 2007; McKinney 2008; Cleland et al. 2016; Elmqvist et al. 2016; Langridge 2018). Infrastructure like roads can also act as barriers, limiting animal movement and seed dispersal that isolates populations and threatens genetic diversity and the ability to adapt to changing conditions (Coffin 2007; Holderegger & Di Giulio 2010). Rapid urbanization and exurban development (i.e., residential development beyond urban areas) can also influence species richness, diversity, and composition due to reductions in the availability of natural habitats (McKinney 2008; Grimm et al. 2008; Elmqvist et al. 2016). Additionally, air pollution from urban areas contributes to excess nitrogen deposition, which can influence primary production and plant growth (Hansen et al. 2005; Grimm et al. 2008; Theodorou 2022). For instance, nitrogen deposition increases biomass of non-native annual grasses, and the resulting fine fuels is associated with significant increases in wildfire risk (Talluto & Suding 2008; Rao et al. 2010). Urban development often introduces invasive non-native plant species, leading to competition with native vegetation and disturbing the ecosystem's balance (Ford & Hayes 2007; Mayfield et al. 2021). Urbanization and its effects such as noise pollution (e.g., traffic from roads) can alter species interactions (e.g., competition, pollination, herbivory), trophic relationships, and animal behaviors like nesting and foraging (Ware et al. 2015; Miles et al. 2019).
- **Invasive plants** increase competition for resources within coastal scrub ecosystems and lead to a reduction in the richness and diversity of native species within them (D'Antonio & Vitousek 1992; Alvarez & Cushman 2002; Mayfield et al. 2021). In California, Monterey pines (*Pinus radiata*) that are growing outside of their natural range (e.g., GGB region) and were introduced by humans are classified as invasive cultivars (Steers et al. 2013). Monterey pines can readily recruit and disseminate seeds with limited competition, potentially shading out native coastal scrub species and resulting in changes in vegetation composition, including a decrease in native species richness and cover (Steers et al. 2013; Langridge 2018). Additionally, invasive forbs and annual grasses often become established in recently burned areas when high rates of vegetation mortality occurred (Cleland et al. 2016).

- **Livestock grazing** often affects vegetation composition and succession, native species richness, and the prevalence of invasive plant species (Callaway & Davis 1993; Alvarez & Cushman 2002; Cleland et al. 2016). Livestock grazing has been connected to a reduction in biodiversity and has been found to impact trophic levels within associated wildlife communities (Filazzola et al. 2020). For example, grazing has been linked to declines in small mammal and invertebrate herbivore abundance resulting from competition for food resources, destruction of critical shelter such as burrows, and increased predation risk due to reduced vegetation cover (Filazzola et al. 2020). Livestock grazing can also influence soil moisture and fire frequency, intensifying effects on community structure, composition, and species diversity (Milchunas & Lauenroth 1993). Carefully managed grazing practices can, in some instances, contribute positively to the structural integrity and extent of coastal scrub ecosystems (Elliott & Wehausen 1974; Ford & Hayes 2007), particularly when coupled with periodic controlled burning (Davison & Barbour 1977; de Becker 1988). Nevertheless, sustaining an equilibrium in managed grazing is essential, as excessive stocking density and duration of grazing can lead to degradation by diminishing plant height and species richness (Ford & Hayes 2007; Hayes & Holl 2011) and even trigger the replacement of coastal scrub by grasslands (Davison & Barbour 1977).
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Adaptive Capacity → Moderate (high confidence)

***Adaptive capacity** is the ability of an ecosystem to respond to or cope with climate change impacts with minimal disruption. High adaptive capacity corresponds to lower overall climate change vulnerability, while low adaptive capacity means that the ecosystem will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the ecosystem.*

Ecosystem extent, integrity, and continuity → Low (high confidence)

Northern coastal scrub is distributed along the California coastline, predominantly occurring at elevations lower than 500 meters (1,640 ft) in environments influenced by coastal fog (Ford & Hayes 2007). Coastal scrub ecosystems characterized by complex structure and high species diversity are declining due to the ongoing expansion of urbanization and the loss of frequent disturbances such as grazing and fire (Ford & Hayes 2007). These anthropogenic impacts threaten the ecosystem's integrity and decrease its permeability to animal movement (Reed et al. 2011; Vuln. Assessment Worksheets, pers. comm., 2022). Existing geological features, urbanization, and road networks also fragment the ecosystem (Ford & Hayes 2007; Steers et al. 2016; Vuln. Assessment Worksheets, pers. comm., 2022), which can restrict gene flow between plant and wildlife populations and reduce genetic diversity (Cleland et al. 2016), potentially hindering effective adaptation to changing conditions (Jump & Peñuelas 2005). While in many areas coastal scrub vegetation has expanded into adjacent grasslands, the extent of diverse scrub is progressively diminishing, and the absence of disturbance can expedite the conversion of this ecosystem into woodland environments (Ford & Hayes 2007).

Ecosystem diversity → High (high confidence)

Northern coastal scrub vegetation is characterized by diverse vegetation assemblages and extends inland from the Golden Gate through the Coast Ranges across varied topography (Ford & Hayes 2007; Steers et al. 2016). Complex interactions of microclimates, soil attributes, and topography play a significant role in shaping the diversity of coastal plant communities. Variations in factors like water availability, temperature, salt content, humidity, wind exposure, and fog prevalence establish distinct niches that foster the growth of northern coastal scrub plant species (Wrubel & Parker 2018). The transition from northern coastal scrub to southern coastal sage scrub in the central Coast Ranges is partially attributed to increasing aridity from northern to southern latitudes. Changing moisture levels also affect plant diversity along the coast-to-inland climatic gradient (Ford & Hayes 2007; Steers et al. 2016), with plant communities farther inland generally exhibiting lower diversity compared to those closer to the coast (Riordan & Rundel 2009; Wrubel & Parker 2018). Species diversity also tends to increase within more open shrub canopies and continuous herbaceous layers (Steers et al. 2016). Historical land use practices and disturbance regimes (e.g., fire) play a crucial role in shaping the diversity of coastal plant communities (Steers et al. 2016; Vuln. Assessment Worksheets, pers. comm., 2022).

Resistance and recovery → Moderate (high confidence)

Coastal scrub vegetation is well-adapted to hot, dry conditions, with many plant species having small, thick leaves that help reduce water loss through evapotranspiration. Additionally, many species in coastal scrub ecosystems have extensive root systems that allow them to access water stored deep in the soil or can utilize moisture from coastal fog (Steinberg 2002; Harrison et al. 2015; Copeland et al. 2016; Puritty et al. 2019). Some species are drought-deciduous and can shed their leaves in response to water scarcity and drought stress, which helps them survive dry periods by reducing their water needs and minimizing the risk of desiccation (Steinberg 2002; Ford & Hayes 2007). These traits also give coastal scrub species an advantage over non-native annual grasses, which generally do not possess these traits (Harrison et al. 2015; Copeland et al. 2016; Puritty et al. 2019). Furthermore, coastal scrub species are generally able to recover rapidly from fire through resprouting or germination from the soil seed bank, allowing them to expand into disturbed areas (Steinberg 2002; Ford & Hayes 2007).

Increases in the isolation or degradation of coastal scrub communities might hinder their resilience to climate change by limiting species migration and range shifts in response to changing conditions (Jump & Peñuelas 2005; Cleland et al. 2016). Additionally, decreases in species diversity and richness can reduce the capability of the community as a whole to accommodate and respond to shifting environmental conditions.

Management potential → Low (moderate confidence)

Although coastal scrub ecosystems hold aesthetic and ecological values, they are generally most valued by the public for their recreational opportunities. It is likely that strategic outreach could enhance their appeal to the public (Vuln. Assessment Worksheets, pers. comm., 2022). Management strategies for coastal scrub ecosystems generally focus on controlling invasive species and ensuring suitable disturbance patterns through practices such as managed grazing, prescribed fire, and the manual removal of trees (Ford & Hayes 2007; Wrubel & Parker 2018). Removing invasive species at early growth stages may help minimize the adverse effects of invaders on native plant cover and species richness in coastal scrub ecosystems (Steers et al. 2013). In light of increased wildfire risk due to climate change, carefully-managed prescribed fires and grazing could help reduce fuel loads, potentially lessening the negative impacts of fire on this system (Alcañiz et al. 2020). Ecosystem connectivity should also be prioritized to protect genetic diversity and provide corridors for migration of native plants and animals, supporting increased adaptive capacity (Cleland et al. 2016). However, there can be a range of challenges that managers face when implementing these strategies. For example, monitoring and controlling invasive species can be challenging in this landscape due to difficulty accessing many coastal scrub areas on steep slopes (Vuln. Assessment Worksheets, pers. comm., 2022). Managers are also faced with rapidly changing ecosystems and a lack of tools and knowledge to effectively address emerging issues, as well as conflicting land use priorities, and advancing developmental pressure (Vuln. Assessment Worksheets, pers. comm., 2022).

Recommended Citation

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Further information on the Golden Gate Biosphere Region Climate Adaptation Project is available on the project page (www.ecoadapt.org/goto/GGBRClimateProject).

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