Mixed Grasslands

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 ***mixed grasslands 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

Mixed grasslands in the Santa Cruz Mountains region are dominated by a mix of annual forbs and non-native annual grasses, with fewer perennial grasses compared to coastal prairie[1]. Mixed grasslands can occur across a range of soil types, including serpentine soils that harbor distinct plant communities[1,2]. These are generally dominated by native annual forbs, with some native grasses and lower exotic grass cover compared to more productive grasslands[2,3]. Both serpentine and non-serpentine grasslands are often interspersed with chaparral and oak woodlands[1,3].

Vulnerability Ranking

Moderate Vulnerability

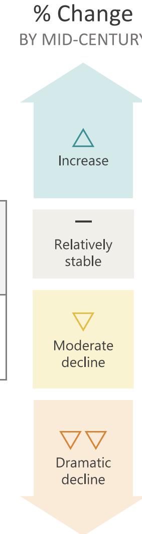
Low → High

High Confidence

Mixed grasslands are sensitive to changes in precipitation and soil moisture that reduce water availability for native grasses and forbs, impacting plant productivity, species composition, and vulnerability to invasion. Altered wildfire regimes are also likely to shift species composition and functional group dominance, driving expansion of non-native grasslands. Non-climate stressors (e.g., invasive plants, nitrogen deposition associated with roads and highways, livestock grazing) impact grassland productivity, species composition, and fire regimes, which is likely to exacerbate habitat vulnerability to climate change.

Mixed grasslands are widely distributed in the region, but habitat fragmentation and loss are increasing due to land-use conversion and degradation. Climate-driven changes in water availability and fire regimes, combined with the continued expansion of invasive annual grasses, are likely to reduce resistance to and recovery from stressors and disturbances. In the context of climate change, management of mixed grasslands may focus on strategies that maintain frequent disturbances and promote the persistence of native species, including climate-informed grazing practices, increased use of prescribed fire, and invasive species management.

As part of this project, Pepperwood Preserve modeled how major vegetation types in five landscape units of the Santa Cruz Mountains region are projected to shift in response to climate change.[1] They found that moderate declines in grasslands are likely to occur across all landscape units.



Vegetation Type	San Francisco	Santa Clara Valley	Santa Cruz Mtns. North	Santa Cruz	Sierra Azul
Grasslands	▽	▽	▽	▽	▽

Table 1. Projected trends in vegetation distribution (increase, relatively stable, moderate decline, or dramatic decline) by mid-century within five landscape units of the Santa Cruz Mountains region.

Sensitivity and Exposure

High Impact

Low → High

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

Mixed grasslands are sensitive to climate stressors that reduce water availability for native grasses and forbs, impacting plant productivity, species composition, and vulnerability to invasion.

Climate Stressor	Trend Direction	Projected Future Changes
Precipitation	▲▼	• Shorter winters and longer, drier summers likely, with higher interannual variability[4,5]
Soil moisture	▼	• Reduced soil moisture likely due to increased evaporative demand[4,6]

- **Changes in precipitation amount and timing** and **soil moisture** are likely to impact grassland productivity (e.g., biomass and seed production), which is tightly linked to interannual precipitation variability[1,7–11]. These changes are also likely to drive shifts in functional group dominance and species composition due to differing sensitivity to soil moisture among annual and perennial grasses and forbs[11]. Due to their more extensive root systems, perennial grasses are generally more tolerant of dry years and variable precipitation timing than annual forbs and grasses[1,12,13]. However, perennial grasses are highly sensitive to consecutive dry years that prevent deep soil recharge, particularly in the presence of exotic annuals that compete for

[1] Information about the methods used to generate these projections can be found on the project page (http://ecoadapt.org/programs/awareness-to-action/santa-cruz-mountains).

shallow soil moisture resources[11]. Consecutive dry years may also provide an advantage to native annual forbs over invasive annual grasses[14]. Changes in community composition (e.g., loss of perennial grasses) can drive further changes in water availability by affecting soil porosity and infiltration, creating a positive feedback loop by driving further shifts in species composition[11]. Because low nutrient availability in serpentine grasslands is a stronger limiting factor than moisture availability, species composition, diversity, and biomass in these areas is less responsive to interannual precipitation variability compared to more productive sites[15–17].

Overall, mixed grasslands are likely less sensitive to changes in moisture availability than other habitats (e.g., oak woodlands, shrublands), and drier overall conditions may allow expansion of non-native grasslands into disturbed areas[18,19].

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

Wildfire is the key disturbance regime in mixed grassland habitats within the Santa Cruz Mountains region due to its strong influence on successional dynamics.

Disturbance Regimes	Trend Direction	Projected Future Changes
Wildfire	▲	• Slight to moderate increase in wildfire risk, particularly in areas of higher rainfall[20,21]

- Climate-driven changes in **wildfire regimes (e.g., increased fire frequency)** are likely to expand the distribution of mixed grasslands dominated by exotic annual grasses over the coming century, largely due to type conversion of oak woodlands and shrublands following more frequent fires combined with drier overall conditions that slow regeneration of these species[18,22–25]. Within existing native-dominated grasslands, changes in fire timing, frequency, and intensity are likely to shift species composition and functional group dominance, depending on factors such as site conditions, post-fire moisture availability, and additional stressors (e.g., nitrogen deposition)[18,26–28].

Sensitivity and current exposure to non-climate stressors

Non-climate stressors can exacerbate habitat sensitivity to changes in climate factors and disturbance regimes due to their interacting effects on grassland productivity, species composition, and fire regimes.

- **Invasive plants** limit the establishment, recruitment, and growth of native grasses and forbs by competing for soil moisture and other resources (e.g., light, space)[29–31]. Displacement of native perennial grasses and annual forbs by invasive annual grasses and forbs is common, altering grassland species composition and physical structure[31,32]. By increasing fuel availability and continuity, exotic annual grasses also contribute to changes in fire frequency, intensity, and rate of spread[8,25,33]. Projected increases in interannual precipitation variability and fire frequency under future climate conditions are likely to support continued expansion of invasive plants into mixed grasslands, driving further changes in species composition and ecosystem functioning[32].
- **Nitrogen deposition** from **roads and highways** can drive major shifts in grassland species composition by increasing the productivity and dominance of non-native annual grasses[16,34]. Nitrogen deposition has particularly large impacts on serpentine grasslands as native species

are displaced by invasive grasses that are no longer constrained by nutrient limitations[2,35], resulting in decreased native plant diversity[1,8,36] and declines in specialized pollinators dependent on rare serpentine plants[35–37]. Roads and highways can also contribute to the spread of invasive plants whose seeds may be carried to new areas on vehicles, and many non-native species thrive in disturbed roadside environments[38].

- **Livestock grazing** that is inappropriately managed can have significant detrimental effects on grasslands[1,12,39]. For instance, grazing late in the season can have detrimental effects on perennial grasses, which stay green longer and so are preferentially grazed at that time of year[32]. Grazing is also often associated with increased cover of non-native forbs and non-native grass species richness[39]. However, careful management of grazing timing, frequency, duration, and intensity can be an effective strategy to maintain native plant communities, though appropriate grazing prescriptions vary widely based on site-specific conditions.

Adaptive Capacity

Moderate Adaptive Capacity

Low → High

High Confidence

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

Mixed grasslands are widespread within the Santa Cruz Mountains region and across the state[1,40]. However, increased dominance by invasive species has permanently altered many grasslands, resulting in relatively few remaining areas that are dominated by native species[40]. Most of these are on patchily-distributed serpentine soils, which occupy a small proportion of the overall grassland area[2]. Exotic species have a particularly significant negative impact on the integrity of serpentine habitats[2]. Serpentine grasslands are also increasingly threatened by habitat fragmentation and modification as a result of human land-use conversion and associated impacts (e.g., roads), and decreased patch size as a result of fragmentation may further reduce their resistance to invasion[2]. Additionally, the dependence of serpentine grasslands on small and spatially isolated areas of suitable substrate is likely to limit opportunities for migration of serpentine specialists in response to climate change[41].

Habitat diversity

Mixed grasslands within the Santa Cruz Mountains region have high physical and topographical diversity[32], contributing to variable species composition within and across sites[1]. However, functional group diversity is low, particularly where invasive annual grasses have excluded native grasses and forbs and increased the vulnerability of many individual species to extirpation[32,35].

Mixed grasslands support many wildlife species, and are recognized as particularly important for pollinators and nesting birds[1,32].

Resistance and recovery

Overall, mixed grasslands are resistant to changing climate conditions, due in part to the high proportion of non-native species[32]. However, several functional groups (e.g., native annual forbs and perennial grasses) are vulnerable to changes in water availability and/or are poorly suited for competition with invasive annual grasses following disturbances such as wildfire[15,17,30,40]. As a result, species composition within mixed grasslands is highly likely to shift towards even greater dominance of non-native annual grasses[32]. Refugia for native-dominated grasslands likely include serpentine soils[32], where nutrient limitations generally restrict the growth of non-native species[2]. Serpentine plant communities have also demonstrated slower changes in community composition and species diversity in response to climate change[42], likely due to the high prevalence of stress-tolerant functional traits within serpentine endemics[15,16].

Management potential

Mixed grasslands are valued by the public for their scenic qualities (e.g., vistas, wildflower displays) and recreational opportunities[1]. Grasslands are also valued for the many ecosystem services they provide to society, including livestock forage production, erosion control, water infiltration, carbon sequestration, and support of biodiversity (e.g., rare/endemic species, pollinator communities)[1]. A significant proportion of mixed grasslands within the state are under private ownership, which reduces the efficacy of conservation and restoration activities at the landscape scale[1]. However, conservation easements and other forms of protection are in place in some areas[40], and most grasslands within the Santa Cruz Mountains region are heavily managed[32]. There is some regulatory support for the management and protection of grasslands in the form of land-use restrictions or voluntary measures such as the California Land Conservation Act of 1965 (also known as the Williamson Act), which relieves property taxes in exchange for a 10-year agreement to not develop open space. However, mixed grasslands are generally less regulated than forest lands[32]. High priorities for future protection may include serpentine grasslands and areas that remain dominated by native plant species.

Lack of institutional knowledge is one of the primary impediments to effectively managing mixed grasslands under changing climate conditions, and many potential management tools are not well-understood[32]. Livestock grazing, prescribed burning, and invasive species management are likely to be important actions to consider when managing for grassland persistence and integrity under changing climate conditions[1,32,33,40]. For instance, livestock grazing at appropriate intensities can be an effective strategy to reduce the abundance of invasive annual grasses and maintain native plant communities within both serpentine and non-serpentine grasslands[12,35,39,43]. It is particularly beneficial for native forbs[12,39] and as a tool to slow shrub encroachment[28], and grazing practices can be adapted to account for climate-driven changes in precipitation[32]. However, results are strongly dependent on site-specific conditions as well as the timing, frequency, duration, and intensity of grazing, and inappropriately-managed grazing can have significant detrimental effects on grasslands[1,12,12,39]. Additionally, lack of water availability for livestock can limit the ability to manage grasslands through grazing[32].

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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