



## Freshwater Marshes, Wetlands, and Ponds

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

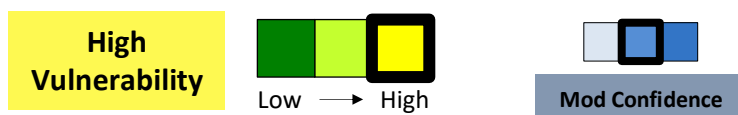
This document represents an initial evaluation of mid-century climate change vulnerability for freshwater marshes, wetlands, and ponds in the Santa Cruz Mountains region based on expert input during an October 2019 vulnerability assessment workshop as well as information in the scientific literature.

### Habitat Description

Freshwater marshes and wetlands are often found on the margins of lakes, creeks, and rivers<sup>1,2</sup>. Ponds generally occur within natural depressions or isolated channels, and can be associated with wetlands and/or riverine habitats<sup>3,4</sup>. Artificial ponds in the form of stock ponds, irrigation ponds, and agricultural reservoirs are also common within the study area, and are generally supplied by water diversions or instream flow<sup>5</sup>. Within natural wetlands and ponds, winter precipitation is the primary water source although some can receive a portion of their water supply from groundwater<sup>5,6</sup>.

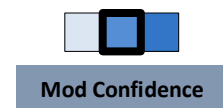
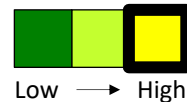
Freshwater marshes and ponds may be flooded seasonally or permanently, and plant species composition is dependent on both water depth and hydroperiod (i.e., timing and length of inundation)<sup>1,7</sup>. In shallow areas, plant communities are characterized by perennial herbaceous plants such as rushes (*Juncus* spp.), bulrushes (*Bolboschoenus*, *Schoenoplectus*, and *Scirpus* spp.), cattails (*Typha* spp.), common reed (*Phragmites australis*), and sedges (*Carex* spp.)<sup>1,2</sup>. Where water depth is over 1 m (3 ft), aquatic plants such as water lilies (*Nymphaeaceae*), duckweed (*Lemna* spp.), and pondweed (*Potamogeton* spp.) may occur<sup>1,7</sup>. Ponds are more likely to include areas of open water due to greater depths, and tend to have lower oxygen content compared to wetlands fed by running water<sup>3,4</sup>.

### Vulnerability Ranking



Freshwater marshes, wetlands, and ponds are sensitive to climate stressors and disturbances that alter hydrologic and thermal regimes, including changes in patterns of precipitation and runoff, altered stream flows, increased drought, warmer water temperatures, heat waves, and sea level rise. These changes are likely to impact water levels, hydroperiods, and water quality, altering habitat suitability for many wildlife and plant species and driving changes in wetland and pond structure and function. Non-climate stressors can exacerbate habitat sensitivity by altering wetland and pond hydrology, water quality, and connectivity. Although freshwater wetlands and ponds were historically extensive within riparian floodplains in the region, many have been eliminated or degraded by historical development, agricultural activities (e.g., water diversions), and other anthropogenic factors. These fragmented and/or degraded systems are particularly vulnerable to the impacts of climate change. However, management activities such as maintaining or restoring natural hydrologic regimes, retaining water within the system, managing vegetation (e.g., through planting, mowing, disking, or grazing), reducing nutrient inputs, and protecting floodplains may increase the climate resilience of these habitats.

## Sensitivity and Exposure



**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



Freshwater marshes, wetlands, and ponds are sensitive to climate stressors that alter hydrologic and thermal regimes, which can drive changes in wetland and pond structure, species composition, and function.

Climate Stressor	Trend Direction	Projected Future Changes
Precipitation	▲ ▼	<ul style="list-style-type: none"> <li>Shorter winters and longer, drier summers likely, with higher interannual variability<sup>8,9</sup></li> </ul>
Drought	▲	<ul style="list-style-type: none"> <li>Increased frequency of drought years, including periods of prolonged and/or severe drought<sup>8,10</sup></li> </ul>
Streamflow	▲ ▼	<ul style="list-style-type: none"> <li>Generally, wet season flows are projected to increase and dry season flows are projected to decrease<sup>11</sup></li> </ul>
Water temperature	▲	<ul style="list-style-type: none"> <li>1.1–2.0°C (2.0–3.6°F) increase in mean summer stream temperature by the 2090s<sup>12</sup></li> </ul>
Heat waves	▲	<ul style="list-style-type: none"> <li>Significant increase in heat wave frequency and intensity<sup>8,13</sup></li> </ul>
Sea level rise	▲	<ul style="list-style-type: none"> <li>High likelihood (67% probability) of 0.2–0.3 m (0.6–1.1 ft) sea level rise by 2050<sup>14–16</sup></li> </ul>

- Changes in precipitation patterns (e.g., amount and timing), increased drought, and altered stream flows** impact water availability. For instance, shifts towards shorter winters with more rain falling in heavy precipitation events, coupled with prolonged dry seasons, are likely to increase surface water runoff and limit groundwater recharge<sup>11</sup>. Overall drier conditions are likely to reduce water levels, shorten wetland hydroperiods, and cause substantial drying of marshes, riparian edges, and ponds during the summer months<sup>17–19</sup>. Regional water shortages can also result in less available water to divert to irrigation ponds<sup>5</sup>. These changes can impact vegetation productivity, survival, and community composition in plant communities associated with freshwater wetlands and ponds, potentially allowing shifts towards more drought-adapted and upland species<sup>17,20,21</sup>. During severe multi-year droughts, extreme conditions can cause collapse of the food web and extirpation of many aquatic and semi-aquatic species (e.g., pond turtles)<sup>22</sup>.
- Warmer water temperatures** may benefit some species, potentially increasing plant and invertebrate growth, development, and productivity<sup>17,23,24</sup>. However, these changes are also

likely to alter community composition and structure, and altered food webs may ultimately lead to a decline in ecosystem functioning<sup>23</sup>. For instance, warmer water temperatures are associated with increased growth of harmful algal blooms in nutrient-rich waters, which deplete dissolved oxygen, reduce water clarity, alter the food web, and produce toxins<sup>25–27</sup>.

- **More frequent and/or intense heat waves** are likely to exacerbate thermal stress in aquatic species, potentially leading to direct mortality and facilitating the establishment of non-native species more tolerant of high temperatures<sup>28</sup>.
- **Sea level rise** is likely to increase salinity within tidal freshwater marshes directly (i.e., through increased mixing of saltwater and fresh water), but it may also impact salinity in groundwater-fed wetlands where saltwater intrudes into coastal aquifers<sup>29,30</sup>. Increased salinity associated with sea level rise is likely to result in reduced wetland productivity, shifts in species composition towards salt-tolerant species, and potentially the loss of freshwater marsh areas<sup>5,30</sup>. Increasing salinity may be further exacerbated by drought and water diversions that reduce inflow of fresh water into the system<sup>30</sup>.

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



Storms are the key disturbance in freshwater marshes, wetlands, and ponds within the Santa Cruz Mountains region due their impact on habitat structure and functioning.

Disturbance Regimes	Trend Direction	Projected Future Changes
Storms & flooding	▲	<ul style="list-style-type: none"> <li>• Increased storm intensity and duration, resulting in more frequent extreme precipitation events and flooding<sup>8,31,32</sup></li> </ul>

- While freshwater marshes, wetlands, and ponds are well-adapted to seasonal flooding and can benefit from scouring and increased surface water runoff<sup>5,33,34</sup>, **more frequent and/or intense storms and associated flooding** may damage habitats by altering structure and community composition<sup>5</sup>. For instance, flash floods can be associated with landslides and debris flows<sup>35</sup>. Floods also increase the amount of silt and pollutants carried into wetlands and ponds, affecting water quality and biological communities<sup>17</sup>.

### Sensitivity and current exposure to non-climate stressors

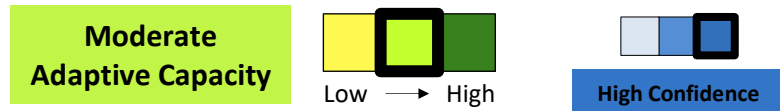


Non-climate stressors can exacerbate habitat sensitivity to changes in climate factors and disturbance regimes by altering wetland and pond hydrology, water quality, and connectivity.

- **Land-use conversion to residential and commercial development** damages and fragments wetlands directly through draining, vegetation removal, channel incision, and loss of floodplain connectivity<sup>5,6</sup>. Although continued development of freshwater wetlands and ponds is now limited in the region, historic floodplain development resulted in significant habitat loss<sup>5</sup>.
- **Roads, highways, and trails** increase runoff of stormwater and pollutants, deliver large amounts of sediment into waterways, and facilitate the spread of invasive species<sup>36–38</sup>. Roads frequently reduce or eliminate connections between floodplains and creeks or rivers, altering wetland hydrology<sup>36–38</sup>.
- **Water diversions** significantly reduce summer stream flows<sup>39</sup>, decreasing surface water supplied to wetlands within riparian areas and potentially resulting in habitat drying and loss<sup>2</sup>.

- **Invasive plants** can degrade freshwater marshes by displacing native species, altering nutrient cycles, and reducing water quality, particularly where they form dense stands<sup>6,40</sup>. While hydrologically-intact wetlands are resistant to terrestrial invasives, degraded systems are vulnerable to invasion by drought-tolerant species such as giant reed (*Arundo donax*), which drive further changes in hydrology and biodiversity as well as increased fire risk<sup>6</sup>.
- **Introduced fish, invertebrates, and amphibians** can also alter the abundance and diversity of native species through competition for resources, increased predation risk, and/or disease spread<sup>41,42</sup>.
- **Pollutants** such as pesticides, excess nutrients, and heavy metals (e.g., mercury associated with historical mining) can significantly degrade wetland and pond water quality, with potentially severe impacts on aquatic organisms due to direct toxicity or indirectly through effects on the food chain<sup>26,27,43</sup>. Excess nutrients (especially phosphorus) have been identified as a major driver of harmful algae blooms, and are likely to be exacerbated by climate-driven increases in water temperature<sup>26,27</sup>.

## 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



Freshwater wetlands and ponds were historically extensive within riparian floodplains, but the expansion of urban development resulted in the loss of many of these areas over the past century<sup>6,44</sup>. Infrastructure associated with development (e.g., roads, flood protection and water storage/delivery systems) can further fragment wetland habitats, hindering the movement and dispersal of native plants and animals<sup>17,45,46</sup>. Altered hydrology and changes in sedimentation/erosion processes due to climate change or anthropogenic causes can also reduce the structural and functional integrity of freshwater marshes by contributing to floodplain disconnection, channel incision, lowered groundwater tables, and reduced wetland area<sup>2,5,17,44</sup>.

### Habitat diversity



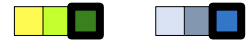
Freshwater wetlands are unique because of their role as transitional ecotones between aquatic and terrestrial ecosystems, and both wetlands and ponds are dynamic and productive ecosystems with diverse structural characteristics and biological communities<sup>1,6,17</sup>. These systems provide food, water, and cover for numerous species of fish, invertebrates, amphibians, reptiles, and mammals, including many rare species such as the California red-legged frog (*Rana draytonii*), western pond turtle (*Actinemys marmorata*), and San Francisco garter snake (*Thamnophis sirtalis tetrataenia*)<sup>2,6,47</sup>.

### Resistance and recovery



In general, wetlands and ponds supported primarily by surface water inputs are less resistant to precipitation declines and warming temperatures compared to groundwater-supplied systems<sup>17,48</sup>.

## Management potential



Freshwater wetlands and ponds are critically-important ecosystems that provide water filtration, flood protection, groundwater recharge, and habitat for resident and migratory birds, fish, amphibians, and mammals<sup>17,49,50</sup>. These habitats are also valued by the public for their recreational opportunities, including swimming and bird watching<sup>5</sup>. Regulatory support for wetland habitats exists through the Federal Clean Water Act of 1972 (33 U.S.C. §§1251-1387), though this legislation does not fully protect these habitats from non-point source pollution that can lead to eutrophication and harmful algal blooms<sup>51</sup>. There is generally ample grant funding available for wetland restoration, although environmental regulations, permitting requirements, and competing land use can make restoration and management of freshwater wetlands and ponds complex<sup>5</sup>.

Management activities designed to reduce climate vulnerability in freshwater marshes, wetlands, and ponds often focus on restoring natural hydrology, retaining water within the system, and managing vegetation through planting, burning, mowing, disking, or grazing<sup>49</sup>. Reducing nutrient inputs to wetlands and ponds would also minimize eutrophication and limit the risk of harmful algal blooms, particularly during periods of drought<sup>27</sup>. Finally, acquiring and restoring modified historic floodplains adjacent to creeks will prevent continued habitat loss, protecting potential refugia and enabling aquatic systems to recover from disturbances<sup>5</sup>. In addition to reducing the impacts of climate stressors and disturbances (e.g., warmer water temperatures, changing precipitation patterns, drought), climate-informed management of these habitats would also benefit conservation target species (i.e., frogs, fish), maintain high biodiversity across the landscape, and provide the public with important water resources and recreational benefits<sup>49</sup>.

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## 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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