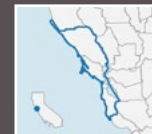# Riparian Forests & Woodlands

Climate Change Vulnerability and Adaptation Strategies for the Golden Gate Biosphere Region

Ecosystem Description

Riparian forests and woodlands are areas of transition between uplands and streams, lakes, or wetlands, and are often located along current or former stream corridors. In the Golden Gate Biosphere (GGB) region, streams are generally low-lying and are characterized by rain-dominated hydrologic regimes, with variable flows and frequent disturbances. Common species include willows (*Salix* spp.), coast redwood (*Sequoia sempervirens*), bigleaf maple (*Acer macrophyllum*), various oak species (*Quercus* spp.), California blackberry (*Rubus ursinus*), and blue elderberry (*Sambucus mexicana*). Riparian forests provide important ecosystem services, including bank stabilization, flood attenuation, interception of pollutants, and wildlife habitat.

Ecosystem Vulnerability - *High*

Sensitivity & Exposure - *High*

Projected Changes	Trend
Air temperature	▲ Increase
Precipitation	▲▼ Varies
Drought	▲ Increase
Stream flow	▲▼ Varies
Sea level rise	▲ Increase
Wildfire	▲ Increase
Flooding and storms	▲ Increase

Potential Impacts:

- Decreased plant growth and shifts towards drought-tolerant species as a result of reduced water availability and warmer air temperatures
- Changes in patterns of stream bank erosion and increased opportunities for non-native vegetation encroachment
- More variable establishment of riparian plants due to altered stream flows and shifts in nutrient transport
- Rise in salinity and upstream migration of tidal wetlands, potentially resulting in declines of freshwater riparian forests
- Increased plant mortality, runoff, erosion, and debris flows in stream channels following severe disturbances

Non-climate stressors may interact with climate stressors and disturbance regimes:

- *Changes in land use*, including development, result in deforestation and fragmentation, soil compaction, and reduced groundwater recharge, among other impacts
- *Agriculture and livestock grazing* contribute to water withdrawals that reduce instream flows, and lead to soil trampling and bank erosion
- *Dams, water diversions, and flood control structures* disconnect floodplains from rivers, reduce channel complexity, and contribute to channel incision, reducing riparian health and function
- *Invasive species* outcompete native species and reduce the diversity and abundance of stream-associated invertebrates and vegetation

Riparian forests and woodlands are sensitive to factors that affect hydrology and vegetative structure and function, as well as non-climate stressors that fragment and degrade these ecosystems.

Ecosystem Vulnerability - *Moderate*

Adaptive Capacity - *Low*

Intrinsic factors (i.e., inherent characteristics) that enhance or undermine adaptive capacity:

Enhance:
- Support diverse vegetation communities
- Dynamic and adapted to recover from a variety of disturbance regimes, as long as hydrology remains relatively intact
- Provide critical ecosystem services

Undermine:
- Severely degraded and constrained by stressors such as land-use conversion
- Fragmentation and changes in hydrologic regimes may prevent post-disturbance recovery

Extrinsic factors (i.e., management potential) that enhance or undermine adaptive capacity:

Enhance:
- Valued by birders and bird organizations
- May benefit from their proximity to wetlands with regulatory protections

Undermine:
- Lack of general public awareness of importance as a natural resource

Significant areas of riparian forests and woodlands have been lost, and many remaining areas are fragmented and degraded, reducing the ability of these naturally-dynamic systems to respond to and recover from disturbances and environmental changes.
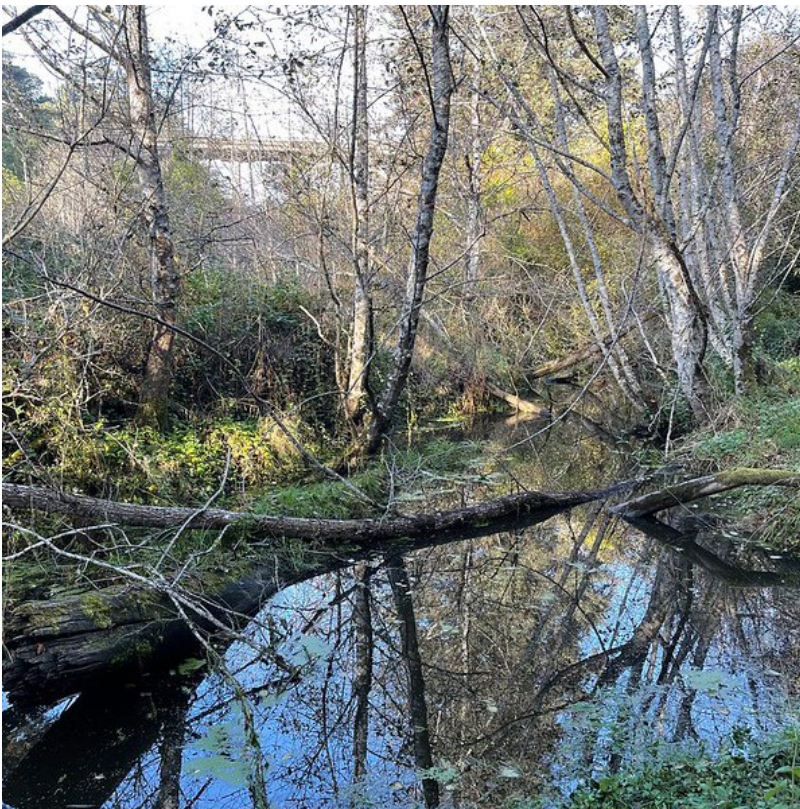
Sarah Stierch, Flickr (CC BY 2.0)

Nature Shutterbug, Flickr (CC BY 2.0)

Adaptation Strategies & Actions

Adaptation strategies can reduce climate change vulnerability of a given ecosystem or species by addressing any or all of the three components of vulnerability (i.e., by reducing sensitivity, reducing exposure, and/or increasing adaptive capacity). The table below presents examples of adaptation strategies and actions, which fall within five categories, or approaches: Resistance/Resilience **(R)**, Acceptance **(A)**, Direct/Response **(D)**, Knowledge **(K)**, and Collaboration **(C)**. *Please note that the strategies and actions provided here should not be considered a checklist or plan, but rather as a set of examples for land managers to consider for further study when developing site- or species-specific actions.*

Adaptation Strategies	Adaptation Actions
Protect and enhance riparian forests and woodlands	• Conduct modeling to see where the potential is greatest for increasing riparian width under climate change projections throughout the GGB region **(K)** • Implement riparian protection (e.g., through fee simple acquisition, conservation easements) and enhancement strategies at high-priority sites identified through modeling **(R)** • Ensure there are ordinances/regulations that protect riparian systems from inappropriate development **(R)** • Remove invasive species that act as the biggest stressors **(R)** • Monitor for pests and pathogens **(K)**
Maintain and restore hydrologic function	• Slow and reinfiltrate water into the landscape **(R)** • Remove dams and other infrastructure that interfere with natural hydrological flow patterns and processes **(R)** • Educate and build public support for the reintroduction of beavers **(C)** • Reintroduce beavers in high-priority areas at a pilot scale and monitor their effects on riparian forest **(R)**

Adaptation strategies and actions generated through breakout group exercises during the adaptation workshop in December 2023.

BLM, Flickr (CC BY 2.0)

Further information and citations can be found in the source reports of the Golden Gate Biosphere Region Climate Adaptation Project, available online at http://ecoadapt.org/goto/GGBRClimateProject.