PRELIMINARY
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APPENDIX Q2: Key Considerations and Best Available Science for Protecting, Restoring, and Enhancing the Delta Ecosystem

Delta Plan Amendments

November 2019

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Purpose

The Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act) set out two coequal goals for the Delta: 1) protecting, restoring, and enhancing the Sacramento-San Joaquin Delta and Suisun Marsh as the heart of a healthy estuary and wetland ecosystem; and 2) providing a more reliable water supply for California.[1] The Delta Reform Act requires that these coequal goals be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054).

Pursuant to the Delta Reform Act, the Delta Stewardship Council (Council) adopted the Delta Plan, a legally enforceable management framework for the Delta for achieving the coequal goals. The purpose of this appendix is to highlight key considerations and best available science for protecting, restoring, and enhancing the Delta ecosystem.

The Delta Reform Act requires the Delta Plan to include measures that promote all of the following characteristics of a healthy Delta ecosystem (California Water Code section 85302(c)):

1. Viable populations of native resident and migratory species;
2. Functional corridors for migratory species;
3. Diverse and biologically appropriate habitats and ecosystem processes;
4. Reduced threats and stresses on the Delta ecosystem; and
5. Conditions conducive to meeting or exceeding the goals in the existing species recovery plans and state and federal goals with respect to doubling salmon populations.

The Delta Reform Act also requires the Delta Plan to include the following subgoals and strategies for restoring a healthy ecosystem (California Water Code section 85302(e)):

1. Restore large areas of interconnected habitats within the Delta and its watershed by 2100;
2. Establish migratory corridors for fish, birds, and other animals along selected Delta river channels;
3. Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm by invasive species;
4. Restore Delta flows and channels to support a healthy estuary and other ecosystems;

[1] The Sacramento-San Joaquin Delta and Suisun Marsh are referred to throughout the Delta Plan collectively as "the Delta," unless otherwise specified.

5. Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals; and
6. Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.

The use of best available science is essential to ensuring that actions to protect, restore, and enhance the Delta ecosystem contribute to the subgoals and strategies for restoring a healthy Delta ecosystem, as defined by the Delta Reform Act. Delta Plan Policy **G P1(b)(3)** (23 CCR section 5002(b)(3)) requires covered actions to document use of best available science as relevant to the purpose and nature of the project. Criteria for best available science include relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review. The regulatory definition of best available science is set forth in 23 CCR 5001(f) and can also be found in Appendix 1A of the Delta Plan.

This Appendix Q2 summarizes best available science as it relates to protecting, restoring, and enhancing the ecosystem, consistent with the policies and recommendations in Chapter 4 of the Delta Plan. It draws on the literature synthesized in the Council's paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (2018a) which was subject to review and input by the Delta Independent Science Board (Delta ISB) and the public. The information contained in this appendix does not replace or supersede the documented use of best available science relevant to the purpose and nature of the project as required for all covered actions by policy GP 1(b)(3) (23 CCR section 5002(b)(3)).

Appropriate Elevation, Sea Level Rise, and Subsidence

Land elevation in the Delta and other tidal systems is a strong determinant of ecological patterns and outcomes because it affects how frequently and deeply an area may be inundated by river or tidal flows, and it is often defined in relation to tidal elevations (SFEI-ASC 2016). For example, tidal wetland vegetation occurs in the upper range of the tides; channels in tidal wetlands occur in the lower range of the tides; and riparian vegetation communities occur within river floodplains, above the regular reach of the tides. Terrestrial ecosystems generally do not exist below the lower range of tides unless they are not hydrologically connected (such is the case in Death Valley, which is more than 200 feet below sea level).

Land elevations are often, though not always, defined in relation to local tidal datums, which are standard reference elevations defined by a certain phase of the tide. Tidal water elevations are highly variable, fluctuating from low tide to high tide twice within a day, and also varying across days, months, and years depending on the gravitational pull of the moon and sun, and weather (NOAA 2000). For this reason, tidal reference elevations are generally characterized as an average of specific tidal heights over a period of time that accounts for natural variability. Common tidal datums used in this appendix are mean lower low water (MLLW), mean higher high water (MHHW), and mean tide level (MTL). MLLW is the average of the lower low water height of each tidal day; MHHW is the average of the higher high water height of each tidal day; MTL is the average of all observed water heights.

Human modifications to tidal wetland ecosystems, including levee construction and land reclamation, have caused a widespread decrease in land elevations to levels below MLLW. A decrease in land elevations relative to a starting condition is known as subsidence. Land reclamation exposes peat soils to air, causing oxidation and decomposition of the organic matter, and consequently, subsidence (Deverel et al. 2016). Levees prevent hydrologic connections and tidal inundation, which promotes further land subsidence. Exposing these subsided areas to tidal inundation, whether intentionally or via a levee breach, would result in open water habitat—as the land elevations have subsided too far below the tidal range to function as tidal wetland (Durand 2017).

The dominant farming practices on subsided islands in the Delta continue to expose peat soils to oxidation, causing ongoing subsidence. Subsidence can be halted by activities that saturate the soil, reducing the exposure of the soil to oxygen, and resulting in less decomposition of organic matter. Rice cultivation is an agricultural practice that halts subsidence, as it maintains land elevations at or near their starting condition. Some practices can also reverse subsidence, by creating or promoting accumulation of new soil layers. Examples of such practices include, but are not limited to, managed wetlands, placement of fill, and levee breaching to reestablish hydrological connections. Subsidence and subsidence reversal are both processes that change the elevation of land relative to tidal datums, and are therefore important considerations for actions to protect, restore, and enhance Delta ecosystems.

Another process that will change land elevations, relative to water levels and tidal datums, is sea level rise. Sea level rise is a change in average global sea level caused by a change in ocean volume. Local sea level rise can be greater or lesser than global sea level rise, because local sea levels are also affected by local land changes, ocean circulation, and changes to the earth's gravitational field due to melting ice sheets. The California Ocean Protection Commission recommends preparing for 2.4 to 10.2 feet of sea level rise at the Golden Gate Bridge by 2100 (OPC 2018). Local sea level rise will increase levels of MLLW, MTL, and MHHW within Suisun Marsh and much of the Delta.

The Council's synthesis paper *Climate Change and the Delta: A Synthesis* identified the expected impacts of sea level rise to tidal wetland ecosystems (Council 2018b). The locations, types and extents of tidal wetland patches in the Delta and Suisun Marsh will shift in response to increase in MHHW (Kirwin and Megonigal 2013, Goals Project Update 2015, Dettinger et al. 2016, Robinson et al. 2016, CDFW 2017a as cited in Council 2018b). If tidal wetlands can accrete new material at pace with the rate of sea level rise, those patches may persist. If sea level rise accelerates beyond local accretion rates, wetland patches will lose elevation, and over time, may be permanently inundated and converted to aquatic ecosystems. The land that was previously at elevations within the tidal range will be submerged below it due to sea level rise.

Where upland space is available adjacent to tidal wetland patches, wetland vegetation can migrate to higher elevations in concert with, and in response to the increased mean tidal levels (Orr and Sheehan 2012, Dettinger et al. 2016). The band of unimpeded upland space that is expected to be within the future tidal range is called sea level rise accommodation space because it can accommodate processes like tidal wetland migration in response to sea level rise.

Sea level rise, like subsidence and subsidence reversal, therefore changes the existing relationship between land elevation and tidal elevations, and thus, the extent and distribution of ecosystem types. Because land elevation is a primary determinant of ecological outcomes, understanding and planning for changes to land elevation—relative to tidal elevations—should be factored into actions that protect, restore, and enhance Delta ecosystems.

In order to inform and support this understanding, the Council commissioned a detailed spatial analysis of future land and tidal elevations, accounting for current land elevations, local sea level rise projections, and variation in the tidal range within the Delta. Detailed methods used in this analysis are provided in Appendix Q1. The resulting elevation guidance map (Figure 1) illustrates five elevation bands that correspond to the dynamic relationship between land elevation, subsidence, and sea level rise:

- **Deep Subtidal Elevation Band**: in the Delta, land area that is located more than 8 feet below MLLW. In Suisun Marsh, land area that is located more than 4.5 feet below MLLW. Land in this elevation band is not capable of being restored to MTL without the addition of substantial fill given its existing subsided condition and projected local sea level rise.
- **Shallow Subtidal Elevation Band**: in the Delta, land area that is located between MLLW and 8 feet below MLLW. In Suisun Marsh, land area that is located between MLLW and 4.5 feet below MLLW. Land in this elevation band has an existing subsided condition that could potentially be restored to MTL through subsidence reversal activities.
- **Intertidal Elevation Band**: land area that is located between MLLW and MHHW. Land in this elevation band could potentially keep pace with local sea level rise, where it is hydrologically connected to tidal inundation.
- **Sea Level Rise Accommodation Band**: land area that is located between MHHW and 10 feet above MHHW. With sea-level rise, land in this elevation band could fall within the future tidal range by 2100.

- **Upland Elevation Band:**[2] land area that is located at elevations higher than 10 feet above MHHW, and not within the Floodplain Elevation Band. Land in this elevation band is not expected to be impacted by sea level rise over the next century.
- **Floodplain Elevation Band**: lands above the Sea Level Rise Accommodation Band within the Yolo Bypass and the Lower Mokelumne-Cosumnes Rivers and lower San Joaquin River corridors.

These six elevation bands correspond to those specified in Appendix 4A. The elevation band illustrative map in Figure 1 is provided as a resource to inform the general locations of these elevation bands.

Successful actions to protect, restore, or enhance the Delta ecosystem will be implemented at elevations that can support project goals and where the benefits of the project will be sustainable; considering current elevations, anticipated sea level rise, and the potential for subsidence reversal. As discussed above, tidal wetland protection, restoration, and enhancement can only be successful long-term if implemented in areas that are within the tidal range, or likely to be within the tidal range in the future (such as the Intertidal Elevation Band and Sea Level Rise Accommodation Band).

Tidal wetland protection, restoration, and enhancement is not appropriate at elevations that are too far below MLLW to be capable of reaching the tidal range in the future; however, managed wetlands that are designed to promote subsidence reversal and carbon sequestration would be appropriate for lands at these elevations. Conversely, present-day elevations that *are* capable of reaching the tidal range in the future are not appropriate for activities that continue to cause subsidence because those activities could foreclose on the potential to reach MTL.

Other actions to protect, restore, or enhance the ecosystem are appropriate at elevations far below MLLW and well-above MHHW. For example, the Deep Subtidal Elevation Band is appropriate for agricultural practices that leave crop residues as feed that can contribute to the protection and recovery of certain special-status native resident and migratory birds. The Upland Elevation Band is appropriate for actions that protect, restore, or enhance oak woodland, grassland, and seasonal wetlands. The Floodplain Elevation Band is appropriate for actions that protect, restore, or enhance upland and lowland river floodplain ecosystems.

[2] Upland areas are not specified on the map, but they consist of land at elevations above the sea level rise accommodation band and outside of floodplain areas.

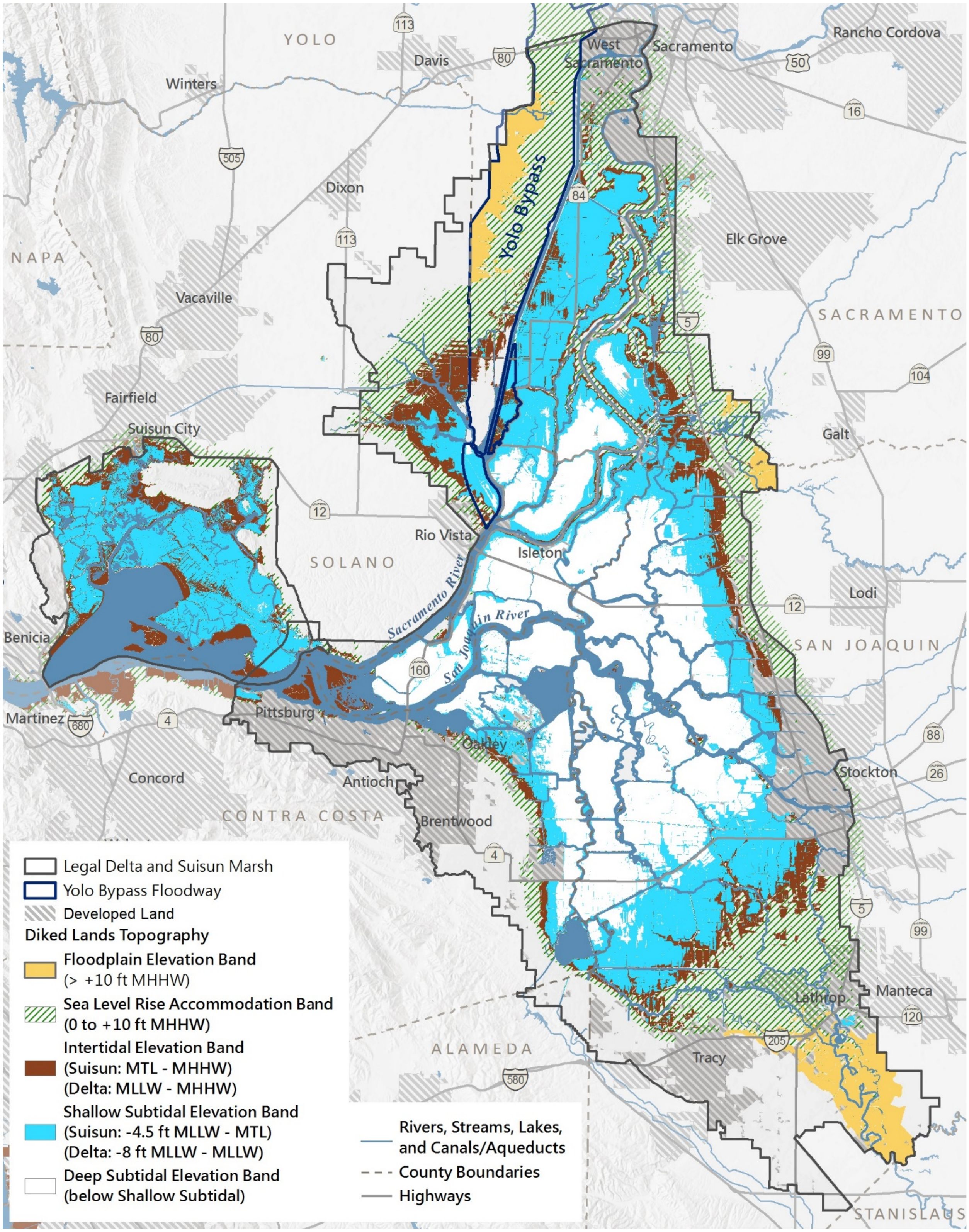

Figure 1. Elevation Band Illustrative Map

Figure 1. Elevation Band Illustrative Map (contd.)

Figure 1 is a map that illustrates Elevation Bands within the Legal Delta and Suisun Marsh, shown with existing tidal marsh extent. The map shows an outline of the Legal Delta and Suisun Marsh in black. The map shows unlabeled rivers, streams, lakes, and canals/aqueducts within the Legal Delta and Suisun Marsh colored in a solid blue. County boundaries are depicted in gray dotted lines. Major highways are depicted in gray solid lines and labeled by highway number. Developed land is shown in gray hatching. The Yolo Bypass is outlined in a solid dark blue line.

Elevation Bands depicted are:

- The Floodplain Elevation Band is depicted in solid yellow, and consists of land at elevations that are greater than or equal to 10 feet Mean Higher High Water;
- The Sea Level Rise Accommodation elevation band is depicted in green hatching, and consists of land at elevations that are between 0 to 10 feet Mean Higher High Water;
- The Intertidal elevation band is depicted in solid brown, and consists of land at elevations between Mean Tide Level and Mean Higher High Water in Suisun Marsh, and between Mean Lower Low Water and Mean Higher High Water in the Delta;
- The Shallow Subtidal elevation band is depicted in solid cyan, and consists of land at elevations between 4.5 feet below Mean Lower Low Water and Mean Tide in Suisun Marsh, and between 8 feet below Mean Lower Low Water and Mean Lower Low Water in the Delta; and
- The Deep Subtidal elevation band is depicted in white and consists of land at elevations that are below the Shallow Subtidal elevation band.

The Floodplain Elevation Band is the least extensive among those shown in the map. Land areas within the Floodplain Elevation Band are concentrated as follows: on the western side of the Yolo Bypass; two small areas west of the City of Galt along the Cosumnes and Mokelumne Rivers; and a conical shaped area at the southeastern tip of the Legal Delta, along the San Joaquin River, south of the City of Lathrop.

The Sea Level Rise Accommodation Band includes: a narrow strip of land at the northern boundary of Suisun Marsh, small patches of land at the eastern edge of Suisun Marsh; a wide swath of land at the western edge of Cache Slough that continues into much of Yolo Bypass; waterside levee area along the Sacramento River and adjacent channels and sloughs; a strip of land at the eastern boundary of the Legal Delta along Highway 5, between Stockton and Sacramento; a wide swath of land north of Tracy and Lathrop at the base of the San Joaquin River floodplain; and a narrow strip of land extending from Tracy west to Clifton Court Forebay, and northwest to Oakley.

Existing tidal wetlands in Suisun Marsh and western Delta islands near Pittsburg are located in the Intertidal Elevation Band. Other concentrated land areas located within the Intertidal Elevation Band are within Cache Slough and in the south Delta. There are narrow strips of land located in the Intertidal Elevation Band at the edges of the Sea Level Rise Accommodation Band, extending along Highway 5 between Stockton and Sacramento, and from Tracy to Oakley. Scattered patches of land in the Intertidal Elevation Band are also present on Decker Island, Prospect Island, Merritt Island, Pearson District, McCormack Williamson Tract, and New Hope Tract.

Figure 1. Elevation Band Illustrative Map (contd.)

The Shallow Subtidal and Deep Subtidal Elevation Bands are the most extensive. The Shallow Subtidal Elevation Band consists of: the majority of Suisun Marsh; the southeastern corner of Cache Slough; land between the Sacramento River Deep Water Ship Channel and the Sacramento River in the north Delta; the majority of the Pearson District; a strip of land along the eastern edge of the Delta, adjacent to and west of the Intertidal Elevation Band; land south of Highway 4 and adjacent to the Intertidal Elevation Band, in the south Delta; and a narrow strip of land running north from Clifton Court Forebay to Oakley.

The Deep Subtidal Elevation Band consists primarily of land areas on islands in the central and western Delta, from Sherman Island in the west to Rindge Tract in the east, and from Victoria Island in the south to Liberty and Grand Islands in the north.

Please contact the Delta Stewardship Council with any questions regarding this figure.

Ecosystem Function

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* provides a review of approaches to ecosystem restoration, and it identifies key ecosystem properties that promote resilience (Council 2018a). Given that Delta ecosystems are expected to be further stressed by a rapidly changing climate, reestablishing ecological resilience is an important restoration target (Ibid, p. 19). Delta Plan Chapter 4, *Protect, Restore, and Enhance the Delta Ecosystem*, translates these ecosystem properties into priority attributes for actions that include protection, restoration, and enhancement of the Delta ecosystem, to ensure that actions contribute to restoring ecosystem function. These priority attributes are:

1. Restore hydrological, geomorphic, and biological processes;
2. Be large-scale;
3. Improve connectivity;
4. Increase native vegetation cover; and
5. Contribute to the recovery of special-status species.

Hydrological, Geomorphic, and Biological Processes

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified the reestablishment of hydrological, geomorphic, and biological processes—also termed *process-based restoration*—as key to improving vegetation community composition and structure, and habitat conditions for sensitive specialist species (Council 2018a, p. 13). Process-based restoration is also essential to creating dynamic and variable conditions like those of the pre-Columbian Delta (see Delta Plan Chapter 4, section "The Delta's Historical Ecology," pp. 4-5).

Hydrological processes are physical flows and cycles exhibited by water, including streamflow, flooding, tidal action, percolation, and subsurface flow. Geomorphic processes are the physical forces that shape and form the surface of the earth including sediment erosion and deposition, river meander migration, and channel formation. Biological processes are processes exhibited by the living components of an ecosystem such as nutrient cycling, primary production, vegetation and wildlife recruitment and growth, predation, and evolution. Process-based restoration is restoration that aims to reestablish the rates and magnitudes of these processes that can sustain dynamic ecosystems (Beechie et al. 2010, Greco 2013, Wiens et al. 2016).

The hydrological, geomorphic, and/or biological processes that a project could restore, vary based on the ecosystem type. For example, within willow thicket, willow riparian scrub or shrub, and valley foothill riparian ecosystems, the creation of unrestrained (natural) stream channels may reestablish hydrological processes that allow cut-bank and point-bar formation, meander migration, and the development of shaded riverine aquatic habitats (DeHaven 1998). To restore seasonal wetlands, water input from precipitation, runoff, groundwater, or subsurface flow can reestablish hydrological processes that support temporary or seasonal wetting (Calhoun et al. 2014).

Reestablishment of geomorphic processes such as sediment delivery, scour, and accretion can restore tidal wetlands or willow thicket in upland and lowland river floodplains. Additionally, reestablishing biological processes, such as native vegetation recruitment, growth, and succession can restore a variety of habitats, including wet meadow, alkali seasonal wetland complex, vernal pool complex, upland and lowland river floodplain, and emergent wetland.

Restoring hydrological, geomorphic, and biological processes addresses the root causes of ecosystem degradation and promotes self-sustaining ecosystems that require less active management or corrective action (Beechie et al. 2010). Process-based restoration also promotes resilience to changing conditions, such as sea level rise and changes in precipitation due to climate change. A process-based approach to restoration will lead to the development of a healthy Delta ecosystem, which includes diverse and biologically appropriate habitats and ecosystem processes (California Water Code section 85302(c)(3)).

Scale

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified spatial and temporal scales as essential properties that affect ecosystem resilience and the attainment of subgoals of the Delta Reform Act (Council 2018a, p. 22). Critical biotic interactions and physical processes depend on appropriate levels of diversity (Larkin et al. 2016) made possible by large-scale projects. Large intact core areas of habitat are important for reducing human disturbance and facilitating the ecological interactions that are important to species persistence (Soule and Terborgh 1999).

The hydrological, geomorphic, and biological processes described above operate at various spatial scales across different ecosystem types, requiring consideration in siting and design of covered actions (Palmer et al. 2016b, SFEI-ASC 2016). For example, emergent wetlands—which include tidal and non-tidal wetlands with non-woody vegetation—require a patch size equal to, or greater than, 200 hectares (500 acres) to support the formation of long, multi-order channel networks and associated chemical and biological functions (Whipple 2012, SFEI-ASC 2016). Without branching channel networks, the wetland patches will not support the recovery of special-status species that rely on blind channels for refuge and/or high residence times in large core areas for foraging and feeding. Therefore, restoration of emergent wetlands must occur at-scale in order to fulfill the subgoals of the Delta Reform Act, to reduce the risk of harm from invasive species (California Water Code section 85302(e)(3)), and to restore channels to support a healthy estuary (California Water Code section 85302(e)(4)), among other subgoals and strategies.

In contrast, river geomorphic processes operate at the site (erosion), reach (meander/braiding), and watershed (watershed zone) scale (Schumm 1977). For upland and lowland river floodplains—including willow thicket, willow riparian scrub or shrub, and valley foothill riparian—river corridor restoration that reestablishes floodplain inundation and stream channel dynamics over a distance orthogonal to the channel (i.e., floodplain width) that is equal to, or greater than, the mean of six reach-specific bankfull channel widths is required to support riverine hydrological, geomorphic, and biological functions (Larsen et al. 2006). In some regions, topographic features such as the presence of natural levees may constrain this width interval (SFEI-ASC 2014).

Seasonal wetlands (including vernal pool complexes, alkali seasonal wetland complexes, and wet meadows) require patch sizes of at least 40 to 100 acres to optimally support the life history needs of sensitive species (ICF 2013, Johnson et al. 2010). Riparian vegetation in upland and lowland river floodplains—including willow thicket, willow riparian scrub or shrub, and valley foothill riparian—need to be greater than 200 acres (Laymon and Halterman 1989, SFEI-ASC 2014), and contiguous oak woodlands and grasslands need to be greater than 40 to 100 acres (ICF 2013, Johnson et al. 2010). To stabilize interior dune vegetation, sand mound features need to be greater than 1.5 acres—the smallest size that occurred in the historic Delta (Whipple et al. 2012).

Actions that restore the ecosystem at large spatial scales will increase the likelihood of creating and supporting natural systems capable of sustaining desired functions through uncertain future environmental conditions (Peterson et al. 1998, SFEI-ASC 2016).

Connectivity

The Delta Reform Act specifies that the Delta Plan must include subgoals and strategies to restore large areas of *interconnected* [emphasis added] habitats within the Delta and its watershed by 2100 (California Water Code section 85302(e)(1)). The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified connectivity as essential for ecosystem resilience (Council 2018a, p. 20).

Reestablishing connectivity is essential for the long-term persistence of native species in the Delta. Issues of connectivity include restoration of physical (e.g., hydrology and sediment transport) and biological (e.g., movement of vegetation that propagates, fish, and wildlife) connections. This section provides descriptions for different aspects of connectivity that should be considered in restoration actions.

Since watersheds are three-dimensional hydrological systems, restoring hydrological connectivity requires consideration of longitudinal (between upper watersheds to the San Francisco Bay), lateral (between channels and floodplains), and vertical (between surface and groundwater) connections. Reestablishing longitudinal connectivity from the upper watersheds throughout the Delta to the Bay is critical to many species that reside or migrate through the Delta. Remediation of fish passage barriers—including dams, diversions and other impediments, and improvements of poor habitat conditions—can improve connectivity for fish movement. Fish passage improvement actions would reduce stress and mortality in lower parts of the system, reconnecting fish with cold water habitats above dams, thus reducing the need to manage spawning conditions with flows on specific watersheds (Moyle et al. 2008).

In the Delta, restoration of lateral connections between channels and floodplains, and vertical connections between surface and groundwater, are other facets of connectivity that are essential to ecosystem function and resilience. Such connections are necessary for tidal wetland and floodplain inundation; sediment and nutrient delivery and export; disturbance processes; trophic processes; and the establishment, growth, and succession of native vegetation communities. It has been well studied that increased lateral connections improve access to food resources for fish, nutrient and carbon cycling, vegetation community patch dynamics, and species-habitat interactions (Vannote et al. 1980, Naiman et al. 1988, Ward 1989, Junk et al. 1989, Poff et al. 1997, Naiman and Decamps 1997, West and Zedler 2000).

Another critical aspect of connectivity is the distribution, extent, and proximity of different ecosystem and habitat types. The distance between patches of similar ecosystems determines the degree of animal movement, energy flow, and gene flow, and varies within and across ecosystem types. The distance between individual vernal pools is measured in meters, while the distance between pool complexes may be in kilometers. The maximum distance between patches should incorporate species' movement capabilities, resource needs, population dynamics, and gene flow (e.g., distance between tidal wetlands should be less than 15 km for salmon rearing, and between 0.2-5 km for wetland wildlife movement). Many species need different ecosystem types in their life histories. Minimizing distances between patches of different ecosystem types can increase survival. For example, Chinook salmon require a sequence of hydrologically connected habitats to migrate, spawn, rear, and mature; including rivers, seasonal floodplains and tidal marsh habitat.

Improved connectivity will also increase ecosystem resilience and adaptive potential in the face of a rapidly changing climate (Naiman et al. 1993, Seavy et al. 2009, SFEI-ASC 2016). Connections between tidally inundated habitats and adjacent uplands with suitable elevations can support landward wetland migration as sea level rises. Wetland migration within the Delta and Suisun Marsh was historically common, but is currently limited by the presence of levees, roads, railways, and other obstacles.

In the long-term, restoring connections between aquatic and wetland habitats, such as between channels and marsh plains, and connectivity to spawning habitats are of the utmost importance for species' viability and genetic resilience. The various aspects of connectivity are crucial to the ability of riparian and wetland systems to support biodiversity.

Native Vegetation Cover

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified the positive effects that native vegetation communities have on ecosystem processes (Council 2018a, p. 31, 39). Increasing the extent and variety of native vegetation cover can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support. This section identifies the characteristics of different Delta ecosystems and their associated native vegetation communities.

The classification of ecosystems and vegetation communities draws primarily from the San Francisco Estuary Institute-Aquatic Science Center's (SFEI-ASC) habitat types (2014) and the Vegetation Classification and Mapping Program (VegCAMP). VegCAMP is the California component of the National Vegetation Classification system, maintained by the California Department of Fish and Wildlife in collaboration with other agencies and organizations. Delta Plan Chapter 4, *Protect, Restore, and Enhance the Delta Ecosystem*, and its appendices, utilize the 2018 Delta Fine Scale VegCAMP Vegetation Map and 2015 Suisun Marsh Fine Scale VegCAMP Vegetation Map to characterize native vegetation communities in different Delta ecosystem types.

Freshwater emergent wetlands in the Delta include tidal and non-tidal wetland ecosystems. Tidal freshwater wetlands are wetted or inundated by spring tides at low river stages or by lower tidal levels at higher river stages. These ecosystems are characterized as being permanently saturated, having a high water table, and are typically dominated by emergent vegetation. Woody vegetation (e.g., willows) may be a significant component for some areas, particularly the western-central Delta. Non-tidal wetland ecosystems in the Delta occupy upstream floodplain positions above tidal influence. These ecosystems are temporarily to permanently flooded, permanently saturated, and are dominated by emergent vegetation (SFEI-ASC 2014).

Upland and lowland river floodplain habitats in the Delta include willow thicket, willow scrub or shrub, and valley foothill riparian. Willow thicket are characterized as perennially wet, dominated by woody vegetation, and generally located at the *sinks* of major creeks or rivers as they exit alluvial fans into the valley floor. Emergent vegetation may also be a significant vegetation component in these habitats (SFEI-ASC 2014). Willow scrub or shrub habitats are riparian vegetation habitats dominated by scrubs or shrubs with few or no tall trees. This ecosystem type generally occupies long, relatively narrow corridors of lower natural levees along rivers and streams. Valley foothill riparian habitats are mature forests that are usually associated with a dense understory and mixed canopy, including sycamore, oaks, willows, and other trees. Historically, this ecosystem type occupied the supratidal natural levees of large rivers that were occasionally flooded (SFEI-ASC 2014).

Seasonal wetlands in the Delta include wet meadows, vernal pool complexes, and alkali seasonal wetland complexes. These three ecosystems often comprise the upland edge of perennial wetlands (SFEI-ASC 2014) and they are seasonally or temporally flooded. While all three occur on poorly drained soils, they differ by soil conditions. Wet meadow ecosystems are characterized by clay-rich soils and associated with herbaceous plant communities. Vernal pool complexes are characterized by a relatively impermeable subsurface soil layer and distinctive vernal pool flora. Alkali seasonal wetland complexes are characterized by clay-rich soils with a high residual salt content and associated with herbaceous or scrub communities.

Upland ecosystems in the Delta include stabilized interior dune vegetation, grassland, and oak woodland. Stabilized interior dune vegetation is dominated by shrub species, with some locations also supporting live oaks on the more stabilized dunes with more well-developed soil profiles. Grasslands are low herbaceous communities occupying well-drained soils and are composed of native forbs and annual and perennial grasses, usually devoid of trees. Oak woodlands are oak-dominated communities with sparse to dense cover (10-65 percent) and an herbaceous understory (SFEI-ASC 2014).

Restoration of the Delta ecosystem will require increasing the native vegetation cover, and restoring the underlying processes that support recruitment, disturbance regimes, and community succession (as described under the Hydrological, Geomorphic, and Biological Processes sections of this document). As previously discussed in the Scale section, these underlying processes operate at various spatial scales across different ecosystem types. Therefore, the extent of native vegetation cover should align with the scale at which ecosystem processes can support the vegetation communities to be self-sustaining.

Special-Status Species

The Delta Reform Act is clear that protecting, restoring, and enhancing the Delta ecosystem means protecting and recovering special-status species. The Delta Reform Act requires the Delta Plan to include measures that promote viable populations of native resident and migratory species; conditions conducive to meeting or exceeding the goals in the existing species recovery plans (California Water Code section 85302(c)(1) and (5)); and to promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species, among other subgoals and strategies (California Water Code section 85302(e)).

Special-status species are a species or subspecies of animal or plant, or a variety of plant, that is endangered, rare, or threatened as defined by California Code of Regulations sec. 15380. At least 35 native plant species, and 86 fish and wildlife species in the Delta are imperiled by human activities (Appendix Q4) and are at varying risks of either local or outright extinction. Habitat loss and degradation, and the resulting impacts on food-web dynamics, have been a major cause of the statuses and listings of these species. Recovering these species is essential to preventing the loss of the unique biodiversity in the Delta.

Different species and communities are supported by different ecosystem types. For example, managed wetlands can protect and support the recovery of native migratory bird species, such as sandhill cranes (Appendix Q4). In contrast, the California black rail requires emergent wetland with gently grading slopes and upland refugia (see Appendix Q4), and is not supported by managed wetland projects. Therefore, actions that protect, restore, or enhance ecosystems can contribute to the recovery of different special-status species and ecological function, depending on the type and scale of the action (Suding 2011, Palmer et al. 2016).

Human Context for Protecting, Restoring, and Enhancing the Ecosystem

The Delta Reform Act requires that the coequal goals be achieved, “in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place” (California Water Code section 85054). The Delta is not a blank canvas, but rather a region with existing agricultural and urban land uses, diverse cultural values, and human needs. Literature on ecosystem restoration increasingly affirms the need to consider human needs and benefits from restored lands (Council 2018a, Suding et al. 2015). Covered actions must leverage best available science to successfully integrate into this existing human context.

Existing Land Uses

Chapter 5 of the Delta Plan, “Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place,” describes the vision for the Delta as an evolving place and identifies regulatory policies and recommendations to achieve that vision. Delta Plan Policy **DP P2** (23 CCR section 5011) requires that ecosystem restoration (and other types of projects and improvements) avoid or reduce conflicts with existing or planned future land uses, when feasible, among other requirements.

The Delta Reform Act’s requirement to achieve the coequal goals in a manner that protects and enhances the unique values of the Delta as a Place recognizes the potential conflicts between certain covered actions and existing land uses. Consequently, it is important that covered actions that include protection, enhancement, or restoration of the ecosystem are implemented in a manner that reduces such conflicts. One way to avoid or reduce conflicts with existing land uses is through proactive engagement and coordination with adjacent and nearby landowners and users, starting early in the planning stages of a project. Coordination with neighboring landowners and local communities helps covered actions avoid unintended consequences like trespassing, property damage, crop damage, or damage to the ecosystem. Consequently, the Delta Plan recommends that restoration project managers use the Department of Water Resources' Good Neighbor Checklist to avoid or reduce conflicts with existing uses. A copy of the Good Neighbor Checklist is included as **Attachment 1** to this Appendix Q2.

The California Department of Water Resources developed the Good Neighbor Checklist to support proactive communication with nearby landowners. The checklist is based on a discussion paper that was developed in consultation with local landowners and other stakeholders, to identify strategies for addressing priority conflicts and unintended consequences (DWR 2019). The checklist provides a framework for covered actions to avoid or reduce conflicts with existing uses. All covered actions are unique, and not all of the checklist questions and strategies will apply in all cases.

Social Benefits

Proper planning, implementation and management of covered actions that include protection, restoration, and enhancement of the ecosystem, can ensure that actions do more than simply avoid conflict or harm. Actions can also provide social benefits that enhance the cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

Social benefits are positive values that are derived by individuals, communities, or society at-large. The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified a variety of social benefits that can be derived from actions to protect, restore, and enhance the ecosystem (Council 2018a). The synthesis paper also identified methods to assess and value those benefits. In the context of Chapter 4 of the Delta Plan (Protect, Restore, and Enhance the Ecosystem), social benefits are indirect cultural, recreational, natural resource, and agricultural benefits that individuals or groups of people derive from the protection, restoration, or enhancement of the ecosystem. These categories were identified to correspond to the cultural, recreational, natural resource, and agricultural values of the Delta as identified in the Delta Reform Act (California Water Code section 85054).

The benefits described within each category are not a comprehensive list. The specific benefits discussed in this section have a well-established scientific basis, and a direct connection to restoring, enhancing, and protecting the Delta ecosystem. However, actions that restore, enhance, and protect the Delta ecosystem could result in social benefits beyond those discussed here.

Cultural Benefits

Cultural benefits are a type of social benefit derived by individuals and/or communities with distinct cultural ties to the ecosystems, plants, fish, and wildlife of the Delta. Cultural benefits may include, but are not limited to, support of ecocultural resources, human health and well-being, and environmental justice. These types of cultural benefits were identified in the Council's synthesis paper *Towards the Protection,* *Restoration, and Enhancement of the Delta Ecosystem* as social benefits that can be derived from actions to protect, restore, and enhance the ecosystem (Council 2018a, p. 10).

Ecocultural resources are resources needed to maintain the nature-dependent components of culture (Pretty 2011), such as plants, fish, and wildlife that hold special cultural and/or spiritual value to American Indian tribes. For example, salmon are "integral to the customs, religion, culture, and economy of the Hoopa Valley Tribe and its members" (Hoopa Valley Tribal Council 2012). Tribal engagement during project planning and management can help proponents identify, assess, and protect resources of eco-cultural importance (Hankins 2018). For example, the Miwok have identified specific species of eco-cultural importance in the Delta, including Delta smelt, longfin smelt, winter-run Chinook salmon, spring-run Chinook salmon, steelhead, Sacramento splittail, green sturgeon, white sturgeon, Pacific lamprey, river lamprey, riparian brush rabbit, San Joaquin kit fox, Ridgway's Rail, California Black Rail, California Clapper Rail, Greater Sandhill Crane, Swainson's Hawk, Western Burrowing Owl, Yellow-breasted Chat, western pond turtle, California red-legged frog, California tiger salamander, California linderiella, conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, vernal pool tadpole shrimp, brittlescale, and San Joaquin spearscale (Hankins 2018).

Human health and well-being is a condition of bodily comfort and happiness that is free from sickness or suffering (King et al. 2009, Roche and Rolley 2011). The Delta Reform Act finds that, "to promote the public safety, health, and welfare… it is necessary to protect and enhance the ecosystem of the Delta" (California Water Code section 85022(c)) and identifies a fundamental goal for land-use management in the Delta to "improve water quality to protect human health" (California Water Code section 85022((d)). These findings are supported by scientific literature. Human health and well-being have been linked to environmental quality and access to natural systems (Bowler et al. 2010, MacKerron and Mourato 2013). Exposure to nature has been demonstrated to improve wellness (Roche and Rolley 2011), and health outcomes have been tied to environmental quality (King et al. 2009). Covered actions that improve environmental quality (e.g., air quality, water quality) can improve health (Schwarzenbach et al. 2010, WHO 2013).

Research on multiple restoration projects in the United States suggests that restoration can also help communities alleviate environmental injustices (Pastor 2007). Warlenius et al. (2015) argue that significant environmental degradation harms communities and therefore produces an *ecological debt*. Ecological debt is the concept that the exploitation or degradation of a natural resource creates a responsibility to repay that "debt" to human communities harmed by the degradation. Ecosystem restoration is one method for achieving environmental justice through repaying that ecological debt. One way to address environmental justice concerns is for proponents of covered actions to engage and co-plan with disadvantaged communities, provide access for safe subsistence fishing, and to improve environmental conditions for at-risk groups (Shilling et al. 2009, Sze et al. 2009).

Recreational Benefits

Recreation benefits are a category of social benefits that are derived by individuals that recreate in the Delta, and the business operations and communities that such recreation supports. These types of recreational benefits were identified in the Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (Council 2018a, p. 8).

The Delta Reform Act identifies the goal to maximize public access to Delta resources and maximize public recreational opportunities in the Delta (California Water Code section 85022(d)). However, at present, much of the restoration land in the Delta is hard to access and/or off-limits to the public (Milligan and Kraus-Polk 2016). Covered actions can address this need by planning for human use, such as including features that encourage and provide access to land for exercise and relaxation.

Covered actions can provide amenities that support the long-term operations and maintenance of the asset, in addition to recreational uses. Boat ramps can be jointly used by monitoring staff and contractors, as well as by recreational boaters and those who fish. Parking and restroom facilities can be jointly used by land-management staff as well as individuals who recreate in the Delta. Anticipating and planning for human uses, including unsanctioned uses, of restoration sites will improve project outcomes (Milligan and Kraus-Polk 2016).

Not all covered actions will be appropriate for public access and recreation; hence the Delta Plan does not require that access be provided. Indeed, the Delta Reform Act notes that public access and recreational opportunities should be "consistent with sound resources conservation principles and constitutionally protected rights of private property owners" (California Water Code section 85022(d)).

Covered actions that contribute to the recovery of salmon and sturgeon populations, and that support viable populations of native resident and migratory birds, will promote a healthy Delta ecosystem (California Water Code section 85302(c)), while also indirectly benefitting recreational fishing, bird-watching, and wildlife observation. Delta community members identify water, waterways, wildlife, bird-watching, and exploring as among the best qualities of the Delta (AugustineIdeas 2015). These results indicate the centrality of the Delta ecosystem to attracting tourists into the region and meeting their expectations. Protecting, restoring, and enhancing the Delta ecosystem can help improve conditions for recreation in the Delta. Past research on recreation confirms that including tourism as part of restoration planning can help drive restoration on the landscape and benefit the tourism industry (Blangy and Mehta 2006).

Natural Resource Benefits

Natural resource benefits are a category of social benefits that are derived from ecosystem processes, goods, and services. Ecosystem services are the economic benefits that society derives from ecosystem processes, such as soil formation, water storage and regulation, climate regulation, and others (Costanza et al. 1997, Turner and Daily 2008, Postel and Carpenter 1997). These types of natural resource benefits were identified in the Delta Stewardship Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (DSC 2018, pp. 6-9).

Cooperative ecosystem and resource management can maximize these benefits (Madani and Lund 2011). For example, maximizing natural resource benefits could mean managing Delta fisheries in a way that reduces risks to human health (Shilling et al. 2010), or restoring wetlands to provide flood control benefits and improve water quality (Mitsche and Gosselink 2000). Many ecosystem processes include services upon which all humans depend and it behooves resource managers to find ways to incorporate these natural resource benefits into projects, where possible.

Agricultural Benefits

Agricultural benefits are a category of social benefits that are derived from agricultural operations in the Delta, and the individuals and communities that those operations support. Covered actions can support agricultural food production (Gontheier et al. 2014, Phalan et al. 2011). For example, protection, restoration, or enhancement of natural communities that support invertebrates and birds can provide pollination and/or natural pest control for surrounding agriculture (Tscharntke et al. 2005, Potts et al. 2010, Garibaldi et al. 2014).

A variety of covered actions can reduce flood risk for agricultural businesses and landowners. Tidal wetlands absorb tidal energy, so protecting or restoring tidal wetlands can attenuate tides further inland (Mitsche and Gosselink 2000). Setback levees can create more space in river and stream channels, reducing pressure on levees, increasing flood system capacity, and reducing velocity and erosion (USACE 2017). The Yolo Bypass is an example of a restoration project, which is managed for flood control, agriculture, and ecosystems (Sommer et al. 2001).

Subsidence reversal is another opportunity to reduce flood risk for agricultural operations in the Delta. Subsidence in the Delta is driven by the oxidation of the peat soils on reclaimed islands, increasing systemic risk of levee failure (Mount and Twiss 2005). Subsidence reversal is a process that halts soil oxidation and accumulates new soil material, in order to increase land elevations relative to a starting condition in which land elevations are below mean sea level. Over time, subsidence reversal can raise land elevations and reduce the risk of levee failure (Bates and Lund 2013).

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Attachment 1. Good Neighbor Checklist

The Sacramento-San Joaquin Delta (Delta) is the home of numerous habitat restoration efforts. Many Delta farmers are concerned that habitat lands could harm nearby agriculture in various ways. They would like assurance that entities that establish and manage habitat projects will consult with their neighbors and find ways to avoid impacts and resolve problems if they arise.

Restoration project managers can use the following checklist to ensure that they comprehensively consider and examine the impacts of their project on neighbors, and vice versa. The checklist is based on a discussion paper, "Agricultural and Land Stewardship Strategies" (see https://water.ca.gov/programs/california-water-plan/water-resource-management-strategies/ agriculture-and-land-stewardship-framework), which identifies a menu of mitigation measures and enhancements for the Delta. The measures described in the discussion paper, called Strategies, are referenced in the checklist.

- Have project proponents consulted with all neighboring landowners and operators about the project and its potential impacts? (See Strategy E1.1, which recommends involvement of landowners in project planning.)
- Have project proponents designated a local contact person to meet with neighboring landowners and discuss any issues of concern? (See Strategy D5.1, which suggests establishment of a public advisor position to help the public work with government agencies.)
- Will the project need access through other properties? If so, have access agreements been obtained?
- Does the management plan for the project provide for an on-site patrol or manager to deter trespass and vandalism? (See Strategy A4.3, which suggests the hiring of game wardens, sheriff's deputies, or private security guards.)
- Will the project increase the presence of vegetation susceptible to fire? (If yes, see Strategy A4.3.)
- Will the project discontinue maintenance of flood control features, involve prolonged or repeated flooding of previously dry land, or affect wind fetch across waterways? (If yes, see Strategy A1, which discusses flood protection improvements, and Strategy E1.3.2, which discusses drainage and seepage.)
- As a result of the project, are species on the project site expected to increase markedly in abundance and move from the site to neighboring lands or waterways? If yes, which species? (And see Strategy A4.2, which suggests ways to protect landowners from liability under endangered species laws.)

- Is it reasonably possible that species in the project area could damage crops or promote the growth of weeds or diseases on neighboring farms? (If yes, see Strategy A3, which suggests ways to control weeds, and Strategy A4.1, which suggests the use of buffer zones and mechanisms for compensation for crop damages.)
- Will the project disturb utilities, roads, bridges, or other infrastructure that serve agricultural uses? (If yes, see Strategy D3, which suggests improvements to transportation infrastructure.)
- Will the project fragment or isolate farmland? (If yes, see Strategy E1.1, which encourages collaborative project planning.)
- Do domestic or feral animals or livestock occur on lands neighboring the project? (If yes, see Strategy A4.1, which suggests the use of buffer zones.)
- Do neighboring farms use chemicals as fertilizer, or to control weeds or crop pests? (If yes, see Strategy A4.1, which suggests the use of buffer zones.)

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