Appendix F

Climate Change and the Santa Clara Valley Habitat Plan

Appendix F

Climate Change and the Santa Clara Valley Habitat Plan

Climate change is defined as any significant change in climate metrics, including temperature, precipitation, and wind patterns, over a period of time. Climate change—broadly speaking—may result from natural or human activities that change atmospheric composition. There is now broad scientific consensus that humans are changing the chemical composition of the earth's atmosphere. Activities such as fossil-fuel combustion, deforestation, and other changes in land use are resulting in the accumulation of greenhouse gases (GHGs) such as carbon dioxide (CO_2) in the atmosphere. An increase in GHG emissions is said to result in an increase in the earth's average surface temperature, commonly referred to as *global warming*. Global warming is expected, in turn, to affect weather patterns, average sea level, ocean acidification, chemical reaction rates, precipitation rates, and other climatic conditions; such changes, taken collectively, are commonly referred to as *climate change.* Because climate change is predicted to have potential adverse effects on the natural environment, the effects of climate change in the context of the Santa Clara Valley Habitat Plan (Plan) are discussed in this appendix.

Regulatory Context

To date there have been no significant environmental regulations enacted in the United States at the national level specifically designed to address climate change. However, several federal and state court decisions and pending cases anticipate the need for addressing climate change in future regulatory processes as a "changed circumstance." Recent case law suggests that plan developers ignore climate change at their peril. In *Massachusetts v. Environmental Protection Agency (2007)*, the Supreme Court sided with the petitioners, upholding that the potential threats of carbon dioxide (CO_2) are sufficiently understood and should be regulated by the Clean Air Act, despite scientific uncertainty. Similarly, in *Natural Resources Defense Council v. Kempthorne (2007)*, the courts contended that the uncertainty associated with climate change was not a reason to fail to address it in the context of a Biological Opinion under Section 7 of the federal Endangered Species Act (ESA) (Bernazzani et al. 2012).

In addition, some state and federal regulations and policies provide a framework within which climate change can be addressed. Below is a summary of these regulations and policies.

Endangered Species Act and No Surprises Policy

Habitat Conservation Plans (HCPs) are required to address any changed circumstances that are reasonably foreseeable within the HCP permit term (63 Federal Register [FR] 35, February 23, 1998). Changed circumstances are defined by the U.S. Fish and Wildlife Service (USFWS) in the No Surprises Policy (63 FR 35, February 23, 1998) as "changes in circumstances affecting a species or geographic area covered by a conservation plan that can reasonably be anticipated by plan developers and the Service and that can be planned for." The No Surprises policy ensures that no additional land-use restrictions or financial compensation will be required of the permit holder as long as the plan is being properly implemented.

Natural Community Conservation Planning (NCCP) Program

Like the ESA, the Natural Community Conservation Planning (NCCP) program is tasked with sustaining species and their habitat and maintaining viability of listed species. The NCCP Act is broader in its orientation and objectives than both its federal counterpart and the California Endangered Species Act. The NCCP Act includes provisions to contribute to the recovery of listed species and to specifically address natural communities and ecological processes.

"Changed circumstances" are also a component of NCCPs and are defined by the NCCP Act as "reasonably foreseeable circumstances that could affect a Covered Species or geographic area covered by the plan." Accordingly, an NCCP must "incorporate a range of environmental gradients (such as slope, elevation, aspect, and coastal or inland characteristics) and high habitat diversity to provide for shifting species distributions due to changed circumstances." [Section 2820(a)(4)(D)].

Prior to 2010, approved HCPs or NCCPs did not typically address climate change as a changed circumstance (Bernazzani et al. 2012). However, as general scientific consensus emerges regarding human-induced changes to the atmosphere, it can be assumed that climate change is now "reasonably anticipated" and must therefore be addressed along with measures that would be taken by the Permittees to respond to those changes. USFWS regulations require that HCPs and NCCPs take potential "changed circumstances" into account in the Plan, along with measures to address these changed circumstances.

California Assembly Bill 32

In 2006, the State of California passed into law the Global Warming Solutions Act of 2006, commonly referred to as Assembly Bill 32 (AB 32), which is designed to significantly reduce short- and long-term greenhouse gas emissions generated by California. AB 32 states that global warming poses a serious threat to the environment of California.

Guidance

Over the past decade, there has been a growing recognition at national, state, and local levels of the need to consider climate change in natural resource management and conservation planning. Nationally, federal agencies such as the USFWS, Government Accountability Office (GAO), the U.S. Global Change Research Program (GCRP), and the U.S. Environmental Protection Agency (EPA) have released reports calling for natural resource management that increases the resilience of ecological resources to climate change (Global Change Research Program 2009; U.S. Environmental Protection Agency 2009). Resilience refers to the amount of change or disturbance that an ecological system can absorb without undergoing a fundamental shift to a different set of structures and functions (Julius et al. 2008). A fundamental goal of climate change adaptation is to reduce the risk of adverse environmental outcomes by increasing the resilience of ecological systems.

In 2009, Congress asked the White House Council on Environmental Quality (CEQ) and the U.S. Department of the Interior (DOI) to develop a national strategy for helping the nation's natural resources adapt to climate change. This draft strategy, released in January 2012 (Council on Environmental Quality and U.S. Department of the Interior 2012), is the first joint federal, state, and tribal effort to identify adaptation strategies. It identifies some of the key actions that agencies should consider implementing over the next five to ten years.

Even prior to the release of federal guidance, the State of California developed its *Climate Adaptation Strategy*, which focuses on a multi-sector approach to respond to the current and future impacts of climate change. California was one of the first states to pursue a multi-sector state wide adaptation strategy and many of the objectives are being implemented today. The California Department of Fish and Game (CDFG) has created a Climate Science and Renewable Energy Branch with a climate science program that specifically works to plan for and respond to the effects of climate change on the state's fish and wildlife and their habitats. In September 2011, the CDFG released their vision for confronting climate change in California, which highlights an approach centered around 1) Unity: creating and maintaining vital climate change partnerships and collaborations, 2) Integration: integrating climate change into CDFG activities, and 3) Action: meeting conservation objectives for maintaining healthy ecosystems while taking into account climate change threats and impacts. In addition, within this vision the CDFG has detailed multiple mechanisms for incorporating climate change into natural resource planning, including national,

regional and local coordination, particularly around Landscape Conservation Cooperatives; California's Wildlife Action Plan; and the NCCP program. The NCCP program is one of the few existing planning programs put into law that addresses climate change adaptation.

Observed Climate Change

The Earth's climate varies naturally over many temporal and spatial scales as a result of meteorological processes such as changes in atmospheric circulation patterns. *Climate variability* refers to deviations from the average climate, whereas *climate change* refers to changes in the long-term average, generally based on averages of twenty to thirty years.

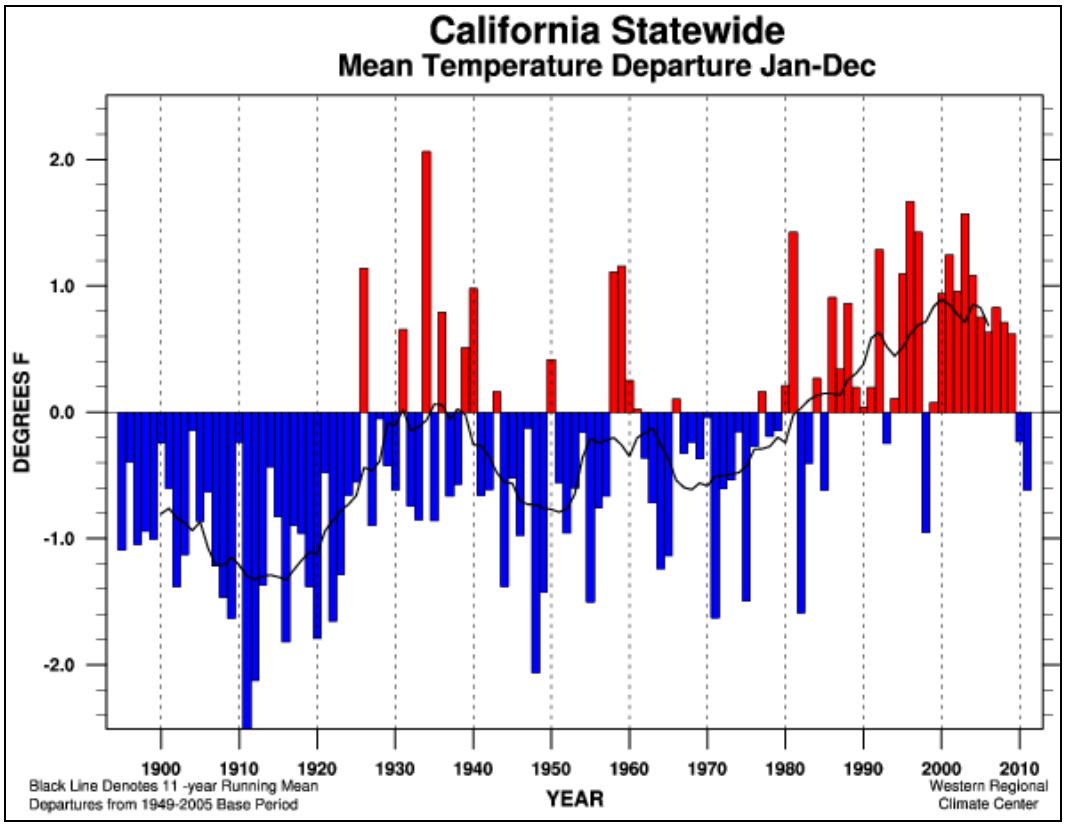
Climate change is occurring as a result of high concentrations of greenhouse gases in the Earth's atmosphere (National Research Council 2010; Intergovernmental Panel on Climate Change 2007). Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and ozone. These gases absorb energy emitted by the Earth's surface, and then re-emit some of this energy back to Earth, warming the Earth's surface, and influencing global and local climates. As more and more greenhouse gases are emitted into the atmosphere from human activities such as the burning of fossil fuels, the Earth's energy balance is disrupted, resulting in a number of changes to the historical climate. Evidence of long-term changes in climate over the twentieth century includes the following (Intergovernmental Panel on Climate Change 2007; National Research Council 2010; Global Change Research Program 2009):

- An increase of 0.74 degree Celsius (°C) (1.3 degrees Fahrenheit [°F]) in the Earth's global average surface temperature;
- An increase of 0.17 meter (6.7 inches) in the global average sea level;
- A decrease in arctic sea-ice cover at a rate of approximately 4.1% per decade since 1979, with faster decreases of 7.4% per decade in summer;
- Decreases in the extent and volume of mountain glaciers and snow cover;
- A shift to higher altitudes and latitudes of cold-dependent habitats;
- Longer growing seasons; and
- More frequent weather extremes such as droughts, floods, severe storms, and heat waves.

Observed Climate Change in California

Temperature

The western United States has warmed at a faster rate compared to the national average (Moser et al. 2009). From 1949–2005, California's average annual mean temperature was approximately 12°C (56°F). Over the twentieth century, California has experienced an increase in this average of roughly 0.8°C (1.5°F), with some variability in the rate of warming within the state (see Figure F-1).[1] The warming trends are asymmetrical, with nighttime minimum temperatures rising faster than daytime maximum temperatures, and winter/spring seasonal temperatures experiencing greater warming compared to summer/fall (Nemani et al. 2010; Gershunov et al. 2009). Some locations within California are no longer frozen at night during winter (Moser et al. 2009).



Source: Abatzoglou et al. 2009.
Data downloaded from: <http://www.wrcc.dri.edu/monitor/cal-mon/index.html>.

Figure F-1. Change in Annual Mean Temperature (°F) for California for the Twentieth Century Relative to 1949–2005 Baseline

[1] The Western Regional Climate Center provides monthly, seasonal, and annual averages of temperature and precipitation for California and subregions within the state. The monthly station data, taken from cooperative observers (COOP), along with gridded data from the PRISM database, are used to assess climate across the state. Note that a limited number of stations were reporting prior to 1918.

In spring, summer, and fall the pattern of twentieth-century warming has been similar, according to an analysis available from the Western Regional Climate Center presented in **Table F-1** below (Abatzoglou et al. 2009). Across California, spring has been arriving earlier in the year and fall has occurred later (Moser et al. 2009). The frequency of heat waves also has been increasing, and it is generally becoming more humid (Gershunov et al. 2009).

Table F-1. Seasonal Temperatures (°F, 1949–2005) and Twentieth Century Trends (Δ°F) for California

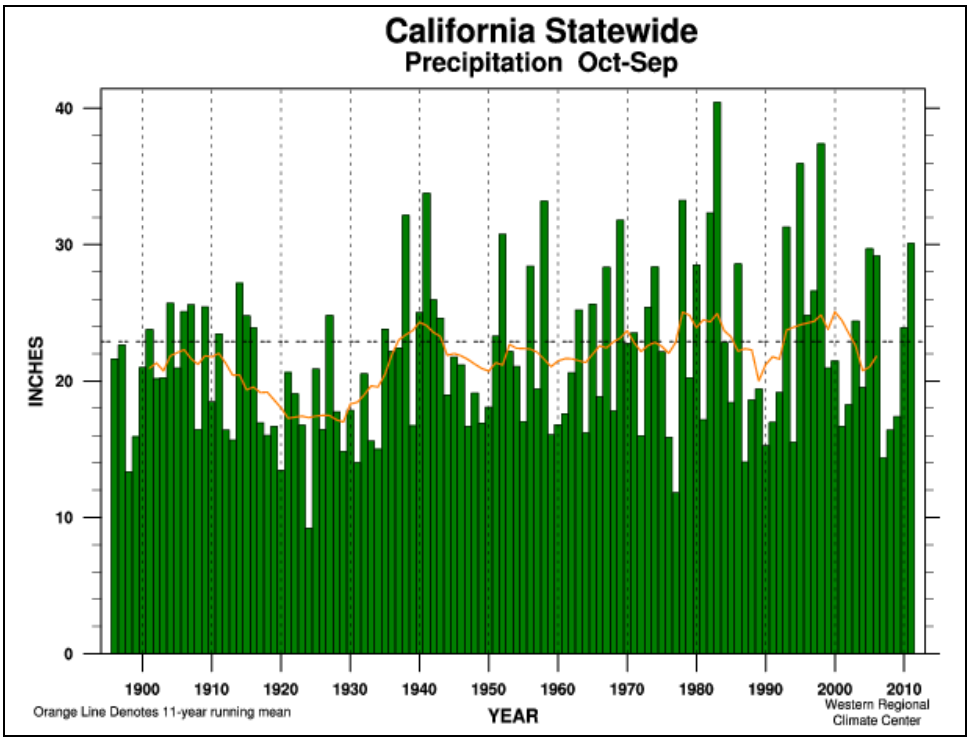
Season	Seasonal Temperature (°F, 1949-2005) and Twentieth Century Trends (ΔF, in Parentheses)		
	Minimum Temperature	Maximum Temperature	Mean Temperature
Winter (DJF)	32 (1.4)	53 (1.0)	43 (1.2)
Spring (MAM)	41 (1.8)	66 (1.4)	53 (1.6)
Summer (JJA)	55 (2.6)	86 (0.6)	70 (1.6)
Fall (SON)	44 (2.2)	71 (0.9)	58 (1.5)

Source: Abatzoglou et al. 2009.

Note: DJF = December, January, February; MAM = March, April, May; JJA = June, July, August; SON = September, October, November.

Precipitation

Over the twentieth century, California, however, has experienced a statewide increase in annual precipitation of approximately 3.5 inches (Abatzoglou et al. 2009). Figure 2 shows the year-to-year variability of annual precipitation compared to the 1950–2005 average of 23 inches (indicated by the dashed line). **Table F-2** provides the seasonal precipitation averages and twentieth-century trends.



Source: Abatzoglou et al. 2009.
Data downloaded from: <http://www.wrcc.dri.edu/monitor/cal-mon/index.html>.

Figure F-2. Annual Precipitation (inches) for California during the Twentieth Century (Water-Year)

Table F-2. Seasonal Precipitation Averages (inches, 1949–2005) and Twentieth Century Trends for California (inches, in parentheses)

	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Seasonal Precipitation	12 (1.6)	6 (0.5)	0.8 (0.2)	4.5 (0.8)

Source: Abatzoglou et al. 2009.

Note: DJF = December, January, February; MAM = March, April, May; JJA = June, July, August; SON = September, October, November.

Projected Climate Change in California

Scientists use global climate models to simulate current climatic conditions and to project the future climate. The models incorporate state-of-the-science understanding of earth processes (e.g., biogeochemistry of ecosystems on land and in the ocean) and are based on fundamental physical, atmospheric and oceanographic principles. Overall, scientists have greater confidence in the ability of climate models to simulate changes in temperature and less confidence about precipitation, especially regional precipitation patterns and other climatic

variables that are affected by local conditions such as topography (Global Change Research Program 2009), which is not accounted for in current models (Intergovernmental Panel on Climate Change 2007).

By mid-century, the average annual mean temperature in California is projected to rise from 1.1°C (2°F) to more than 2.8°C (5°F), with little to no change in total annual precipitation (Luers et al. 2006). There is significant variability in the precipitation projections by individual model and emissions scenario. Individual simulations suggest that there could be up to a 10 to 20% decrease in total annual precipitation (Luers et al. 2006).[2]

Effects of Climate Change on Ecological Processes in the Study Area

Both land cover types and covered species within the study area are vulnerable to climate change based on their ecology and natural history. While temperature rise in itself will have direct consequences on species viability and natural community distribution and composition, the effects of global warming on the amount and timing of precipitation and the frequency of severe weather and related disturbance events are also likely to affect the study area and, as a result, the natural communities, covered species, and the Plan's proposed conservation strategy. These potential effects of climate change are discussed below.

Precipitation

Several of the land cover types in the study area will be influenced by continuing shifts in the amount and timing of precipitation, with effects on soil moisture available for plants, runoff and ground water recharge, and sediment movements from the hillsides to the watershed drainage areas. Two climate models and predictions of climate change for Northern California are widely accepted by scientists (Suttle and Thomsen 2007; Dukes and Shaw 2007). Both models predict increases in the annual total amounts of precipitation and in each rainfall event, but differ in timing changes. In one model, the typical mid-winter rain-free period would decrease. Changes in precipitation patterns would affect land cover types differently. In grasslands, mature native bunchgrasses have deep roots and can access water during short dry periods (Holmes and Rice 1996), but seedlings with shallow roots may not be able to survive during these periods. Therefore, a reduction in the mid-winter rain-free period could favor seedling establishment of native grasses. Woody plant seedling establishment could be similarly favored (Dukes and Shaw 2007). This could improve the native grass component of the

[2] The California Climate Change Center report summarizes projections using the National Center for Atmospheric Research Parallel Climate Model (PCM1), Geophysical fluids Dynamic Laboratory (GFDL) CM2.1, and the United Kingdom Met Office Hadley Centre Climate Model, version 3 (HadCM3) under the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES) B1 (low emissions), A2 (moderately-high emissions), and A1Fi (high emissions).

grasslands, increase shrub encroachment into the grasslands, and increase oak regeneration. However, increases in annual precipitation may favor the encroachment of mixed evergreen forests on areas of chaparral and oak woodlands (Lenihan et al. 2003). Redwoods and close-coned pines would expand from remnant, fragmented groves into surrounding oak woodlands and chaparral land covers.

In the second model, the rainy season would be extended from spring to summer, thus potentially benefiting native grasses and summer annual forbs, including summer wildflowers and the pest plant, yellow starthistle (*Centaurea solstitialis*). Increased herbaceous and woody biomass growth in response to increased precipitation would pose the risk of higher fire hazards. More frequent drought years are also predicted which in combination with more intense rainfall events would pose higher risks of soil erosion and drops in ground water levels. Temperatures are also predicted to increase (Dukes and Shaw 2007). As temperatures increase, non-native grasses would become more dominant and invasive.

Increased Risk of Fire, Flooding, and Drought

California could experience a 55% increase in wildfire risk by mid-century (Luers et al. 2006). Many factors influence the likelihood of fires, including precipitation, winds, temperature, and vegetation. For some locations, increasing precipitation and temperatures may stimulate increased vegetation growth through a portion of the year, creating more fuel to burn later; other locations may experience decreasing precipitation and increasing temperatures, creating dry vegetation that can burn easily (Luers et al. 2006). Simulations indicate that the probability of fires greater than 500 acres increases under wetter conditions and decreases under drier conditions (Westerling and Bryant 2008).

The distribution and composition of vegetation communities may change due to increased fire activity (Brown and Hebda 1998). In the study area this could result in an increase in grasslands over woody land cover types (Lenihan et al. 2003).

Increased drought and flooding could also occur. Drought would reduce water availability for covered species and could in and of itself change natural community composition and distribution. Flooding could result from extreme rainfall events. Increased flooding could compromise the ability to restore streams and riparian areas and would have an unknown effect on aquatic species and natural communities.

Effects of Climate Change on Species, Natural Communities, and Ecosystems

Several ecological responses to climate change have occurred during the past century. Most studies use species response to changes in temperature as the indicator of the effects of climate change. These responses, in concert with historic and predicted climatic changes, serve as the basis for identifying species, natural community and ecosystem vulnerabilities and predicting how individual species, natural communities, and the ecosystem will be affected by climate change in the study area. Four broad mechanisms of biological response to climate change are discussed below.

Phenology

Phenology is the timing of seasonal events such as migration, flowering, and egg laying. Changes in phenology are reflected in shifts in the timing of events, potentially leading to phenological mismatch—that is, events that previously occurred at the same time would occur at different times. An example of phonological mismatch is the hatching of butterfly larvae *after* the peak flowering of host plants. Many studies have confirmed that the timing of biological events has shifted with changes in climatic conditions during the past few decades (Walther et al. 2002; Root et al. 2003; Root et al. 2005; Forister and Shapiro 2003). In general, species have demonstrated a phenological shift of 4.2 ± 0.2 days/decade earlier at the middle latitudes (32^{o}–49.9^{o}) and 5.5 ± 0.1 days/decade earlier at the higher latitudes (50^{o}–72^{o} N) (Root et al. 2003). Phenological shifts are expected to increase as global climate change intensifies.

Range and Distribution

Range is the area over which a species occurs or can potentially occur; distribution refers to where a species is located within its range. Range shifts can occur when a species moves from one location to another or expands its area due to changes in the environment (e.g., climatic variables, availability of food sources). A species' distribution can change in location and the number of disjunct populations within its range. Documented changes over the past century include shifts in dominant vegetation and in the documented ranges of butterflies and birds (Parmesan 1999; Pimm 2001; Walther et al. 2002; Easterling et al. 2000). Changes in range and distribution are especially problematic given the present fragmented character of species habitats. Shifts in range or distribution can isolate populations from one another, making them more vulnerable to genetic drift or local extinction. The shifting range of a species can also make previously protected areas unsuitable. Finally, narrowly distributed species (e.g., Bay checkerspot butterfly, Mount Hamilton thistle) and natural communities that already have restricted ranges due to urban growth, altitudinal gradients, or dependence on narrow environmental gradients are particularly vulnerable

because they likely have nowhere to move if their habitat becomes less suitable (Shainsky and Radosevich 1986; Murphy and Weiss 1992; Parmesan 1999; Pimm 2001; Walther et al. 2002; Easterling et al. 2000; Hillman pers. comm.).

Abundance

Abundance is the number or density of individuals found in a particular location. Shifts in abundance can occur when climatic variables alter microhabitats, juvenile survival, resource availability, competition, and species dominance (Martin 1998; Walther et al. 2002; Millar et al. 2006). Documented changes include shifts in species density due to changes in resource availability and climatic gradients, decrease in species abundances due to increases in diseases and pests, and decrease in native species abundance due to increased competition from invasive species (Dukes and Mooney 1999; Millar et al. 2006; Pounds et al. 2006).

Morphology and Genetics

Morphology is the study of form and structure in organisms; genetics is the internal code that governs morphology and behavior. Over very long time horizons, evolution changes morphology (and genetic frequency) to enhance species survival. Because these adaptations typically occur more slowly than do the environmental changes anticipated to result from climate change, many species will have difficultly adapting to climate change, resulting not only in a loss of genetic variability but in extinction of some populations and entire species as well (Davis and Shaw 2001).

Land Cover Types

Land cover types with isolated ranges are most susceptible to climate change. In the study area, these land cover types are ponderosa pine woodlands, knobcone pine woodlands, redwood forest, lower-elevation scrub, and serpentine grassland. With the exception of lower-elevation scrub, regeneration of these land cover types is disturbance driven. Most commonly, fire frequency and intensity determine each community's ability to regenerate. Rises in sea level could restrict the range of lower-elevation scrub by flooding out lower elevations. Changes in fire regime and rise in sea level, along with other climatic variables that may increase or decrease environmental stressors, will either lead to expansion or reduction of these land cover types with isolated ranges.

Ponderosa Pine Woodlands

Ponderosa pine woodlands have a limited distribution in the study area, occupying approximately 419 acres, or 0.1% of the study area. The stands are relics of a wider historic distribution during a cooler climatic period. Increased fire frequency could benefit the ponderosa pine community because the species is fire adapted. However, temperature rise is likely to further restrict the range of ponderosa pines by favoring species that thrive under warmer conditions. Ponderosa pine woodlands provide modeled habitat for three covered animal species (California tiger salamander, California red-legged frog, and western pond turtle).

Knobcone Pine Woodlands

Knobcone pine woodlands occur only on the Santa Cruz Mountain ridgetops, often on serpentine-derived soils, at the western edge of the plan area, where they occupy approximately 711 acres, or 0.2% of the study area. The climatic conditions of marine fog, along with the water-retaining properties of serpentinite, allow continued persistence of knobcone pines in these locations (Vogl 1973). As an obligate fire-climax species, knobcone pines depend on periodic fires for regeneration. Fire allows for the release of seeds from the serotinous[3] cones, as well as creation of the bare mineral soil required for seed germination. Knobcone pine woodlands are bordered by chaparral at lower elevations and redwood or Douglas-fir at higher elevations. An increase in fire frequency and favorable climatic conditions could benefit knobcone pine. Conversely, if fires are too frequent, there is a risk that knobcone pine seedlings would be killed before producing seeds, thus jeopardizing the viability of the natural community. Knobcone pine woodlands provide habitat for three covered animal species (California tiger salamander, California red-legged frog, and western pond turtle).

Redwood Forest

Redwood forest occupies approximately 9,693 acres, or 2% of the study area, in the Santa Cruz Mountains along creeks and valleys and on lower north- and east-facing slopes in the foothills. Although found in moist microclimates like knobcone pine woodland, redwood forest depends on fog to fulfill its moisture needs (Dawson 1998) and on fire for regeneration. In addition to fire, disturbances such as tree fall gaps and flooding also favor regeneration. Expansion of redwood forests could occur with increased fire frequency, although it is unclear how fire would affect the mosaic of redwood forest, knobcone pine, chaparral, and ponderosa pine, all of which are fire-adapted communities. Redwood forest provides habitat for four covered animal species:

[3] Serotinous cones require fire to open and release the seeds they contain.

California tiger salamander, California red-legged frog, foothill yellow-legged frog, and western pond turtle.

Serpentine Grassland

The presence of serpentine soil limits the distribution of serpentine grassland, which includes serpentine bunchgrass grassland, serpentine outcrops, and serpentine seeps. Serpentine soils provide habitat for a number of native grassland species because the extreme soil conditions allow natives to outcompete invasive European grasses. While changes in climatic conditions may not affect the extent of serpentine grassland as a whole, changes in microclimate conditions could lead to changes in species composition and dominance. Serpentine bunchgrass grassland occupies approximately 10,308 acres, or 2% of the study area. Serpentine outcrops occupy approximately 260 acres, 0.1% of the study area and provide habitat for four covered plants (Metcalf canyon jewelflower, most beautiful jewelflower, smooth lessingia, and Santa Clara Valley dudleya). Serpentine seeps—small wetlands located within serpentine grasslands and coastal scrub—occupy approximately 34 acres, or 0.01% of the study area and provide habitat for seven covered animal species (Bay checkerspot butterfly, California tiger salamander, California red-legged frog, western burrowing owl, western pond turtle, tricolored blackbird, and San Joaquin kit fox) and three covered plant species (smooth lessingia, most beautiful jewelflower and Mt. Hamilton thistle), of which one—Mt. Hamilton thistle—is restricted solely to serpentine seeps.

Lower-Elevation Northern Coastal Scrub/Diablan Coastal Scrub

In the study area, northern coastal scrub/Diablan coastal scrub (coastal scrub) is found throughout the Santa Cruz Mountain and the Diablo Range, usually below elevations of 300 feet on south-facing slopes (California Partners in Flight 2004). Increases in sea level would decrease the range and distribution of this natural community if climatic conditions and habitat connectivity did not allow for upslope expansion. Coastal scrub occupies an estimated 10,306 acres, or 2% of the study area. Covered plants that may be found in this community include fragrant fritillary, and coyote ceanothus. Coastal scrub provides habitat for California red-legged frog and western burrowing owl.

Covered Species

Life history, behavioral characteristics, and habitat requirements predispose certain covered species to be more susceptible to climate change than others. Within the study area, the species most vulnerable to climate change are those with limited dispersal ability, slow reproductive rate, specific habitat or soil

requirements, and limited habitat connectivity, as well as those already at the extreme of their range. Moreover, those species for which the study area includes a high proportion of their range or those for which critical habitat has been designated within the study area are of particular concern. For this analysis, covered species have been grouped into four categories on the basis of these characteristics and the ecological responses discussed above: butterflies, amphibians, reptiles, and plants. The four groups comprise a total of 10 species: Bay checkerspot butterfly, California red-legged frog, California tiger salamander, foothill yellow-legged frog, western pond turtle, coyote ceanothus, Santa Clara Valley dudleya, Metcalf Canyon jewelflower, Mount Hamilton thistle, and smooth lessingia (**Table F-3**). This analysis discusses the life history, behavioral characteristics, and habitat requirements that predispose these species groups are to be particularly susceptible to climate change.

Butterflies

Butterfly species are sensitive to climate change due to their larval host plant and nectar-source dependence (Murphy and Weiss 1992). If the timing of host-plant availability changes without equal shifts in life-cycle timing, the phenological mismatch could affect reproductive success. In addition, the narrow habitat requirements of butterflies and host plants may lead to shifts in range, distribution, and abundance as a result of climate change.

In the study area, climate change has the potential to affect Bay checkerspot butterfly, a covered species under the Plan (**Table F-3**). This species occurrence is restricted to narrow environmental gradients, with the majority of its habitat located in the study area. Additionally, 16,601 acres or 91% of designated critical habitat for the species is located within the study area (66 FR 21450–21489).

Amphibians

Amphibians' permeable skin, biphasic life cycles, and unshelled eggs make them sensitive to small changes in temperature and moisture (Carey and Alexander 2003). In most cases, amphibians in temperate climates can tolerate wide variations in temperature, but their dependence on aquatic environments for reproductive success could be comprised by changes in seasonal and regional climatic patterns. Decreases in precipitation or shifts in timing of precipitation would have an effect on reproductive success and adult survivorship due to increased risk of desiccation, reduced food supply, and increased predation due to reduced habitat availability. Such changes could lead to a range shift and changes in distribution and abundance. Increased evaporation of aquatic habitat due to increased temperatures could have indirect effects, such as the concentration of toxic chemicals that could lead to increased mortality and decreased reproductive success (Davidson et al. 2001; Carey and Alexander 2003).

In the study area, climate change has the potential to affect three covered amphibian species: California red-legged frog, California tiger salamander, and foothill yellow-legged frog (**Table F-3**). California red-legged frog and California tiger salamander both have limited dispersal ability and are dependent on the proximity and connectivity of aquatic environments with their upland habitat for reproductive success. Of the designated critical habitat for California red-legged frog, 150,962 acres (9%) is within the study area. Critical habitat for the Central population of California tiger salamander encompasses 28,096 acres, or 14% of the study area. Because foothill yellow-legged frog is not federally listed, critical habitat has not been designated. Nevertheless, the species has limited dispersal ability and is restricted to aquatic environments. Reproductive success is dependent on a narrow range of in-stream environmental gradients (e.g., temperature and stream flow velocity).

Reptiles

The potential effects of climate change on reptiles are less well studied than its effects on amphibians. Some reptiles exhibit temperature-dependent sex determination, whereby increased air temperatures skew the sex ratio to favor females over males (Janzen 1994). If such a phenomenon applies to covered reptile species in the study area, global warming could result in a preponderance of females in the study area.

In the study area, climate change has the potential to affect western pond turtle (**Table F-3**). Gender shifts would not be notable until later in the permit term as this species is long lived and does not reach sexual maturity until at least 10 years of age. No critical habitat has been designated for this species and its range extends well beyond the study area.

Plants

Even more than wildlife, plants are vulnerable to climate change. Changing the habitat conditions that are necessary for persistence of a given sensitive plant species (e.g., increased temperature, increased or decreased moisture) could result in extinction if the species' minimal habitat requirements are not met, or if the habitat becomes more favorable for other species (Hillman pers. comm.). Day length, temperature, moisture conditions, and the presence of the appropriate pollinators all play a critical role in reproductive timing and success. The dependence of plants on seed dispersal for movement across habitats and climatic gradients prevents them from moving quickly in the face of changing climatic conditions and habitat suitability. In addition, the specific soil requirements and physiological tolerance limits of plants along with limited habitat connectivity make plants particularly susceptible to climate change. All of the covered species in the study area have some degree of affinity for serpentine soils and most are dependent on serpentine soils for their habitat requirements (**Table F-3**).

Conservation Strategy

Conservation biology is the basis of the conservation strategy, and the proposed reserve design anticipates some effects of climate change using a multi-scale approach. As such, it is designed to reduce species vulnerability and provides opportunities for species and natural communities to adapt in responses to climate changes. Biological goals and objectives were developed at the *landscape level* to encompass ecological processes, environmental gradients, biological diversity, and regional wildlife linkages. Conservation actions were developed to implement these goals and objectives. Landscape-level objectives and actions are generally developed at the scale of miles or tens of miles. By working at the landscape level, flexibility for climate change–driven shifts in range and distribution of species and natural communities is allowed. This landscape level approach allows for replication of ecosystems and populations to achieve a balance representation of natural communities and species habitats, support multiple species within the Reserve System, and protect of key ecosystem features. Land acquisition will target properties that provide connectivity within the Reserve System and among existing protected areas within and outside the study area and rural private lands. This will allow for northward and upslope movement, maintain and restore habitat linkages, and reduce fragmentation. In addition, habitat types across environmental gradients (topographic diversity) are targeted to provide topographic diversity and reduce the chance of population extinction (Murphy and Weiss 1992). Protection of a range of environmental gradients allows natural communities and species to adapt to changes in temperature and precipitation. It provides an opportunity for movement to areas where environmental conditions remain favorable for their persistence if climate change causes their current location to become unfavorable. Protection of key ecosystem features (i.e., riparian, aquatic) throughout the study area ensures that vulnerable species such as amphibians will have available habitat across a variety of environmental gradients. In addition, removal of barriers (i.e., fences and medians) and creation of safe passage ways (i.e., culverts under roads) within the study area will increase the permeability of the landscape to allow for species movement through and within the study area. Both increased landscape connectivity and permeability allow for species migration to occur across the landscape. Consequently, some species and natural communities within the study area would be able to "move" in response to climate change, allowing for shifts in range and distribution.

Conservation actions were also developed to address natural communities primarily through the enhancement, restoration, and management of vegetation types (i.e., land cover types). This medium scale is called the *natural community level*. Enhancement, restoration and other land management actions would increase the resilience of natural communities in the face of climate change. For example, grazing can be managed to provide some control of increasing shrub encroachment and pest plants, but an integrated program including non-grazing methods will be needed. Specific actions that would increase resilience include controlling invasive species and diseases through integrated pest and vegetative management, and improving habitat quality to increase resource availability for native species.

Finally, the specific needs for protection and enhancement of individuals, populations, and groups of populations of covered species were addressed. *Species-level* conservation actions were developed to supplement and focus actions developed at the broader scales and to ensure that all the needs of each covered species are addressed. Species-level conservation measures have a habitat focus. Examples include protection of specific habitat elements to allow for plant population expansion and creation. These species-specific actions would ensure that populations of each covered species are maintained, and monitoring would identify any early negative trends caused by climate change.

While the conservation strategy can help to ensure the movement of some communities across the landscape and can address through management actions, some of the effects of climate change are beyond the control of management or land acquisition. The conservation strategy cannot address changes in phenology, nor in morphology and genetics. For example, the serpentine communities are adapted to persist on serpentine soils. It is outside the scope of the conservation strategy to genetically modify these plants so that they can outcompete nonnative grasses on other soil types. Additionally, some responses, in terms of connectivity, are needed at scales greater than the Plan can provide and would necessitate planning in multiple counties. While the Plan can combat small shifts in range, distribution, and abundance at the landscape, natural community, and species levels, larger shifts due to climate change would extend outside the study area.

Adaptive Management and Monitoring

The Adaptive Management and Monitoring Program enables the conservation strategy to respond to the effects of climate change. Landscape-level monitoring is designed to detect large-scale changes, such as changes in ecosystem processes, shifts in natural community distribution, and the integrity of landscape linkages. Community-level monitoring, in turn, is designed to detect changes in the composition and function of natural communities, populations of key predator or prey populations, invasive species, and other important habitat factors for covered species. Finally, species-level monitoring measures the effects of management actions on covered species abundance and distribution, as well as, the status and trends of covered species in the Reserve System. Collectively, these monitoring actions will allow for early detection and response to the effects of climate change, such as early identification of stressors (i.e., fire, flood, drought, pollution), increased abundance and distribution of invasive species, and changes in range, distribution, and abundance of natural communities and covered species. Both the conservation and monitoring actions described above will help to buffer the effects of climate change in the study area.

Covered Activities and Climate Change

The Plan will provide endangered species permits to development in the study area. Accordingly, the covered activities may contribute to climate change by allowing increased emissions that result from urban expansion and vegetation removal. The covered activities listed below are expected to have the greatest potential effect on GHG emissions.

- **Urban Development.** All projects related to urban growth within designated urban areas. This covered activity will facilitate population growth in the study area and will likely result in increased motorized vehicle use, which in turn contributes to climate change. Increased energy use driven by population growth is also predicted.
- **Rural Capital Projects.** Projects related to new road construction in rural areas. As with urban development, any project that facilitates increased motorized vehicle use qualifies as a potentially significant contributor to climate change.
- **Rural Development.** Projects related to development outside designated urban areas. This covered activity will facilitate population growth in the study area, and will likely result in increased motorized vehicle use. Increased energy use driven by population growth is also predicted.

This impact analysis does not quantify the impacts from covered activities due to climate change. Predictions of how much covered activities will contribute to climate change cannot be made and it will be up to those projects to develop and implement their own mitigation for their future effects.

Conclusions

The Plan will not be implemented independent of global climate change. The conservation strategy and Monitoring and Adaptive Management Program are designed to ensure that lands are acquired and managed in a way that preserves flexibility and increases resilience and that adverse impacts on the natural communities and covered species will be detected early. As the requirements of natural communities and species shift over time, the flexible nature of the plan and the perpetuity of funding will allow for management to occur throughout implementation and beyond the permit term. Accordingly, the Plan will change with the climate, ensuring species persistence to a much greater extent than would be afforded by other alternative approaches such as project-by-project mitigation.

Literature Cited

Abatzoglou, J.T., K.T. Redmond, L.M. Edwards, 2009, Classification of Regional Climate Variability in the State of California. *Journal of Applied Meteorology and Climatology* 48, 1527–1541.

Bernazzani, P., B.A. Bradley, and J.J. Opperman. 2012. Integrating Climate Change Into Habitat Conservation Plans Under The U.S. Endangered Species Act. *Environmental Management*. DOI 10.1007/s00267-012-9853-2.

Brown, K.J. and R.J. Hebda. 1998. Long-term Fire Incidence in Coastal Forests of British Columbia. *Northwest Science*, Volume 72, Special Issue No. 2, Washington State University Press, 1998.

California Partners in Flight. 2004. Version 2.0. *The Coastal Scrub and Chaparral Bird Conservation Plan: A Strategy for Protecting and Managing Coastal Scrub and Chaparral Habitats and Associated Birds in California*. (J. Lovio, lead author). Stinson Beach, CA: Point Reyes Bird Observatory (PRBO) Conservation Science. Available: <http://www.prbo.org/calpif/plans.html>.

Carey, C and M.A. Alexander. 2003. Climate change and amphibian declines: is there a link? *Diversity and Distributions,* Vol.9, pp. 111–121.

Council on Environmental Quality and U.S. Department of the Interior. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Public Review Draft, January 2012. Available: <http://www.wildlifeadaptationstrategy.gov/>.

Davidson, C., H. Bradley Shaffer, Mark R. Jennings. 2001. Declines of the California Red-Legged Frog: Climate, UV-B, Habitat, and Pesticides Hypotheses. *Ecological Applications,* 11(2), pp. 464–479.

Davis, M.B and R.G. Shaw. 2001. Range Shifts and Adaptive Responses to Quaternary Climate Change. *Science*, 292, 173–180.

Dawson, T.E. 1998. Fog in the California redwood forest: ecosystem inputs and use by plants. *Oecologia,* 117: 476–485.

Dukes, J.S. and H.A. Mooney. 1999. Does global change increase the success of biological invaders? *Tree* 14(4): 135–139.

Dukes, J.S. and M.R. Shaw. 2007. Responses to changing atmosphere and climate. Pp. 218-229, in: M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio (Eds.) California grasslands: ecology and management. Berkeley: University of California Press.

Easterling, David R.; Gerald A. Meehl; Camille Parmesan; Stanley A. Changnon; Thomas R. Karl; Linda O. Mearns. 2000. Climate Extremes: Observations,

Modeling, and Impacts. *Science,* New Series, Vol. 289, No. 5487. pp. 2068–2074.

Forister, M.L. and A.M. Shapiro. 2003. Climatic trends and advancing spring flight of butterflies in lowland California. *Global Change Biology,* 9, 1130–1135.

Gershunov, A., D. Cyan, and S. Iacobellis. 2009. The Great 2006 Heat Wave over California and Nevada: Signal of an Increasing Trend. *Journal of Climate*. pp. 6181–6203.

Global Change Research Program. 2009. Global Change Impacts in the United States. Available: <http://www.globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009.>

Holmes TH, Rice KJ. 1996. Patterns of growth and soil-water utilization in some exotic annuals and native perennial bunchgrasses of California. *Annals of Botanty* 78:233–43.

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis, Summary for Policymakers. Approved at the 10th Session of Working Group I of the IPCC, Paris, February 2007. IPCC Secretariat, Geneva, Switzerland.

Janzen, Fredric J. 1994. Climate Change and Temperature-Dependent Sex Determination in Reptiles. *Proceedings of the National Academy of Sciences of the USA,* 91(16), pp. 7487–7490.

Julius, S.H., J.M. West, G.M. Blate, J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott. 2008. *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Julius, S.H., J.M. West (eds.), J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA, 873 pp.

Lenihan, James M., Raymond Drapek, Dominique Bachelet, and Ronald P. Neilson. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. *Ecological Applications,* 13(6), pp. 1667–1681

Luers, A., D. Cayan, G. Franco, M. Hanemann, and B. Croes. 2006. *Our Changing Climate: Assessing the Risks to California*. A Summary Report from the California Climate Change Center. CEC–500–2006–077.

Martin, T. 1998. Are Microhabitat Preferences of Coexisting Species under Selection and Adaptive? *Ecology,* 79(2), 656–670.

Millar, C.I., R. Neilson, D. Batchelet, R. Drapek, and J. Lenihan. 2006. Climate change at multiple scales. Chapter 3 in Salwasser, H. and M. Cloughesy (eds). *Forests, Carbon, and Climate Change.* Oregon Forest Resources Institute Publication.

Moser, S., G. Franco, S. Pittiglio, W. Chou, and D. Cayan. 2009. *The Future is Now: An Update on Climate Change Science Impacts and Response Options for California*. A Special Report. California Energy Commission. CEC–500–2008–071.

Murphy, D. D., and S. B. Weiss. 1992. Effects of climate change on biological diversity in Western North America: Species losses and mechanisms. Chapter 26 in *Global Warming and biological diversity*, ed. R. L. Peters and T. E. Lovejoy. Castleton, New York: Hamilton Printing.

National Research Council. 2010. America's Climate Choices: Panel on Advancing the Science of Climate Change; National Research Council. Available: <http://www.nap.edu/catalog.php?record_id=12782>.

Nemani, R., M. White, D. Cayan, G. Jones, S. Running and J. Coughlan. 2010. Asymmetric Climatic Warming Improves California Vintages. Available: <http://meteora.ucsd.edu/cap/grapes/grape_final.PDF.>

Parmesan, C. et al. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature.* 399, 579–583.

Pimm, S.L. 2001. Entrepreneurial insects. *Nature.*411, 531–532.

Pounds, J.A. and M.R. Bustamente et al. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature*. 439: 161-167.

Root, T.L. and Jeffery T. Price, et al. 2003. Fingerprints of global warming on wild animals and plants. *Nature.* 421, 57–60.

Root, T.L.; Dena P. MacMynowski; Michael D. Mastrandrea; Stephen H. Schneider. 2005. *Proceedings of the National Academy of Sciences of the United States of America,* 102(21). pp. 7465–7469.

Shainsky, L.J., and S.R. Radosevich 1986. Growth and water relations of Pinus ponderosa in competitive regimes with Arctostaphylos patula seedlings. *Journal of Applied Ecology* 23:957–966.

Suttle, K.B. and M.A. Thomsen. 2007. Climate change and grassland restoration in California. *Madrono* 54(3):225–233.

U.S. Environmental Protection Agency. 2009. A Framework for Categorizing the Relative Vulnerability of Threatened and Endangered Species to Climate Change. Available: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=203743>.

Vogl, R. J. 1973. Ecology of knobcone pine in the Santa Ana Mountains, California. *Ecological Monographs* 43:125–143.

Walther, G., Eric Post, et al. 2002. Ecological responses to recent climate change. *Nature,* 416, pp. 389–395.

Westerling, A.L., and B.P. Bryant. 2008. Climate Change and Wildfire in California. *Climatic Change* 87:S231–S249.

Personal Communication

Hillman, Janell M. Botanist. Santa Clara Valley Water District. San Jose, CA. December 12, 2007—email to Terah Donovan, Conservation Planner, Jones & Stokes, Oakland, CA.

Table F-3. Potential Climate Change Effects on Selected Covered Species

Species	Potential Climate Change Effects during Permit Term				Rationale
	Phenological Mismatch	Range and Distribution Shift	Change in Abundance	Morphology and Genetics	
Butterflies					
Bay checkerspot butterfly	X	X	X		Dependence on larval host plant presence restricts current range to serpentine soils with a suitable microclimate. Change in timing or intensity of seasonal event could have an effect on plant abundance and availability during the critical species reproductive period, as well as macro- and microclimatic suitability, leading to phenological mismatch and decrease in species abundance. Changes in microclimate suitability could further restrict species range and distribution.
Amphibians					
California red-legged frog	X	X	X		Life history and physical characteristics of amphibians make them dependent on climatic variables for reproductive success and species perseverance. Change in precipitation timing and quantity could change habitat availability during the breeding season, leading to a phenological mismatch, shift in range and distribution, or change in abundance. Increases in precipitation and lengthening of the rainy season could favor an increase in range and distribution and abundance. Decreases in precipitation and/or decreases in length or delayed timing of the rainy season could lead to phenological mismatches, range and distribution shifts, and decrease in abundance.
California tiger salamander	X	X	X		
Mountain yellow-legged frog	X	X	X		
Reptiles					
Western pond turtle			X	X	Turtles have exhibited temperature dependent sex-ratios. Temperature increases in the study area could result in skewed sex ratios, favoring females over males. An extreme decrease in males could lead to decreased abundance due to reduced mating frequency.
Plants					
Coyote ceanothus	X	X	X		Serpentine plant distribution is restricted to highly specialized and localized habitat requirements that include species-specific microclimate conditions coincident with serpentine soil occurrence. Restriction to serpentine soils limits species range and distribution to this soil type. Climate change could change microclimate conditions so that species can no longer persist within their current range. Increase in favorable microclimate conditions could lead to an expansion of distribution and increase in abundance, both in terms of number of populations and number of plants within each population. Change in timing or intensity of seasonal events could have an effect on
Santa Clara Valley dudleya	X	X	X		
Metcalf Canyon jewelflower	X	X	X		
Mount Hamilton thistle	X	X	X		
Smooth lessingia	X	X	X		

Table F-3. Continued

Species	Potential Climate Change Effects during Permit Term				
	Phenological Mismatch	Range and Distribution Shift	Change in Abundance	Morphology and Genetics	Rationale
Tiburon Indian paintbrush	X	X	X		pollinator reproductive and plant flowering periods leading to phenological mismatches.
Fragrant fritillary	X	X	X		
Loma Prieta hoita	X	X	X		
Most beautiful jewelflower	X	X	X		