VALLEY FLOOR GRASSLAND AND VERNAL POOL NATURAL COMMUNITY NATURAL COMMUNITY ACCOUNT

Associated Covered Species

Vernal pools and their associated plant communities provide the primary habitat for 15 (40%) of the Covered Species and 25 (69 %) of Special Management Species in the Solano HCP (Table 4-1). Another 4 species will receive secondary benefits from vernal pool conservation in the County. The covered species have been divided into 5 groups based on specific habitat requirements or particular conservation needs. These groups are then used to develop species specific conservation measures (Section 5.0).

B. Turner

Group 1 – Vernal Pool/Grassland Complex Species. This group includes species that can be expected to occur in almost any vernal pool community complex within the County (i.e. they may be capable of tolerating a broad range of water quality/alkalinity, depth and duration, or are associated with lowland grasslands). However, in many cases, some of these species may be quite uncommon and have a very limited range or occurrence within Solano County.

Group 2 – Alkali Playa, Flats, and Meadow Species. This group includes a number of plant species that are more typically associated with higher alkalinity plant communities such as alkali playas, flats, and meadows. These species may also occur in higher salinity zones around the drying edges of other vernal pool communities.

Group 3 – Extremely Rare and/or Range Limited Species. This group includes the species that are extremely rare or range limited listed in objective 4.

Group 4 – Federally Listed Species. Group 4 species include a number of species that are typically more widespread, but require additional species-specific conservation measures because they are either listed as Federally Threatened or Endangered or have been petitioned for federal listing.

Group 5 – Bird Species. These species are more wide spread and occur in multiple natural communities and are dealt with on a landscape level. The conservation needs of these species within the valley floor grassland and vernal pool natural community will be addressed through the natural community conservation measures.

Background

The Valley Floor grasslands are dominated by two, typically intermixed associations: vernal pool system grasslands and grassland associated with low hills such as the Montezuma Hills and Potrero Hills and upper terraces along the valley floor/Inner Coast Range foothills. Vernal pool ecosystems in Solano County consist of seasonally inundated pool basins and swales embedded in a matrix of undulating grasslands. Dominant species and defining characteristics of the grasslands (i.e. the grassland matrix and grasslands associated with low hills) and vernal pools are detailed below.

Grassland Matrix and Grassland Associated with Low Hills. The characteristic species of the grassland matrix in the vernal pool associations and in the higher ground and low-hilly areas on the Valley Floor are introduced annual grasses and forbs. These species include wild oats, various bromes and barleys (*Bromus* spp. and *Hordeum* ssp.), Italian wildrye, filarees, mustards, wild radish, mallows, vetches, and starthistles. In portions of the County, particularly in the Montezuma Hills, the valley floor grasslands are also periodically cultivated for dryland production of oats, wheat, and barley. While these areas are often regularly cultivated, many of the grassland ecosystem functions remain. Therefore, areas of dryland farming are included within the grassland community association versus being incorporated into the primarily irrigated agricultural community (note that the HCP habitat mapping distinguished cultivated grasslands from non-cultivated lands as a component of the baseline mapping).

While the grasslands associated with vernal pools/swales in the central portion of Solano County are dominated by annual, non-native grasses, native grasses such as purple needlegrass (*Nassella pulchra*), one-sided bluegrass (*Poa secunda* ssp. *secunda*), Kentucky blue-grass (*P. pratensis* ssp. *pratensis*), and Nuttall's alkali grass (*Puccinella nuttalliana*), as well as variously-sized stands of meadow barley (*Hordeum brachyantherum* ssp. *brachyantherum*; *H. b*. ssp. *californicum*), creeping wild-rye (*Leymus triticoides*), and saltgrass (*Distichlis spicata*) persist in the non-native grassland. Typically, there are no large stands of these grasses; rather they persist as scattered individuals or in a relatively low percentage of the grassland cover. Even in reserves such as the Jepson Prairie Reserve, native grasses comprise a small percent of the total grassland cover. Several native species of grass associated with vernal pools/swales remain dominant in these wetland features; annual hairgrass (*Deschampsia danthonioides*), Pacific meadow foxtail (*Alopecurus saccatus*), and Lemmon's canary grass (*Phalaris lemmonii*) are common grasses, whereas Solano grass (*Tuctoria mucronata*), Colusa grass, and San Joaquin Valley orcutt grass (*Orcuttia inaequalis*) are rare (federally and State-listed as endangered or threatened species), occurring in large alkaline playa pools.

Vernal Pool Ecosystems. Vernal pools are defined "as precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief waterlogged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration." (Keeley and Zedler 1998).

Vernal pools are spatially discrete, ephemeral wetlands typical in regions with Mediterranean climates (Keeley and Zedler 1998). Distinct wet and dry seasons lead to winter and spring inundation of pools, followed by complete drying in summer. These temporary wetlands, characteristically underlain by an impervious claypan or hardpan layer, support a unique biota capable of withstanding and responding to extreme variation in physical conditions.

Within the Plan Area, northern claypan vernal pools (element code 44120, Holland 1986) is the most common pool type. This community type is typically associated with basin-rim and low-terrace alluvial soils, including Antioch, San Ysidro, Pescadero, Solano, Millsap, Sycamore, and Clear Lake soil series. The pools occur on neutral to alkaline, silica-cemented, hardpan soils that are often more or less saline. Pools may be small, covering only a few square meters, or large, covering several hectares. The larger ones are referred to as vernal lakes or playa pools. The other type of vernal pools occurring within the Plan Area are northern hardpan vernal pools (element code 44110, Holland 1986). These pools occur on old, acidic, iron-silica cemented soils that are typically associated with the Corning, Redding, and San Joaquin soil series, although the Solano Soil Survey (Bates et al. 1977) descriptions for the Corning Soils in the County indicate more claypan conditions, at least in the upper soil horizons, rather than a cemented hardpan in the "typical" Corning Soils.

The vegetation in claypan pools is similar to that in northern hardpan pools. Characteristic native species include goldfields *(Lasthenia fremontii, L. glaberrima*), coyote thistles (*Eryngium* spp.), dwarf blennosperma (*Blennosperma nanum*), spreading alkali-weed (*Cressa truxillensis*), and Douglas' mesamint (*Pogogyne douglasii*). The primary difference between northern claypan and northern hard pan pools is that the typically alkaline-adapted species are mostly absent in the hardpan vernal pools and the vegetative cover is commonly not as tall in the northern claypan pools. Other species present in the northern hardpan vernal pool community include popcorn-flowers (*Plagiobothrys* spp.), willow-herbs (*Epilobium* spp.), downingias (*Downingia bicornuta*; *D. pulchella; D. cuspidata*), and a paintbrush (*Castilleja campestris*).

The Valley Floor Grassland and Vernal Pool Natural Community, incorporates several other recognized plant communities: alkali playa, alkali meadow, and chenopod scrub. These community types support many similar species to and often intergrade with the vernal pools in the County (the northern clay pan vernal pool type tends to exhibit some alkalinity), but there are several plants which are primarily found in these communities.

The alkali playa community occurs in poorly drained soils with high salinity or alkalinity caused by the evaporation of water that accumulates in closed depressions or drainages. The water table is often high and salt crusts are visible on the ground surface. This type of community, which includes Chenopod Scrub is common in closed basins in deserts but also occurs in the Central Valley. Vegetation in this community consists of low-growing, grayish, small-leaved, often succulent shrubs that grow to 1 meter in height, although in Solano County the height averages less than ½ meter. The total vegetative cover is mostly sparse due to the low distributional density of the shrubs and the poorly developed herbaceous understory. Characteristic species of this plant community in Solano County include seep-weed (*Suaeda moquinii*), alkali heath, (*Frankenia salina*), pickleweed (*Salicornia virginica*), and several species of saltbush (*Atriplex* spp.).

Alkali meadows occur on fine-textured, more or less permanently moist, alkaline soils and consist of dense to relatively open growth, dominated by low-growing, perennial grasses and sedges. It intergrades with non-native grassland and northern claypan vernal pool on drier, less alkaline soils. Characteristic species of this community include sedges (*Carex* spp.), saltgrass (*Distichlis spicata*), scratchgrass (*Muhlenbergia asperifolia*), and alkali sacaton (*Sporobolus airoides*).

Other types of seasonal wetlands are also present in the Plan Area. Seasonal wetlands are typically distinguished from vernal pools by a longer or altered hydrology, the presence of more persistent emergent vegetation dominated by taxa of species such as rush (*Juncus* spp.) and spike rush (*Eleocharis* spp.) and occasionally bulrush (*Scirpus* spp.), sedge (*Carex* spp.), or cattails (*Typha* spp.), nonnative plant species such as ryegrass and Mediterranean barley, and/or a reduced number of native forbs that typically grow in vernal pools. In many cases, the seasonal wetlands represent or occur in historic vernal pool habitats, but have lost many or all of their natural characteristics because of land use changes and disturbance. While often lacking significant native components of true vernal pools, seasonal wetlands can support species of concern and can provide important areas for vernal pool restoration.

For the purposes of the Solano HCP, seasonal wetlands within the Plan Area that occur within areas historically supporting vernal pools and occurring on soil types associated with vernal pools are included within the overall vernal pool ecosystem conservation strategies. The HCP also considers the upland components (contributing watersheds) as well as the wetland swales and pools to be an integral component of the vernal pool ecosystem. Seasonal wetlands, including vernal pools, can also occur in most community types such as Upland Grassland, Agricultural, Woodland, Scrub/Chaparral, Developed - Vacant/Disturbed, and Developed - Rural Residential communities. However, in these communities, wetlands typically comprise a smaller percentage of the total area (on average less than 5 percent).

Distribution Within the Plan Area

Potential historic vernal pool areas were mapped based on soil type (i.e. the presence of northern hardpan or northern claypan; Figure 3-6). The Natural Resources Conservation Service (NRCS) soil type mapping was used to distinguish soil series within the Plan Area that are associated with vernal pool habitats. These soil series include Antioch, Antioch-San Ysidro complex, Pescadero, Solano, Millsap, Sycamore, Clear Lake, and Corning. These soil series can be characterized as neutral to alkaline, silica-cemented, hardpan, basin-rim, and low-terrace alluvial soils. As mentioned in Section 3.3.1, a baseline habitat inventory and mapping was completed using a combination of existing sources to categorize and map the various habitat types and land uses within the County. Current potential vernal pool areas were identified by overlaying the results of the soil types with present day information on land use patterns and habitat types remaining within the Plan Area. Current potential vernal pool areas are defined as applicable vegetation or cover types occurring on soil series associated with vernal pool habitats (Figure 3-6 and Figure 3-4). Applicable vegetation or cover types include: native and nonnative annual grassland; vernal pools and other seasonal to semi-permanent wetlands; pasture (irrigated and non-irrigated) and agricultural croplands where the underlying claypan/hardpan/ impermeable layer has not been eliminated by deep ripping and the soil chemistry/characteristics have not been highly altered (e.g., soil alkalinity has not been permanently eliminated through leaching and/or chemical treatment); and ruderal/disturbed where the underlying claypan/hardpan/impermeable layer has not been eliminated by deep ripping.

Orchards and other intensive agricultural croplands on these soil types were generally excluded from the current potential vernal pool areas. Converted or developed lands on suitable soil series/associations where the land alteration has eliminated the capability of the land to support vernal pool habitats (e.g., the underlying impermeable layer has been eliminated, chemical properties have been altered to the extent natural physical and chemical conditions cannot practicably be restored) have been excluded from the Valley Floor Grassland and Vernal Pool Ecosystems. Conservation requirements for such lands shall be determined based on their current biological characteristics (e.g., agricultural land/Swainson's hawk, grassland, etc.). However, in certain agricultural lands where the underlying soil structure has not been severely compromised and wetland or vernal pool characteristics remain (vernal pools or other seasonal wetlands remain), such areas shall be treated under this conservation association (see Figure 4-2).

Historically, vernal pool complexes were widespread in Solano County. The results from the habitat mapping show an estimated 118,227 acres of historic potential vernal pool grassland in the County (Figure 3-6). Currently, there is an estimated 50,762 acres of potential vernal pool grassland habitat remaining within Solano County (43 percent of the historic potential; Figure 3-6) and much of the remaining vernal pool habitats have been highly altered through past land use activities. The remaining large blocks of habitat exist primarily in the Jepson Prairie, north of Travis AFB, and the lowlands around the base of the Potrero Hills. However, there are smaller pool complexes at several sites north and west of Fairfield and in western Suisun, which support populations of the endangered plant, *Lasthenia conjugens* (Contra Costa Goldfields) and perhaps populations of several species of vernal pool crustaceans.

Another larger block of northern claypan vernal pools (element code 44120, Holland 1986) and northern hardpan vernal pools (element code 44110, Holland 1986) are located in a relatively small area north of Vacaville (Figure 3-6).

The level of habitat mapping conducted for the HCP is not of sufficient detail to distinguish between specialized plant communities such as alkali playas, chenopod scrub, alkali meadows, and patches of native grasslands. The alkali playas, chenopod scrub and alkali meadow communities are embedded within the distribution of northern claypan pools and are likely only present in relatively 'pristine' areas such as the Jepson Prairie.

Playa pools are specific types of pools within the northern clay pan vernal pool community that supports a number of uncommon and extremely rare species such as Conservancy fairy shrimp, Solano grass, and Colusa grass. Playa pools are often large (Olcott Lake is approximately 93 acres), but can occur as much smaller pools. The playa pools are primarily associated with Pescadero soils and typically have turbid water. These pools also tend to have longer wetted cycles. Within the County, playa pools occur primarily from the northern edge of the Potrero Hills extending northeasterly across to the Jepson Prairie (see Figure 4-5).

Narrative Conceptual Model

Understanding the essential ecological processes that structure natural communities is critical for conservation planning (Margules and Pressey 2000). This section provides a preliminary narrative conceptual model for the Valley Floor Grassland and Vernal Pool Natural Community. This model will be used to guide the conservation and management programs developed in the Solano HCP. Following concepts developed by Atkinson et al. (2004), the essential ecological processes, habitat variables and anthropogenic threats, described in the model, are considered pressures. Pressures are agents that either promote or inhibit change in the state of the environment (Atkinson et al. 2004). Here pressures are divided into three categories, essential ecological processes and habitat variables, land use practices and the consequences of land use practices. The first category, essential ecological processes and habitat variables, include environmental pressures such as hydrology, water quality and fire that may significantly influence a functional vernal pool ecosystem. Land use practices, also called primary pressures, include activities such as urbanization, agriculture and livestock grazing. The consequences of the land use practices, also called secondary pressures, include threats such as habitat loss and fragmentation, pest and flood control programs, runoff and chemical contamination. All pressures affecting the valley floor grassland and vernal pool community are discussed in sections below, starting with the essential ecological processes and habitat variables, then moving into the land use practices, followed by the consequences of these practices. More detail on the affects of each pressure on individual covered species is discussed in the species accounts.

Essential Ecological Processes and Habitat Variables. The essential ecological processes and habitat variables that structure the valley floor grassland and vernal pool communities are:

Soil. Soil type is considered a natural pressure because it can promote or inhibit the formation of vernal pools, influence hydrology, water chemistry (e.g. alkalinity and salinity) and the establishment of particular plants species and plant communities. Soils with impenetrable layers, such as a hard pan or clay pan, are required for the formation of vernal pools. Soil type also limits the distribution of special-status plants that are only known to occur in alkaline or clay soils. Many special-status plants covered by this HCP occur in alkali playa pools, meadows or flats. Typically these species are able to tolerate highly alkaline conditions that other plant species are not able to tolerate; they find a niche in alkaline conditions and do not have to compete with some of the other species they would have to compete with in non-alkaline conditions.

Fire. Fire is another important pressure in valley floor grassland vernal pool communities. Natural or anthropogenic, fires affect vernal pools and the surrounding uplands by altering plant species composition. For example, fire retards the natural succession of grasslands to shrublands. The largest benefit of fire on this ecosystem is the reduction of thatch build-up and a decrease in nonnative annual grasses in the following year. Reduction of thatch and non-native plants reduces competition for native plants and improves their seed production and cover.

Fire can have a beneficial or detrimental impact on special-status vernal pool plants, depending on the season and intensity of the burn. Fires that burn special-status plants prior to seed set can decrease the abundance of those species. Native perennial grasses have also been shown to respond favorably to appropriately timed burns. Prescribed burning has also been used to control invasive exotic species. At the Jepson Prairie a series of prescribed burns were implemented in the vernal pool grassland complex in the late-spring and fall and results indicated that late-spring burning reduced thatch density and the cover of nonnative exotic grasses such as medusahead (*Taeniatherum caput-medusae*), while increasing the cover of native grasses and forbs (Pollak and Kan 1998). The late-spring burn also increased the cover of some early spring forbs, especially filaree (*Erodium* spp.), a nonnative species. Fall burns also reduced thatch and killed some exotic plant seedlings, but some native plants were also vulnerable.

The deposition of ash into pools increases nutrient levels, particularly phosphorous, which is usually the limiting nutrient in aquatic ecosystems. This nutrient pulse into the community could affect the composition of vernal pool species.

The *Report of Science Advisors: Supplement on Rangeland Management* that was prepared for this HCP reviewed scientific literature on the effects of rangeland management activities such as prescribed burning on the special-status species and their habitats covered by this HCP (Ford and Huntsinger 2004). They point out that prescribed burning research, especially for special-status species covered by this HCP, is limited and sometimes conflicting. Prescribed fire is currently being used in California to enhance native grasses and forbs in grasslands, but the effects are complex, contextual to specific conditions, vary with edaphic and climatic factors and effect different species differently (Ford and Huntsinger 2004). Climate, especially precipitation, has a major impact on the response of perennial grasses and forbs to fire; therefore, long-term research is required to assess the changes caused by manipulating burning treatment verses changes caused by weather (Ford and Huntsinger 2004). Although the effects of fire are complex and species specific research is sparse, speculation about the affects of fire can be made based on more general research and assumptions about a species' habitat requirements (Ford and Huntsinger 2004).

Weather. Weather is one of the largest natural pressures affecting vernal pools. Year-to-year differences in the composition of vernal pool communities in California have been associated with variation in the timing and amount of rainfall (Bliss and Zedler 1998). Weather directly affects the length and timing of all four stages in an annual vernal pool cycle (Keeley and Zedler 1998). Because the effects of weather are closely linked to hydrology it is discussed in the hydrology section.

Hydrology. Vernal pools exhibit four major phases: (1) The wetting phase, when vernal pool soils become saturated; (2) the aquatic phase, when a perched water table develops and the vernal pool contains water; (3) a water-logged drying phase, when the vernal pool begins losing water as a result of evaporation and loss to the surrounding soils but soil moisture remains high; and (4) the dry phase, when the vernal pool and underlying soils are completely dry (Keeley and Zedler 1998). The timing and length of these phases relative to each other influences species composition within pools. Along with these phases, there are three elements that define vernal pool habitat: 1) the source of water, 2) duration of the inundation and waterlogged phases and 3) the timing of these phases (Keely and Zedler 1998).

Water Sources. California's vernal pools begin to fill with the winter rains. Water inundation is largely driven by precipitation and subsurface flows from the surrounding watershed (Zedler 1987, Rains et al. In Press). Zedler (1987) hypothesized that input from subsurface flows is probably minimal except where pools are close together, the hydraulic head is unusually steep, or the pools are connected by animal burrows. But Rains et al. (In Press) found that perched groundwater discharge accounted for 30-60% of the inflow to vernal pools during and immediately following storm events. Hanes and Stromberg (1998) suggested that the relative importance of both overland flow and subsurface flows in pool hydrology is dependent on the upland soil types. Hanes and Stromberg (1998) studied vernal pools near Mather Air Force Base, in Sacramento County, and found that the moderate to deep upland soils of the site and light to moderate rainfall intensities during their study period resulted in little input from overland flow into vernal pools. However, they predicted that the amount of overland flow would increase and the persistence of subsurface lateral flow would decrease as the depth of upland soils decrease. In their study, water exchange between the pool and surrounding upland played a major role in controlling water level relationships. Subsurface inflows dampened water level fluctuations during late winter and early spring (See hydroperiod section for more details). This dampening may affect the water chemistry of pools, pool vegetative composition and play a role in the life cycle of biota in the pool and adjacent uplands.

Timing. The timing and length of the phases described above relative to each other influences species composition within pools (Keely and Zedler 1998). Weather is the primary determinant of timing. For instance, the timing of rains determines the timing of the wetting and aquatic phases. Similarly, temperatures following the initial inundation phase, drives evaporation rates which largely determines the timing of the waterlogged drying phase and the dry phase.

Hydroperiod (duration of inundation). The amount of rainfall largely determines the depth, size and duration of inundation of vernal pools (USFWS 2004). The length of the hydroperiod (duration of inundation or the timing of the onset of the drought phase) is primarily driven by evapotranspiration and subsurface flows (Zedler 1987). In southern California, Zedler (1987) found the drying of pools to be primarily driven by water moving out of pool basins in mass-flow through macropores or channels, or lenses of coarser material in the underlying hardpan. Holes in the hardpan could also occur from roots, rodent burrows or human activity.

The duration and timing of inundation is also influenced by the exchange of water between the pool and the surrounding upland soils (Hanes and Stromberg 1998). The exchange of water between the pool and the uplands is affected by changes in hydraulic gradients. During the onset of the first winter rains, water that enters pools moves laterally through the sides of the pools into the uplands, delaying the onset of sustained inundation. After enough rain has fallen, the upland soils begin to develop a perched water table. The development of this perched water table and the saturation of the surrounding soil shift the hydraulic gradient towards the pools. This initiates the inundation phase of a pool. In addition, subsurface flow into the pool after it is full may be great enough to offset evaporative losses, helping to stabilize water levels near their maximum and delay the onset of drying in the spring (Hanes and Stromberg 1998). The surrounding uplands quickly loose their perched water table through high evapotraspiration rates and vegetative growth which shifts the hydraulic gradient back towards the uplands accelerating seasonal drying (Hanes and Stromberg 1998). Thus, the watershed area and the surrounding soil types are intricately connected with the length of the inundation or aquatic phase and within season fluctuations in water levels, which may affect water chemistry.

Water Quality. The chemical characteristics of California vernal pools are diverse, influencing the type of species found and their life history characteristics. For example, species may have chemical triggers that initiate seed germination or the hatching of eggs or cysts. The distribution of species within and among pools may also be influenced by tolerances to turbidity, salinity, alkalinity or total dissolved solids (Holland and Griggs 1976, Zedler 1987, Eng *et al.* 1990, Simovich 1998).

The water chemistry of vernal pools is said to be similar to oligotrophic lacustrine habitats in high elevations and latitudes (Keeley and Zedler 1998). There are large changes in pH, carbon dioxide and oxygen concentrations and temperature. Temporal changes in pH within a pool are primarily driven by photosynthesis. Depletion of dissolved carbon dioxide concentrations from photosynthesis causes increases in the pH between 2-3 units over the course of a few hours (Keely and Zedler 1998). These large variations in water chemistry within a pool over short time scales may prohibit the invasion of pools by exotic species or stronger competitors not adapted to withstand these fluctuations. Conversely, changes to water chemistry and hydrology can make vernal pool environments unsuitable for native species. In addition, the elimination of variation among pools within an area can decrease overall diversity because certain species, particularly plants, have adapted to tolerate different pool conditions. For example, more alkaline and saline pools support different flora.

Plant-Pollinator Interactions. Vernal pool plants rely on insects to provide pollination services to complete their lifecycle. A preliminary list of floral visitors includes several species of generalist bees, other insects and specialized andrenid bees. Bees of the family Andrenidae specialize on a narrow range of flowering plants as pollen sources (Thorp and Leong 1998). It is likely that these oligolectic andrenid bees contribute significantly to the reproduction of plants in the genera *Blemnosperma*, *Downingia*, *Lasthenia* and *Limnanthes*. These four plant genera typically have one or more native, specialist, solitary bees that collect pollen exclusively from that genus (Thorp and Leong 1998). Because either group is closely dependent upon the success of the other, their life cycles and potentially their population dynamics are closely synchronized (i.e. declines in bee populations could potentially have large affects on plant populations and vice versa). In the case of *Blemnosperma nanum*, Leong and Thorp (1994) demonstrated, that seed set was significantly lowered in experimental plant arrays placed at a created vernal pool site where only generalist pollinators were available as compared to those experimental plant arrays placed at Jepson Prairie Reserve where there is a complete guild of flower visitors including the specialist (oligolectic) bee, *Andrena (Diandrena) blennospermatis*. These experiments show that the specialist bee is important to the reproduction of the plant.

Both generalist and specialist pollinators are dependent upon the uplands to successfully complete their lifecycle. For example, andrenid bees construct nests in the soil of the upland areas surrounding the pools. Thus, a healthy upland component is necessary to provide habitat for solitary bees and, in turn, pollination services to vernal pool plants. These interactions between upland and pool biota have important implications for conservation. Specifically, pool restoration or the creation of new pools as mitigation for the destruction of existing pools must also include the restoration or creation of suitable upland habitat for flower visitors if these sites are to support viable, long lasting vernal pool communities (Thorp and Leong 1998).

Land Use Practices. The land use practices or primary pressures that directly affect vernal pool communities in Solano County are:

Urbanization. Vernal pool habitats have been lost primarily as the result of widespread urbanization (USFWS 2004). Urbanization also results in increased fragmentation of existing vernal pool habitat, decreased watershed area, altered watershed topography, increased runoff and contaminants. Increased urban areas may also result in flood and mosquito control programs which may inadvertently affect vernal pool ecosystems. Urbanization is also associated with increases in certain native predators and competitors and the presence of exotic species (introduced predators and competitors). See Consequences of Land Use Practices for more specific information.

Intensive Agriculture (Croplands). Vernal pool habitats have also been directly lost from conversion to agricultural crops (USFWS 2004). Intensive agriculture or croplands result in increased fragmentation of existing vernal pool habitat, decreased watershed area, altered watershed topography, increased runoff and contaminants from irrigation and pesticide and herbicide application. See consequences of land use practices for more specific information.

Cultivated Grassland/Dry-land Farming. A less intensive form of agriculture is carried out in the Montezuma Hills, portions of the Jepson Prairie, and in a few other limited areas in Solano County where irrigation water is not readily available and/or topography is not suitable for irrigation. Cultivated grassland and dry-farmed areas are largely similar to the non-native annual grasslands characteristic of the grassland matrix associated with vernal pool ecosystems and provides very similar wildlife habitat. The direct affects include reduction of native plant species, reduced diversity, nutrient loading, altered hydroperiod and reduced depth of pools. The negative consequences of this practice include periodically disking or tilling the land and the application of biosolids or sludge.

Livestock Grazing. The *Report of Science Advisors: Supplement on Rangeland Management* that was prepared for this HCP focuses on the effects of grazing on the special-status species and their habitats covered by this HCP (Ford and Huntsinger 2004). They point out that grazing management research, especially for special-status species covered by this HCP, is limited and sometimes conflicting. Furthermore, they state that literature often describes moderate grazing as neutral or beneficial, but little applicable information is available to guide the development of a prescribed grazing plan to benefit specific species or to minimize specific negative effects. Conflicting results on the effects of grazing can sometimes be due to site specific conditions or weather patterns (Ford and Huntsinger 2004). In California annual grasslands, weather can have a major affect on vegetation changes; therefore, long-term research is required to assess the changes caused by manipulating the management regime verses changes caused by weather variables (Ford and Huntsinger 2004). Although the effects of grazing are complex and species specific grazing management research is sparse, speculation about the affects of grazing can be made based on more general research and assumptions about a species' habitat requirements (Ford and Huntsinger 2004).

Livestock grazing has three primary effects on vernal pools: consumption of vegetation, trampling and nutrient input from urine and feces (Vollmar 2002). The following sections describe the negative and beneficial affects of livestock grazing on vernal pools.

Negative effects of livestock grazing. The USFWS (2004) identifies overgrazing, undergrazing, inappropriately timed grazing, and the removal of grazing from a vernal pool grassland complex that is currently grazed as major threats to vernal pool species. Livestock can reduce water quality by increasing turbidity and nitrate levels, causing eutrophication and decreasing dissolved oxygen concentrations. Livestock can draw down water levels in pools, leaving covered species with insufficient water to successfully complete their lifecycle. If livestock are allowed to graze at inappropriate times, they can disturb the habitat of sensitive species, altering pool topography and potentially resulting in trampling and death. For example, livestock trampling may kill pupae of Delta green beetle, Ricksecker's water scavenger beetle and adult and juvenile California tiger salamanders. Different grazing regimes can cause changes to the plant species composition in and around the pools, including the reduction of native vernal pool plants and the introduction or spread of invasive non-native plants.

Beneficial effects of livestock grazing. Appropriate levels and timed grazing can have substantial benefits to vernal pool ecosystems. Grazing can reduce biomass of annual non-native plants and decrease the build up of thatch that may inhibit successful germination of native plants and the movement and foraging behavior of animals such as the California tiger salamander, Delta green ground beetle, and the Ricksecker's water scavenger beetle. Grazing can also be implemented as a vegetation management tool to reduce the cover of non-native grasses or invasive plants. Plants and fairy shrimp may also benefit from livestock grazing by the transport of seeds or cysts from one pool to another in feces, or on fur or hooves.

Recreation. The inappropriate use of designated open spaces, for example off-road vehicle use and vandalism, by recreation enthusiasts can threaten the ecological functions of vernal pools (USFWS 2004). Off-road vehicle use and bicycling may impair the hydrological functions of pools by creating deep rips in the hardpan, decreasing hydroperiods. Off-road vehicle use, bicycling and even hiking in inappropriate areas can lead to soil compaction and the burial of seeds and cysts decreasing germination rates. Site visitors may also inadvertently crush or kill sensitive plants and animals and facilitate the spread of invasive species via seeds transport. Soil erosion can also directly damage special-status plants or their habitat.

Natural Gas Exploration and Production. Natural gas reserves occur in subterranean pockets in the Jepson Prairie area, and exploratory drilling for these reserves could pose a threat (USFWS 2004). In addition, such drilling may necessitate new roads and related infrastructure, resulting in other potential indirect impacts.

Consequences of Land Use Practices. The Consequences of the above land use practices (i.e. secondary pressures) on vernal pool communities in Solano County are:

Habitat Loss and Fragmentation. Habitat loss and fragmentation is the largest threat to the survival and recovery of the covered species occupying vernal pool communities. Urban expansion and agricultural development have destroyed most of the vernal pool habitat in

California, and it is estimated that less than 10% of pools remain (Holland 1998). These activities have also disrupted the historical interconnections among pools within complexes and among the complexes themselves at local and regional scales. Since there is evidence that these connections play an important ecological and evolutionary role in the resilience of vernal pool plant and animal populations to local extinction, the disruption of these connections poses a serious threat to the long-term persistence of the vernal pool biota (Report of the Science Advisors 2002).

Decreased Watershed Area. The watershed of vernal pools (the surrounding uplands) plays an important role in the vernal pool ecosystem. First, the watershed provides critical habitat for species such as California tiger salamanders, burrowing owls, solitary bees and other pollinator species. Second, the watershed plays an important role in pool hydrology. Subsurface flows from perched groundwater in the surrounding uplands can account for 30-60% of the inflow to a vernal pool (Rains et al. In Press). The surrounding uplands also play an important role in dampening water level fluctuations during late winter and early spring (Hanes and Stromberg 1998; See hydrology section for more details). Decreases in the surrounding watershed could directly reduce pool hydroperiod and potentially create more erratic within season fluctuations in inundation levels which may have adverse affects on covered species (Hanes and Stromberg 1998).

Altered Watershed Topography and Drainage Patterns. Alterations to the upland topography from development or agriculture can alter drainage patterns altering pool hydrology and either eliminate or create hydrologic connections between pools (USFWS 2004). Creating connections between isolated vernal pools to more permanent wetlands can result in the invasion of predators such as bullfrogs, fish and crayfish. Altering the upland topography can lead to the diversion of water away from some pools and into other areas. Vernal pool hydrology is intricately related to the extent of perched aquifers in the surrounding uplands (Rains et al. In Press). Land use activity that affects these perched aquifers could alter pool hydrology. Even small changes in local land use, such as the development of irrigated agriculture or parkland, may have considerable impacts on vernal pools. The degree to which small changes in local topography might affect vernal pools is poorly understood because the fundamental hydrogeological characteristics of perched aquifers remain relatively unexplored (Rains et al. In Press).

Urban and Agricultural Runoff. Urban and agricultural runoff (runoff) can carry contaminants, such as petroleum products, pesticides, herbicides, fertilizers and detergents, into vernal pool ecosystems. In addition, increased runoff associated with urban development and water used to irrigate crops may result in altered hydrology (USFWS 2004). This could adversely affect the hydroperiod, timing and frequency of inundation, turbidity, pH, salinity and dissolved oxygen of a vernal pool.

Chemical Contaminants. Impacts to water quality from chemical contaminants such as pesticides, heavy metals, treated effluent, urban runoff, agricultural runoff and mosquito control could have detrimental impacts on vernal pool species (USFWS 2004). There is a general lack of specific studies that assess the effects of chemical contaminants on vernal pool species; however, some speculation can be made as to how such chemicals could adversely affect species. Specifically, herbicides may completely inhibit growth of covered plants (USFWS 2004). Other contaminants may directly or indirectly, via pathways, injure or kill vernal pool invertebrates, plants and amphibians. For example, contaminants may alter the chemical properties of a pool (*e.g.*, pH, salinity, dissolved oxygen, turbidity) and inhibit and/or disrupt biochemical processes creating less suitable conditions for reproduction, germination and growth. For salamanders, contaminants such as pesticides, heavy metals, treated effluent (estrogens), urban runoff and agricultural runoff can affect embryo and larval development, potentially leading to malformations, increased susceptibility to disease and death (Hayes et al. 2003, Marco et al. 1999 and de Solla et al. 2002). Chemicals, such as petroleum products, pesticides, herbicides, fertilizers and detergents, may wash into vernal pools during the course of activities on adjacent areas. Pesticide drift from adjacent agricultural operations or from mosquito control programs could kill important pollinator species such as solitary bees, and covered invertebrates such as the Delta green ground beetle and the Ricksecker's water scavenger beetle. The contamination of pools with fertilizer or detergents can lead to the eutrophication of vernal pools, which can kill vernal pool crustaceans by reducing the concentration of dissolved oxygen (Rogers 1998). Fertilizers may benefit the growth of invasive plants and could effectively lead to localized extirpation of covered plant and animal species.

Eutrophication. Eutrophication results from the addition of excessive amounts of plant nutrients (primarily phosphorus, nitrogen, and carbon) to vernal pools. Runoff from agricultural fields, field lots, urban lawns, and golf courses is one source of these nutrients. Untreated, or partially-treated, domestic sewage is another major source. Eutrophication can increase turbidity, decrease dissolved oxygen levels and alter the water chemistry of pools. It can also lead to algal blooms which may inhibit seed germination in the following years.

Mosquito Control. The use of oil and other chemical pesticides for mosquito control can kill covered invertebrates such as Ricksecker's water scavenger beetle, Delta green ground beetle, fairy shrimp and solitary bees. These chemicals can also indirectly affect covered species by altering food web and plant-pollinator interactions (i.e. can result in decreased prey availability for larval California tiger salamanders and decreased pollinator abundance; Boone and Bridges 2003). In addition to chemical eradication methods, the introduction of mosquito fish, *Gambusia spp*, can have negative affects on covered species. Mosquito fish can reduce survivorship of vernal pool crustaceans and aquatic insects (Leyse and Lawler 2000).

Rodent Control. California ground squirrels (*Spermophilus beecheyi*) are considered pests by farmers and ranchers. In urban and agricultural areas ground squirrel populations are commonly controlled using poisons or by gassing burrows. Burrowing mammals in valley floor grasslands could be considered a keystone species by providing other animals with an important habitat requirement, abandoned burrows. Burrows provide one of the few forms of shelter to many of the wildlife that inhabit these areas. For example, adult and juvenile California tiger salamanders are predominantly terrestrial, living underground in burrows of California ground squirrels, gophers, and other burrowing mammals (Shaffer et al. 1993). The presence of California ground squirrels may be the single most important determinant of whether burrowing owls use a given site. Burrowing owls use abandoned burrows for cover and as nest sites. Rodent control programs may kill California tiger salamanders and burrowing owls directly, via gassing burrows or directly consuming poison, or may kill them indirectly through the contamination of their food resource. Reducing populations of burrowing mammals negatively affects California tiger salamanders and burrowing owls by reducing upland refuge sites and reduce nest burrow availability. In addition to valley floor grassland species, the burrowing activity of rodents in the beds of dry pools may create microvariation in pool environments creating increased diversity of vernal pool plants in the following winter (Science Advisors Report 2002).

Sewage-sludge Application. The application of Biosolids or sewage-sludge, in pastures and rangelands is a controversial farming practice that takes place spring through fall. Sewage-sludge application is the practice of tilling sewage-sludge, or biosolids, into the earth. Biosolids are semi-treated wastes imported from sewer plants all over California to be recycled into the soil. Not only do they contain nitrates, they are also known to contain salmonella, hepatitis A, giardia, parasitic worms, organic compounds and heavy metals (Harrison and Oakes 2002).

The use of biosolids as a soil amendment/fertilizer in grasslands may adversely affect vernal pool ecosystems (USFWS 2004). The nutrients in sludge are likely to aggravate problems with invasive nonnative plant growth due to increased availability of nutrients (USFWS 2004). The application of sewage-sludge in the watershed of a vernal pool could potentially have negative affects on the water chemistry in a pool. Sewage-sludge is known to contain certain contaminates such as heavy metals and other organic compounds which if ended up in pools may alter pool pH, salinity, dissolved oxygen and turbidity. In addition, an increase in nitrate and phosphorus levels could lead to eutrophication.

Disking of Tilling. In dry-land farming areas, periodic fall tillage and seeding is employed to plant and grow various crops, including oats (*Avena* sp.), barley (*Hordeum* sp.), and wheat (*Triticum* sp.). This practice can potentially alter pool hydrology by creating deep rips in the hardpan. This practice also results in “smoothing” of topography and light disking tends to increase the surface area of pools while decreasing their depth. Tilling could also bury seeds and cysts of vernal pool plants and crustaceans decreasing their viability. Disking or tilling can potentially decrease the abundance of native plants by directly removing these species prior to seed set. Competition with non-native species can also be exacerbated in these areas because non-native seeds are planted regularly, leading to increased densities of the non-native species..

Introduced Predators and Competitors and Increased Densities of Native Predators or Competitors. Interference from exotic species is one of the leading threats nationwide to imperiled freshwater fauna (Richter et al. 1997). Introduced species may prey on and/or out-compete natives. For example, introduced honey bees (*Apis mellifera*) may out-compete native solitary bees. California tiger salamanders, fairy shrimp and potentially Ricksecker’s water scavenger beetles are negatively affected by introduced predators such as bullfrogs, bass, sunfish, mosquitofish and crayfish (Jennings and Hayes 1994, Leyse and Lawler 2000). In addition to introduced species, populations of certain native species, such as raccoons and crows, are positively affected by human activity. Populations of natives subsidized by anthropogenic resources can lead to increased predation or competitive pressure on covered species. For example, increased predation pressure from natural predators such as raccoons and crows, whose populations are artificially inflated due to urbanization could reduce juvenile, adult and larval survival of California tiger salamanders (Jennings and Hayes, 1994).

Introduced Annual Plants. California grasslands are dominated by non-native plant species that can either directly out-compete native vernal pool species or indirectly affect native species via the development of thatch that inhibits establishment of native pool plants. Competition from invasive annuals may cause native plant species to set fewer seed, or add fewer seeds to the seedbanks then were removed through germination or other factors. The encroachment by non-native plants often follows surface-disturbing activities, such as disking, grading, filling, ditch construction, and off-road vehicle use, which can alter hydrology and microhabitat conditions. When exotic grasses in the uplands are ungrazed for several years, vernal pool margin and swale natives can experience microhabitat conversion due primarily to shading from the build-up of thatch. The grass thatch inhibits the germination of native annuals, but has little if any retarding effect on the germination and growth of exotic grasses. Results from an on-going California Department of Fish and Game study show that thatch depth is negatively correlated with frequency and percent cover of native forb species (Mary Ann McCrary, pers. comm. 2004). The build up of thatch may also decrease natural runoff into vernal pools affecting pool hydrology. Thatch build-up can be reduced through managed grazing and prescribed burning.

Data Gaps, Uncertainties and Assumptions. Despite their ecological and evolutionary uniqueness, vernal pool ecosystems remain relatively little studied. There is a general lack of basic life history and population biology information for vernal pool species. Therefore, there is also insufficient information on appropriate reserve size, buffer sizes necessary to minimize threats of adjacent incompatible land uses, upland habitat requirements of vernal pool plant pollinators, amount of upland habitat (i.e., watersheds) contributing to, and necessary for the maintenance of, vernal pool hydrological function, and landscape distribution of vernal pools and vernal pool complexes needed to provide for dispersal and genetic exchange (USFWS 2004a).

Vernal Pool Plant and Animal Species. For most vernal pool plant and animal species, little information is available on population trends and dynamics, species interactions, and connections to regional habitats to carefully quantify the probability of long-term persistence.

A considerable amount of uncertainty still remains concerning the responses of vernal pool plant communities to various management regimes, including grazing, burning, and mowing. Current information indicates that essentially any grazing is better than no grazing and there are various management philosophies regarding the most appropriate management techniques: however, specific research or testing of different techniques is limited. In particular, research related specifically to special-status species covered by this HCP or that provides relevant information on managing for specific species is sparse. Research efforts should focus on the temporal and spatial dimensions and intensity of these management regimes. Long-term research is also required to account for changes in vegetation caused by weather variables that can confound the results of changes caused by manipulating the management regime (Ford and Huntsinger 2004).

The extent to which vernal pool plant communities can be restored is still unknown. Most efforts to restore vernal pool ecosystems have failed to fully replace all natural system functions (De

Weese 1998), although it does appear that at least some functions and characteristics can be re-established (Collinge 2003; Starr 2004).

Solitary Bees. Solitary bees appear to be important pollinators of vernal pool plant species. The factors affecting the distribution and abundance of these native bees are poorly understood. The nesting habitat of the bees is also not well known. The nests are assumed to be constructed in bare areas such as along trail edges or between the clumps of native bunchgrass.

Delta Green Ground Beetle. Much about the life cycle of the delta green ground beetle is speculation and is based on observations of similar species. The delta green ground beetle is believed to produce one brood per year. The number and locations of eggs that are laid are unknown. Similarly, the timing and location of pupation are not known. The precise timing of emergence from the pupa is also a matter of speculation and the occurrence of diapause for pupae is inferred.

The effect of livestock on the insect fauna of vernal pools is not known. Livestock result in fertilizing pools, trampling the species within and beside the pools and increasing suspended sediment within the pools, and cattle consume the plants that occur within the pools. Cattle drinking water from the pools may result in the pools drying quicker but trampling may maintain the compaction of the pool bottom and thereby lessen seepage from the pool.

California Tiger Salamander An important critical assumption in the conservation of this species is the ratio of upland habitat to breeding habitat required to support a viable population. Trenham and Shaffer (2005) in an extensive study at Olcott Lake in Solano County found that juveniles were almost as abundant 2,200 feet from the pond as they were adjacent to the breeding pond. Adult abundance declined as distance from the breeding pond increased, but were still present 2,200 feet away. From this study, it was determined that a 330-acre block of undeveloped upland habitat would be required around a breeding pond to support a viable population of California tiger salamanders. There is a considerable amount of uncertainty around the upland habitat requirements for this species. The conservation measures and management pertaining to upland habitat requirements for this species should be reevaluated upon release of additional information.

Issues Relating to Livestock Grazing. California tiger salamanders appear to be very successful in stock ponds with high turbidity and low biodiversity (i.e. very little vegetation and aquatic invertebrates). However, this environment does not manage for other sensitive species. The average lifespan of a natural vernal pool (1,000s of years) is much longer than that of stock ponds (100s of years). In the conservation measures and management for this species, the assumption is being made that natural vernal pool complexes are more important for the long-term recovery of the species than stock ponds.

In general, grazing is compatible with their existence, and, at proper levels, may even enhance their populations. It is the lack of grazing or allowing cattle to draw down water levels at critical developmental stages that is detrimental to this species. A grazing regime appropriate for the enhancement of this species will be incorporated into the management plans for planned reserves and will be re-evaluated annually based on the results of proposed monitoring activities.

Disease. Several wildlife species and domestic animals have been killed in large numbers in the past 10 years by emerging diseases. Emerging diseases are those that have increased in incidence, virulence or geographic range, have shifted hosts or have recently evolved new strains. Specifically, disease has been implicated as a factor in the decline of amphibian populations worldwide. There is a lot of uncertainty around which diseases may affect California tiger salamanders and how these diseases may work synergistically with other factors of decline. The factor of disease was incorporated into the model with the understanding that at present, we do not know how disease impacts the different life stages but that it inevitably plays a role in population dynamics and further research is required in this area to successfully manage for this species.

Current Management and Monitoring Practices. Several reserves and preserves are already established within this Natural Community (ex. Jepson Prairie Preserve, Calhoun Cut Ecological Reserve, Wilcox Ranch and the Elsie Gridley Mitigation Bank) and have either established Adaptive Management and Monitoring Programs or are currently developing one.

The Jepson Prairie Preserve and the Calhoun Cut Ecological Reserve are currently in the process of updating their management and monitoring plan, incorporating the findings of recent research projects. The primary management goal for the Jepson Prairie preserve is to preserve, protect, and enhance vernal pool grassland habitat for native plants and animals. The principal threat to native upland and vernal pool vegetation at the Jepson Prairie Preserve are nonnative invasive weeds such as medusa head grass (*Taeniatherum caputmedusae*), yellow star thistle (*Centaurea solstitialis*), perennial pepperweed (*Lepidium latifolium*) and others. On the Jepson Prairie Preserve, carefully managed sheep grazing is used as an essential tool in weed control. On going adaptive management and monitoring efforts are directed towards continuing to understand the best stocking rates and seasonality of grazing to support the preserves primary management goal. Each spring they spend several days monitoring the cover and distribution of numerous native and nonnative species that represent larger plant guilds such as annual forbs, perennial grasses, etc. Tracking plant distribution and the spread of weeds is a critical component of the monitoring plan. They have recently (starting in 2004) begun a three-year study funded by the California Bay Delta Authority and the Bureau of Reclamation/SCWA Endangered Species Conservation Grant Program to help answer the question of how present grazing regimes affect the native and nonnative vegetation and to test new and hopefully improved methods.

The Jepson Prairie Preserve also uses prescribed burning to control widespread weeds such as medusa head grass. Prescribed burns are conducted each year late in spring (conditions permitting). The burning schedule is science-based and timed to occur after the native grasses has dropped its seed and before the nonnative medusa head grass drops their own seed. By destroying the nonnative seed bank, they hope to eventually eliminate this highly competitive species from the preserve. Once completed, the Adaptive Management and Monitoring Plan for Jepson Prairie Preserve will likely provide a good standard for other management plans in the region.

Two proposed vernal pool mitigation banks in Solano County: the Elsie Gridley Mitigation Bank and the Muzzy Ranch Mitigation Bank are currently developing adaptive Resource Management and Monitoring Plans (LSA 2005; LSA 2004d). Both the Elsie Gridley Mitigation Bank, located in eastern Solano County adjacent to the Solano Land Trust's Jepson Prairie Preserve, and the Muzzy

Ranch Mitigation Bank located in central Solano County, support vernal pool grassland complexes with a number of associated rare, threatened and endangered plant and wildlife species. These plans provide additional examples of currently proposed practices for vernal pool reserves in Solano County.

The resource management plans (RMP) for these sites establish goals, priorities and tasks to monitor, manage, and report regarding vernal pool grasslands and associated species on the site (LSA 2005). The primary management goal of the adaptive management plans is to protect and/or enhance the biological values of the vernal pool grassland ecosystem by maintaining habitats that support native plants and animals associated with this ecosystem, including special-status species. Specific management goals intended to achieve this primary goal are: minimizing the accumulation of thatch from annual grasses, reducing the occurrence of noxious weeds, maintaining and enhancing hydrological integrity of preserved and restored wetlands and preventing accelerated erosion, and expanding the population levels of special-status species and other native plants and animals on the site. The management prescriptions that will be implemented to achieve these goals are livestock grazing, weed control (herbicides, manual removal and mowing), and possibly prescribed burning. Implementing prescribed burning is not currently planned at the sites because of the complexity and difficulty in obtaining permissions for the burns, but the Resource Manager will explore opportunities for implementing appropriately-timed controlled burns with local fire control agencies and associated organizations in the future. Livestock grazing will be the primary management tool that will be implemented to reduce thatch and exotic plants.

Key Monitoring and Adaptive Management Issues from Conceptual Model. The most important and universal pressures affecting valley floor grassland and vernal pool habitat within potential preserves and reserves include nonnative species (including introduced annual plants and invasive weeds), hydrology (onsite changes due to increased annual plant thatch and offsite concerns associated with urban and agricultural runoff), water quality (including chemical contaminants and eutrophication), soil, fire and weather. The severity of surrounding land use practices such as urbanization and the consequences of the land use practices on preserves/reserves will vary depending on site specific conditions. For example, preserves within the Jepson Prairie are less affected by surrounding landscape practices (grazing) than Contra Costa goldfield areas that are surrounded by urban development. Because the relative importance of each pressure will vary depending on the location and species present on each reserve/preserve, reserves/preserves established for the HCP will need to identify and prioritize potential threats in their resource management plans.

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