Report of Science Advisors

Solano County
Natural Community Conservation Plan
Habitat Conservation Plan

November 2002

Reed Noss (Lead Reviewer and Editor), Ronald Amundson, Dick Arnold, Michael Bradbury, Sharon Collinge, Brenda Grewell, Richard Grosberg, Lester McKee, Phil Northen, Christina Swanson, and Ron Yoshiyama

Facilitators: Bruce DiGennaro and Vance Russell

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EXECUTIVE SUMMARY

The authors of this report were assembled as science advisors to offer independent review of the scientific aspects of the Solano County Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP), which is being prepared by the Solano County Water Agency and other applicants (herein collectively referred to as applicants). According to the scope of work for our review, we were "convened to provide expert opinion, scientific information, and data analysis," and "may also be asked to provide technical guidance that arises during the plan development." The three tasks we were specifically charged with completing were 1) a review of background information; 2) attendance of a two-day science workshop and orientation; and 3) preparation of a "written summary report that presents conservation and management guidelines for the Solano NCCP/HCP."

Because the NCCP/HCP for Solano County is a regional plan, we concentrated on conservation issues that are relevant at this broad scale, many of them related to landscape ecology. As a global hotspot of biodiversity that is highly fragmented and modified by human activities, Solano County offers tremendous opportunities and challenges for conservation planning. We emphasize the utility of considering the historical conditions of the landscape as a model for present-day conservation and restoration. Although we think the planning process for the County is off to a reasonably good start, we recommend increased consideration of landscape linkages (especially because further fragmentation and loss of connectivity in the County is highly likely); attention to species that may not be listed by federal or state authorities but which are important for other reasons; and careful scrutiny of databases used in the planning process, particularly the California Natural Diversity Data Base (NDDB).

We summarize the recommendations of our report below. Rationales for, and further descriptions of these recommendations are contained within the body of the report.

- Reserve designs should conserve and restore historic gradients between wetland and upland habitats. In particular, reserve planning should include opportunities for conservation and restoration of historic gradients of tidal marsh to vernal pool and native grasslands. Habitat linkages between Suisun tidal wetlands, low terrace – Suisun region vernal pools, and the Greater Jepson Prairie Ecosystem should be emphasized.

- Increased traffic and upgrades of roads, such as Highway 12 west of Fairfield, threaten to permanently isolate populations of many species on either side. Develop design standards, for example elevated roadways, to accommodate wildlife movement and hydrologic connectivity across roads.

- Target native predators, such as coyote, for conservation as indicators of intact food webs and as potential keystone species (i.e., species whose impact on the ecosystem is disproportionately large)

- Analyze and map habitat type and quality within open space reserves before considering their potential contribution to landscape-level reserve design.

- Identify areas of native grasslands and include them in the reserve designs. Propose strategies for restoring non-native grasslands back to native grasslands, where possible. It may be useful to designate grazed and cattle-free or low intensity grazing reserves for multiple species conservation. Although cattle and native ungulates may coexist on grazing lands, the conservation plan should consider open spaces reserves where native herbivores are free from competition with cattle.

- Preserve some floodplain areas with natural or near-natural inundation frequency and magnitude. Floodplain inundation is a necessary ecological dispersion mechanism for some species and has the added benefit of reducing flooding in downstream areas.

- Address the need for regional recreation opportunities on open space lands, while limiting human activities around and within sensitive reserves for protection of target species. We suggest the Plan identify sanctuary areas closed to all human activities and establish transitional zones with increasing levels of human use with distance from core areas. These measures are especially important for protection of clapper rails, but apply to many of the target species.

- Many "riparian" habitats within and near cities and in agricultural portions of the county are very narrow (i.e., only 1 or 2 tree canopies wide, at most) and are often characterized by non-native trees and shrubs. We suggest these areas be categorized and mapped as a separate habitat type, perhaps "degraded riparian" to distinguish it from the remnant riparian woodland (and riparian scrub) that has a greater diversity of native species and habitat values.

- Because of the high level of spatial variation in vernal pool plant communities across the county, conservation efforts should include representatives of the different plant communities in order to prevent further degradation of biological diversity.

- Fine-scale variations in Contra Costa Goldfields (*Lasthenia conjugens)* characteristics suggests that conservation efforts should consider potential differences among populations within the species range and include adequate representation of each local population in reserves.

- Because only two populations of Colusa grass (*Neostapfia colusana*) are known to occur in Solano County and because Colusa grass is threatened by conversion of habitat to agricultural uses, development, over-grazing, and non-native plants, conservation efforts should emphasize protection of both remaining populations in the county.

- Further research is recommended for both Colusa grass and Solano grass (*Tuctoria mucronata*) to learn more about their distribution and abundance in relation to vernal pool characteristics throughout Solano County.

- The Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) is an important target species for the Plan because it is a Solano County endemic that is vulnerable to extinction. It is threatened by habitat fragmentation and loss, conversion of historic tidal wetlands to managed seasonal waterfowl habitat, and secondary impacts from urban development.

- Soft bird's beak (*Cordylanthus mollis* ssp. *mollis*) is a San Francisco Estuary endemic vulnerable to extinction. Current research suggests it plays an ecologically significant role in tidal wetlands. Hispid bird's beak (*Cordylanthus mollis* ssp. *hispidus*) is a California endemic known from only one location in Solano County and a total of four sites in California. There is speculation that hispid bird's beak is not more widespread in the seasonal alkaline wetlands of Solano because of grazing pressure, but the cause of rarity for this species is unknown. Research on this question is needed.

- Develop additional information on sensitive plant species such as critical life stages, dispersal characteristics, potential corridor use, genetic integrity, and critical interspecific interactions.

- For burrowing owls to survive in the County, they will require the preservation and restoration of large, contiguous tracts of natural grasslands with terrain modifications for burrows and managed for burrowing mammal (especially California ground squirrel) use. Moderate-level cattle grazing may also be required. There is an opportunity to fold burrowing owl needs into the vernal pool and grassland preservation areas with minor management adjustments.

- A map with Swainson's hawk nest sites overlaid on current agricultural land use is needed to identify the most important agricultural lands to preserve.

- Keep unobstructed corridors of natural habitat between pools for conservation of California Red-legged Frog (*Rana aurora draytonii*) and protect breeding areas from invasion by the non-native bullfrog (*Rana catesbeiana).* New development or agricultural activity adjacent to red-legged frog habitat should remain free of artificial ponds and streams that could be invaded by the bullfrog.

- If guarantees can be made that a large percentage of agricultural lands will remain with appropriate crop types, (alfalfa, tomatoes, other specific row crops), it is likely that the Swainson's hawk population will remain at its current population level, and may increase to a level which meets recovery standards.

- An appropriate framework for conservation management of steelhead would include the concept of a metapopulation comprising source and sink subpopulations, as

outlined by the National Marine Fisheries Service (NMFS white paper: "Viable salmonid populations and the recovery of evolutionarily significant units," January 6, 2000; www.nwfsc.noaa.gov/pubs/).

- Annual monitoring of selected streams (Green Valley and Wooden Valley watersheds) over several decades should be conducted to determine the temporal patterns of population variability of steelhead and rainbow trout as well as chinook salmon and other native fishes. Other creeks (e.g., Alamo and Ulatis creeks) also should be sampled at least periodically to determine their use by steelhead, rainbow trout, and salmon during years of favorable streamflows.

- Restoration efforts for Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) should focus on establishing elderberries of all age classes and, where practical, continuous riparian corridors.

- Future developments in urban and agricultural areas should be carried out in a way that minimizes changes in peak runoff, total runoff volume, and seasonality of runoff as a solution to reducing changes to the salinity regimes of tidal areas.

- Future developments should either maintain or enhance groundwater infiltration as one solution for maintenance of crucial dry season / dry year flows and as a contributing factor for maintenance of the riparian zone along creeks.

- Assessments should be done to determine appropriate dry season environmental flows especially in Suisun and Green Valley Creeks but also in Alamo and Ulatis Creeks, and then steps should be taken to ensure that these are met.

- An assessment of historic fauna and flora of Suisun, Green Valley, Alamo and Ulatis Creeks should be done to determine the true baseline. This information should then be used to help determine how, if at all each of these creeks could be restored.

- A scientific study should be conducted to determine the relative magnitude and sources of non-point contaminants so that appropriate management techniques can be selected.

- Should studies or existing data deem it necessary, measures should be taken to reduce the runoff of sediment and contaminants from existing urban and industrial areas and new developments. Measures might include maximizing infiltration, grass swales, retention ponds, and levee setbacks.

- Should studies or existing data deem it necessary, measures should be taken to implement public education programs on the impacts/ use and/ or correct disposal of pet feces, lawn clippings and garden waste, detergents, and garden fertilizers.

- Measures should be taken immediately to improve farm management of sediment and contaminants. The current regime of minimum vegetation cover in rangeland, row

crop, tree crop farming and vineyards is likely contributing to the supply of fine sediment to creek channels. Studies should be undertaken to determine the relative sediment supply from various sediment sources so that appropriate management techniques can be applied.

- Evaluate the use of constructed freshwater wetlands for wastewater treatment to eliminate or reduce the negative impacts of freshwater discharge into Suisun tidal sloughs.

- A more thorough analysis of the population dynamics and population genetics of endemic vernal pool crustaceans should be undertaken, with the aim of determining long-term population cycles and the historic and contemporary interconnectedness of remaining populations of endangered and threatened species (including *Linderiella occidentalis*, *Branchinecta lynchi*, *B. mesovalleyensis*, and *Lepidurus packardi*).

- Maintain existing linkages between vernal pool complexes, and conduct long-term experiments to evaluate the use of restored vernal pools in order to re-establish historical connections.

1.0 INTRODUCTION

As science advisors, we were assembled to offer independent review of the scientific aspects of the Solano County Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP), which is being prepared by the Solano County Water Agency and other applicants (herein collectively referred to as applicants). This is not a completed plan, but rather a plan in progress. NCCPs and HCPs are ecosystem-focused regional conservation plans designed to avoid conflicts between species (and their associated habitats) and economic use or development activities in a manner complementary to resource and regulatory agency endangered species laws and regulations. Both integrate biodiversity conservation with land-use planning. NCCPs are administered by the California Department of Fish and Game and HCPs by the US Fish and Wildlife Service and National Marine Fisheries Service. In most cases, they are developed concurrently for an entire county or region and they incorporate biology, economics, politics, and land use, as pertinent to the plan.

1.1 ROLE OF SCIENCE ADVISORS

The State of California's NCCP Act mandates a process to solicit independent scientific expertise for the development and credibility of each NCCP. The role of science advisors is to establish science-based conservation and natural resource management standards to guide NCCP preparation. According to the scope of work for our review, we were "convened to provide expert opinion, scientific information, and data analysis," and "may also be asked to provide technical guidance that arises during the plan development." The three tasks we were specifically charged with completing were 1) a review of background information; 2) attendance of a two-day science workshop and orientation; and 3)

preparation of a "written summary report that presents conservation and management guidelines for the Solano NCCP/HCP." Given our general mandate, we believe that our most useful function, as science advisors, is to identify the questions, databases, species, and conservation opportunities that the consultants should consider in preparing the NCCP/HCP. It is not our role, for the most part, to supply and rigorously analyze the data (which would require much more time and a larger budget than this review) or to answer planning questions definitively. An implicit objective of our review is to ensure the quality of the data, planning principles, analytic techniques, and interpretation of the results of analyses. We generally do not comment on the goals or outcomes of planning, as these are value-laden policy considerations beyond our purview.

The analysis of conservation needs for the Solano NCCP/HCP will encompass the entire county. As a result, scientific expertise in multiple disciplines is needed in order to integrate the best available science related to each species and the ecosystem as a whole. We were selected by the Solano County Water Agency to conduct this review based on our knowledge of the geographical area and its ecology and/or for our expertise in conservation biology and planning. Collectively, we offer expertise in locally occurring species and natural communities (fishes, birds, reptiles, amphibians, terrestrial and vernal pool invertebrates, plants, vernal pools, grasslands, marshes); key ecological processes and the physical environment (for example, hydrology, soils, natural and anthropogenic disturbance regimes); landscape ecology; reserve design; monitoring; and resource management. We have called upon other experts to supplement our knowledge as needed.

1.2 SCIENCE ADVISORS WORKSHOP

Prior to a two-day workshop we were given an opportunity to consider background material on the planning area, including substantial information on the study region and the species and communities of interest (e.g., LSA Associates 2002) and a set of maps (additional maps of resources in the planning area were provided after our workshop). We were also provided with a list of planning questions (Appendix A) to guide our discussion at the workshop and preparation of the report. These questions were developed by the participating group of resource agencies (California Department of Fish and Game, National Marine Fisheries Service, and US Fish and Wildlife Service) and plan participants in order to guide our work. As noted above, we were not charged with answering these questions definitely—nevertheless, we provide responses to many of them in the body of this report.

We held our workshop August 19-20, 2002, in Vacaville. On the morning of the 19th we were given a motor tour of the plan area. The tour was followed by a presentation on the goals and structure of the planning process from the primary consultant for the Water Agency (Steve Foreman, LSA Associates, Inc.), along with a review of the maps and data we had been provided prior to the workshop. This presentation was followed by a question-and-answer session, discussion, and additional orientation on the planning process and the role of the science advisors. Representatives from the Solano County Water Agency and California Department of Fish and Game attended this first portion of the workshop. After lunch of the first day and for most of the following day, the science

advisors and facilitators met privately to discuss the planning issues and questions and make assignments for the preparation of this report.

Our review of the planning process for the Solano County NCCP/HCP, at this stage in its development, is generally optimistic, although we see several deficiencies and unresolved planning issues that require careful consideration in order to assure that conservation goals are attained. Our comments are meant to help the applicants and their consultants improve the planning process and make it more defensible in the face of public scrutiny. We have strived to make our recommendations consistent with the conservation planning principles of the Natural Community Conservation Planning (NCCP) program and with the findings of recent research in conservation biology and other scientific disciplines.

1.3 REPORT ORGANIZATION

This report represents discussions from the August 19-20, 2002 Science Advisors workshop as well as detailed input provided by each of the Science Advisors regarding their respective areas of expertise. The report has been organized into six sections. Following this introduction, Section 2 - Regional and Historical Context - provides a landscape level overview of Solano County, including major geographical provinces and hydrological characteristics that influence the habitats and species of the planning region. Section 3 identifies significant gaps in information that we feel should be addressed in development of the Plan. Section 4 focuses on key habitat types found in the region and areas of high conservation concern, such as vernal pool ecosystems and riparian habitat. Section 5 - Target Species - discusses the characteristics and needs of specific target species known to exist in the region, particularly species that are very rare, highly vulnerable, and/or of high ecological significance. Finally, Section 6 provides a discussion of some of the dominant threats to biodiversity in the planning region and offers recommendations for countering these threats in the NCCP/HCP, including recommendations regarding reserve design, invasive species, and consideration of ecological processes in conservation planning.

2.0 REGIONAL AND HISTORICAL CONTEXT

The following sections provide a landscape level analysis of Solano County. This includes a contextual review of what is known about the biodiversity of the regional area and an analysis of key geographic, geologic, and hydrologic factors that influence the habitats, physical processes, and biota of the area. Understanding landscape ecological mechanisms is a critical step in effective conservation planning.

It is also useful to appreciate ecological phenomena from a historical perspective. History provides a context for considering the present ecological condition and conservation issues in Solano County, including important ecological system interactions that shape the species communities and biodiversity of the area. This perspective can provide a benchmark for protection and restoration actions as well as a better

understanding of how current, and potential future, landscape alterations may impact or benefit habitat and species conservation.

Although regulatory requirements prescribe a 1999 landscape use/habitat mapping baseline for the Plan, science-based conservation planning and reserve design benefit from a broader historic perspective. The Historical Ecology program at the San Francisco Estuary Institute has compiled a 1770 – 1820 view of baylands and adjacent vernal pool and upland habitats that include much of the Solano County project area: http://www.sfei.org/ecoatlas/Habitat/maps/subregion/hsuis.html)

Historical information of sufficient detail is available to provide a comparative framework for understanding modern habitat conditions in the County and insight into natural ecological and physical processes over a long-term period. It is informative to consider the pre-development distribution and quality of habitat types. The modern pattern of fragmented and degraded habitats should be viewed in the context of the historic distribution and condition of these resources for a complete perspective of the magnitude of habitat change. Only from such a perspective can informed decisions be made.

2.1 BIODIVERSITY OF THE REGION

The Solano County planning region has been recognized as a biodiversity hotspot at both global and national scales, which makes adherence to sound principles of conservation planning and protection of adequate amounts of natural habitat more urgent here than in regions of lesser biodiversity. Chaplin et al. (2000) employed a rarity-weighted richness index to produce a contour map of the United States that highlights areas with large numbers of limited-range species—the peaks of rarity and richness. The Greater San Francisco Bay region, including both coastal and inland habitats, is one of the five highest peaks in the U.S. In a global analysis of biodiversity hotspots, Myers et al. (2000) located 25 regions that together comprise only 1.4% of the earth's land surface, but hold an estimated 44% of all species of vascular plants and 35% of all species of vertebrates. Only three regions in North America—the California Floristic Province, Mesoamerica including tropical regions of Mexico) and the Caribbean (including southern Florida)—are included in these global hotspots. With financial resources and political capital limited, it makes sense for conservation agencies and organizations to direct their efforts largely (though not entirely) to hotspots. Moreover, with so many imperiled taxa, a species-by-species approach will be inefficient and ineffective in Solano County—hence the need to focus on ecosystems and functionally related sets of species (Noss et al. 1997). On the other hand, several species in the County are so highly imperiled or ecologically important that they require individual attention for the foreseeable future. We offer specific information on a number of these species in this report.

Despite its significance as a global and national hotspot of biodiversity, Solano County today is fundamentally a human altered landscape. Natural habitats are degraded to one degree or another and highly fragmented, with disruption of typical dispersal processes. In addition to urban development, agriculture, and roads, hydrological alterations and

invasive species have had profound effects on the structure, composition, and functionality of ecosystems. Despite these impacts, there is still much to save in Solano County. Few places in the nation offer such remarkable challenges and opportunities for conservation planning.

2.2 GEOGRAPHY AND GEOLOGY

Solano County, despite its modest size, lies at the intersection of numerous geographical and geological provinces that, in conjunction with variations in hydrology and climate, has resulted in the formation of unique and (largely because of recent human disturbance) rare biological and ecological conditions. Portions of the west and southwestern regions of the County contain uplands that possess segments of the sedimentary and volcanic rocks of the eastern edge of the central Coast Ranges. Much of the northeastern portion of the region consist of alluvial fill derived from streams draining the uplands of the Coast Range. Finally, the southeastern portion of the County is part of the Sacramento-San Joaquin Delta while the south central portion consists of marshland adjacent to the Suisun Bay and the Sacramento/San Francisco Bay interface. Overlain on this complex and diverse geography is the human imprint, one that first converted much of the alluvial fan landscapes to irrigated agriculture and that drained and converted Delta lands to agricultural Islands and farms. More recently, the growth of cities along the I-80 corridor has added the imprint of urbanization to the County. In summary, Solano County is a small geographical area, possessing a wealth of natural and agricultural landscapes, that faces the intensifying challenge of urbanization ubiquitous to much of the Central Valley region (Sorenson et al. 1997).

Geographical Regions of Solano County

Here we provide a brief description the major geographical provinces of the County using a modified classification scheme utilized by the USDA in the *Soil Survey of Solano County* (Bates et al. 1977). Each major division contains important ecological subdivisions, also described here. This scheme differs from that in the *Biological Resources* section of the LSA Report (LSA Associates 2002), which focuses on habitat classification, but captures the same ecological components. Our intent is to provide a scientifically sound, but not exceedingly complex or controversial, regional classification of the Solano County landscape. Figure 1 provides a graphical depiction of the five major geographical provinces described below.

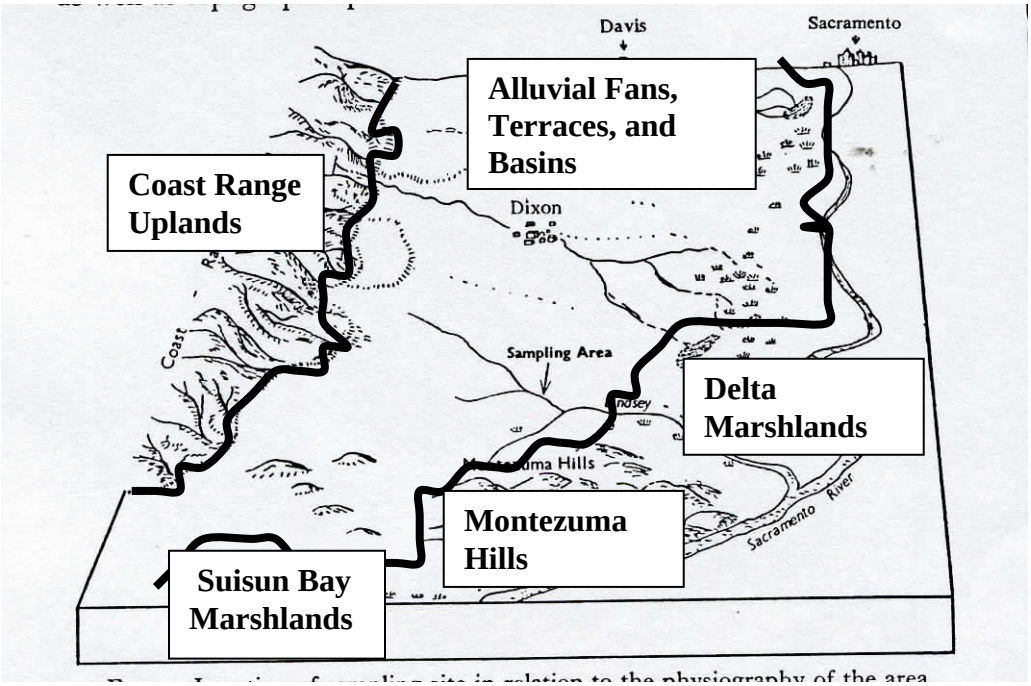

Figure 1. Location of case study of the formation of sodic and saline soils in Solano County. The study was conducted along the eastern edge of the present Jepson Prairie. Note that the figure displays the 3 main geographical provinces outlined in this report: Coast Range uplands, alluvial fans and terraces, and Delta and Bay marshlands (Fig. 1 in Whittig and Janitsky, 1963).

1. Coast Range Uplands and Foothill Terraces

This region, lying in the western margin of the County, possesses a wide range in elevation, bedrock composition, and climate. Elevations range from ~300 to 3,000 feet, and precipitation (which varies with elevation) from 20 to 40 inches per year. Bedrock is dominated by Cretaceous marine sedimentary units, with smaller inclusions of Tertiary sedimentary and basic igneous rocks (geological information here and elsewhere from Wagner et al. [1981] and Wagner and Bortugno [1982]). These units form ridges with intervening narrow valleys that trend in a northwestern direction. Vegetation, which varies with precipitation, contains grassland, oak savanna, oak woodland, and dense chaparral shrubland.

2. Montezuma Hills

While this region, which conspicuously dominates the southeastern portion of the County, might be considered as just another upland component, several factors warrant a separate discussion of its characteristics. The elevation of this area ranges from approximately 25 to 500 feet, and annual precipitation is between 15 and 23 inches. The most distinguishing feature is the bedrock composition: poorly sorted sandy clay sediments of the Quaternary Montezuma formation. This bedrock weathers into exceedingly high clay soils called *Vertisols*. These soils exhibit high shrink/swell characteristics due to the high clay content and the clay composition (dominated by the mineral *smectite*). The Vertisol landscapes of the Montezuma Hills normally experience

deep cracking to 50 cm or more of soil depth, and roads, fence lines, and utility poles are subjected to upheaval and disorientation due to the physical movement of the landscape. This region, because of the soils, is primarily used for dryland farming and grazing, and was likely a perennial grassland, with oaks in higher elevations, in pre-agricultural conditions (Burcham [1957] as cited in Bates et al. [1977]).

3. Alluvial Fans, Terraces, and Basins
This province comprises a significant portion of Solano County and exhibits considerable variability related to local geological and soil characteristics and associated drainage patterns. This province is also the area most heavily impacted by human alterations. Several distinct sub-regions and associated habitats are described below.

A. Well drained to poorly drained recent alluvial fans and basin deposits
This region, lying in the northeastern quarter of the County, comprises the heart of the agricultural development of the county. The sediment consists of loams/silt loams to clays derived from streams draining the Coast Range. Soils are young, lack restrictive horizons, and are amenable to irrigated agricultural development, though drainage or levee systems have been required in the lower basin margin, and basin proper, positions of the landscape. These landscapes generally dip downward in a westerly to easterly direction, and the lands to the east of highway 113 were (prior to channelization) frequently flooded by the Sacramento River.

Dense oak forests reportedly once covered the plains along the major streams (such as Putah Creek) and their fans, with high fans and terraces having more open stands of grass and oaks. Lower lying basin deposits supported tules, reeds, and other water-tolerant plants (Burcham [1957] as cited in Bates et al. [1977]).

B. Well to somewhat poorly drained terraces
With exceptions, this region consists of geologically older alluvial fan deposits that have been incised by streams and are now marginally elevated above the major drainage systems of the region (and the younger deposits described above). The age of the landscapes (Pleistocene) combined with hydrological differences, has resulted in two (in a broad-brush division) distinct divisions of ecological significance:

(1). *Well drained, somewhat acidic, clay pan landscapes*
This area lies mainly northeast of Vacaville. The dense subsurface “clay pan” (formed by long expanses of soil formation and clay development) restrict water penetration, create seasonally-perched water tables, and as in other parts of the state, result in “mima mounds” and vernal pools. In the LSA Report (LSA Associates 2002), this was referred to as “Northern hardpan vernal pools,” presumably from a Holland (1986) map. Because the Solano Soil Survey (Bates et al. 1977) reports no hardpan soils (at least as major components), but does report clay pan soils of the Corning series, it might be best to redefine this area as *clay pan* based on surveyed soil types. This has probably little biological significance

since clay pan and hard pan soils on these landscapes generally result in similar vernal pool habitats peculiar to these old landforms.

(2). *Well to somewhat poorly drained, alkaline landscapes*
This area lies mainly to the north and northwest of the Montezuma Hills and includes the Jepson Prairie and much of the Travis Airbase. Briefly, these landscapes, due to their proximity to shallow ground water from the Delta (to the east) or the Suisum Bay (to the south) have experienced long-term evaporative loss of this water and the subsequent accumulation of dissolved salts. Salt types in the soils are separated by solubility and the generally upward water flow patterns (modified by the downward flow of fresh rainwater) (Figures 1 and 2).

As a result, soils contain significant amount of $NaHCO_3$ and other salts leading to high pHs (>8.3) in some soil horizons (not necessarily to the surface), and sometimes have high salinities (total salt content). Most of these soils have a clay-enriched subsoil (or clay pan) that restricts water movement.

Much of this area has escaped intensive agricultural development due to the combined problems of salinity, alkalinity, and clay pans. However, in many parts of the Central Valley (Fresno county as an example), soils like these are rapidly being converted to irrigated farmland through the use of deep tillage, chemical amendments (to remove Na), and heavy irrigation.

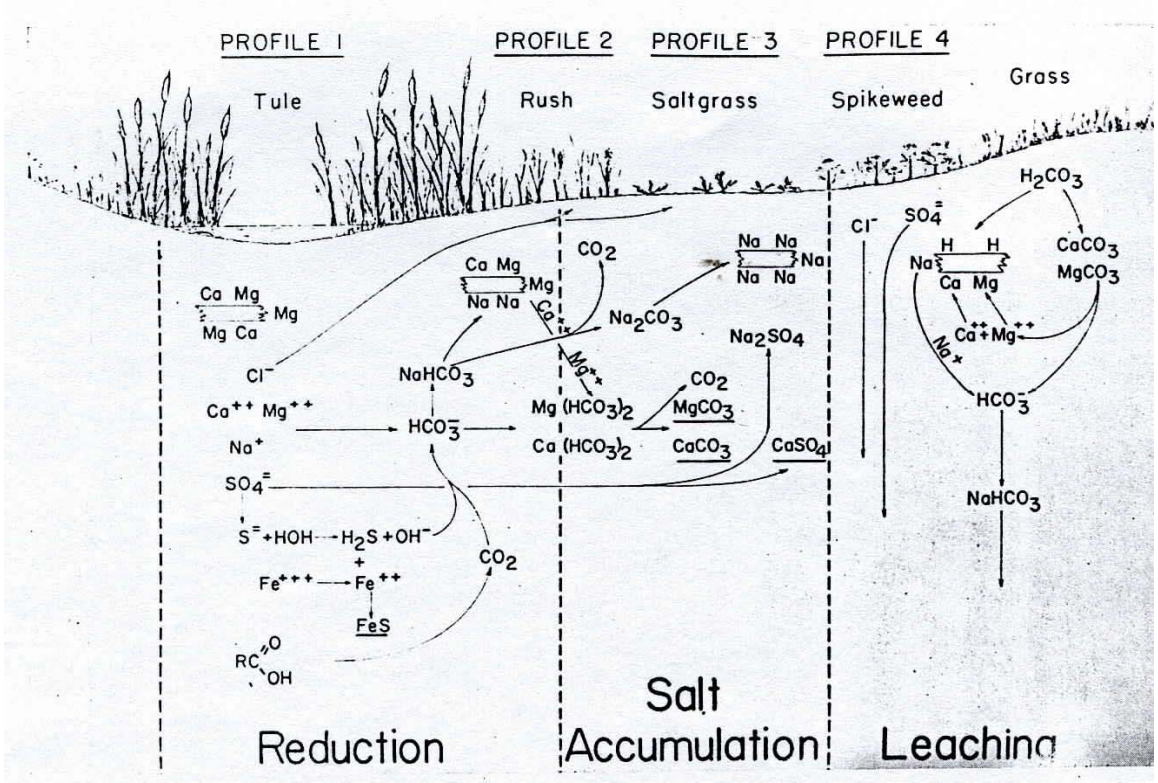

Figure 2. Schematic representation of the movement of salts and their interaction with clay particles along a gradient from a freshwater marsh toward higher topographic

positions. Profile 3 might be roughly correlated with the Pescadero soil series and Profile 4 with the Solano series. (Figure 3 in Whittig and Janitsky, 1963).

4. Delta Marshlands

This area, which lies roughly to the north and northeast of Rio Vista, contains a part of the prominent Sacramento-San Joaquin River Delta (locally known simply as the "Delta"). Prior to human disturbance, this was a freshwater marshland dominated by river distributary channels and dense "tule" vegetation. The dense vegetation, combined with slow baselevel (sea level) rise, led to the accumulation in parts of the area of thick peat deposits (only small parts of the Solano County Delta have peat soils), and in the predominantly mineral-rich lands that dominate the fringe of the Delta in Solano County, relatively high organic matter content.

The combined stabilization of river distributaries through levee building, and the installation of large pumping plants, tidal gates, etc. have succeeded in lowering the ground water table and have allowed the establishment of agriculture in the region. As a result of the drainage, much of the landscape has subsided (due to peat oxidation and compaction) and is now up to 10 feet or more below sea level.

Almost this entire area has been converted to agriculture. A small area near Cache Slough is shown to remain undisturbed on LSA land use maps and a few areas within river distributary channels remain as riparian zones, though the degree of alteration of these areas is unknown.

5. Suisun Bay Marshlands

Located adjacent to Suisun Bay, the Suisan Bay Marshlands, like the Delta Marshlands is also technically a deltaic environment. This marshland was formed in part from sediment from local streams as opposed to the main Central Valley drainage and is in contact with more brackish waters than the marshlands to the east. Tidal marsh formation within the San Francisco Estuary was initiated about 10,000 years ago during the Holocene submergence when sea water flowed into the Golden Gate, and the rate of sea-level rise slowed sufficiently for tidal marsh sediments to accrete near sea level (Atwater et al. 1979). Prior to that time, the Estuary consisted of broad stream valleys far above glacial low sea level. Following European settlement, huge influxes of sediment associated with hydraulic gold mining in the Sierra Nevada also contributed to areas of rapid marsh growth (Hedgpeth 1979). The Suisun Marsh region of Solano County has the most complex origin within the San Francisco Bay-Delta System, and is a composite of tidal wetlands with estuarine and riverine origins (Wells 1995).

The more saline waters that fringe the land in this area have created somewhat differing environmental and ecological conditions. First, it contains mappable areas of peatland: Wheeler Island, Van Sickle Island, and Chipps Island, as well as a region south of Suisun City. Second, many of the non-peat soils are both strongly acid and saline. The acidity arises from the oxidation of pyrite (or other iron sulphides) as a result of human water table lowering and the change from reducing to oxidizing conditions, creating sulfuric

acids and distinctive reddish and yellow-red oxidized Fe colors. The vegetation in this area consisted of tules, reeds, and salt-tolerant grasses and forbs.

2.3 CLIMATE AND HYDROLOGY

The climate of Solano County varies spatially depending mainly on the effects of topography on rainfall distribution. The lowland areas of the County can be classified as semiarid (10-20 inches [254-508 mm] of annual rainfall and 0.3-5 inches [7.6-127 mm] of annual runoff). The upland areas tend toward a subhumid rainfall-runoff regime (20-40 inches [508-1,016 mm] of annual rainfall and 3-20 inches [76.2-508 mm] of annual runoff) (Rantz 1971, 1972). Climate and hydrology have undoubtedly played a role not only in the distributions and success of key native and invasive flora and fauna but also in the distribution of agricultural and urban land use.

Today, the majority of urban development occurs on or downslope of the alluvial fans of the Vaca Mountains or conversely on the upslope side of the seasonal and tidal floodplain wetlands, the interface between the semi-arid and sub-humid climatic zones. There are also urban and rural residential developments on the valley floors of most of the small watersheds but especially in Suisun and Green Valleys. The most intensive agricultural land use occurs on the fertile seasonal and tidal floodplain areas, although there are vegetables and tree crops grown on the valley floors of Ulatis and Alamo Creeks and vegetables, tree crops, and grapes grown in Suisun and Green Valleys. In terms of hydrology, the location of development has necessitated the modification or development of drainage channels that are capable of transmission of runoff from the higher rainfall Vaca Mountains and uplands through the urban and transportation corridors and across the seasonal wetlands (now largely agricultural lands) to the sloughs and estuary.

It is important that the NCCP/HCP adequately portray the watershed as a connected system. The Sacramento – San Joaquin Delta - San Francisco Estuary is a single, hydrologic system. Hence, development within the Vallejo - Fairfield – Suisun – Vacaville development corridor will inevitably impact the hydrologically connected West Delta, Suisun, and Napa River/San Pablo Bay tidal wetlands and receiving waters.

In a regional context, the Bay Area may be considered a midpoint between the wetter coastal climatic zone to the north and the drier coastal zone to the south, and as such displays dramatic regional diversity in both flora and fauna that is enhanced by a complex tectonic geology and local and regional climatic gradients. The Bay Area population (sum of the nine Counties[1]) rose by 15% during the period 1990-2000 and is projected to be eight million by the year 2020 (ABAG 2002). Within the Bay Area, it is the transitional zones between the uplands and the Baylands and the Baylands themselves that have come under the most pressure from development both now and historically and it is these habitats and the flora and fauna that occupy them that are most in danger of extinction (Goals Project 1999).

[1] San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, Marin

In the hydrological, water quality, and habitat context, Solano County cannot be considered uncharacteristic of the Bay Area in general. General (philosophical and scientific) concepts on how preserve and enhance the natural and modified habitats found within Solano County as well as specific measures to conserve either habitats or specific species are likely to be regionally applicable and will have regional consequences.

3.0 DATA GAPS AND RESEARCH NEEDS

We compliment the consultants for providing extensive GIS-based habitat maps and biological resource background information as a starting point for this planning process. We are concerned, however, that some of the existing information is not of sufficient detail or focus to facilitate science-based conservation planning and reserve design. We highlight a number of notable data gaps below. Efforts should be made to address these gaps in further developments of the Plan.

3.1 HABITAT QUALITY

There is a wide range of habitat quality represented by existing conservation and open space lands, including significant areas of degraded habitat. The existing background information and Revised Existing and Planned Open Space Lands GIS map include all public-owned open space and conservation areas without specific indication of habitat quality, degree of protection, or appropriateness for conservation of sensitive habitats and species of concern. This information in its current form is potentially misleading and could result in inappropriate planning or mitigation actions.

For example, the large area of "conservation lands" mapped on Grizzly Island, Island Slough, Joice Island, and diked portions of Hill Slough wetlands within the Suisun Marsh are Department of Fish and Game wildlife management areas where the management emphasis is on wintering waterfowl habitat and public hunting opportunities. These diked wetlands have replaced historic tidal marsh habitat and displaced endangered species; their management requires a take permit under the federal Endangered Species Act.

A preferred approach for conservation planning is to analyze and map habitat type and quality within open space reserves before considering their potential contribution to landscape-level reserve design.

3.2 PLANT SPECIES ACCOUNTS

The species accounts for birds and mammals incorporate information from a variety of sources, and many of these accounts provide valuable information for conservation planning. We are concerned, however, that the individual plant species accounts are based on a fast-retrieval approach from the California Department of Fish and Game's Natural Diversity Database (NDDB) and California Native Plant Society records. Incomplete representation of clapper rail and short-eared owl occurrences suggests that planning maps for birds and mammals also were derived solely from NDDB records.

NDDB record submittals are voluntary and include occurrence records from a range of qualified and less qualified scientists, resource managers, consultants, and volunteers. Location data from scientific surveys are likely to be the most accurate information, but taxonomic errors and misinterpreted threats, habitat, and species information sometimes occur in these records. The NDDB database provides an indication of what sensitive species may be in a project area. It is not intended to be a comprehensive scientific survey or to provide biological information at the level of detail needed for environmental impact analysis.

Occurrence data provide a starting point for development of a conservation plan. The applicants should attempt to improve the quality of science provided for this process. There are substantial gaps in scientific data and understanding of the ecosystems and individual species. We suggest that the evaluation of sensitive plant species is largely inadequate for conservation planning. Important planning information such as the location of locally extinct vs. extant records of sensitive species, and data quality is masked on the GIS maps. Information on such issues as critical life stages, dispersal characteristics, potential corridor use, genetic integrity, and critical interspecific interactions would enhance the success of the Plan.

3.3 RESEARCH NEEDS FOR GRASSLANDS

As discussed by LSA Associates, Inc, the upland grassland community was formerly characterized by bunchgrasses, but now is generally dominated by non-native annual grasses and forbs as a result of grazing and other land uses. Nonetheless, small pockets of native-dominated grasslands still remain in few hilly areas, such as portions of the Sky Valley and in the Pleasant Valley.

Research activities should focus on vegetation management and restoration activities to re-establish bunchgrasses as the dominant plants in areas that are now dominated by annual grasses. For example, grazing may be an appropriate management tool, but the timing and intensity of the grazing needs to be fine-tuned to favor the re-establishment of bunchgrasses. A combination of grazing, fire, mowing, and other techniques should be tested. Cooperative agreements with willing ranch owners should be pursued to expand the acreage of protected grasslands at the Jepson Prairie and elsewhere in Solano County.

3.4 RESEARCH NEEDS FOR RIPARIAN WOODLAND

Sambucus mexicana, the food plant of the Valley elderberry longhorn beetle, also grows as an understory and edge species in the riparian woodland plant community, even in places where the shrub component of the woodland is not well-developed. Examples of this phenomenon are in the hills in the northwestern portion of the county.

Many “riparian” habitats within and near cities and in agricultural portions of the County are very narrow (i.e., only 1 or 2 tree canopies wide) and are often characterized by non-native trees and shrubs. These areas should be categorized and mapped as a separate habitat type, perhaps “degraded riparian” to distinguish it from the remnant riparian

woodland, and riparian scrub, which have greater diversity of native species and habitat values.

Research activities should focus on re-establishment of riparian vegetation along drainages in the County where riparian vegetation formerly occurred. This will require the cooperation of private landowners and public agencies to secure suitable sites and to alter their current land use activities to cooperate in the restoration of riparian woodland habitat. Cost-effective methods to eradicate and control invasive plants, plus propagation and cultivation techniques for plant taxa used for restoration, should be determined.

3.5 RESEARCH NEEDS FOR VERNAL POOL PLANT COMMUNITIES

Despite their ecological and evolutionary uniqueness, vernal pool ecosystems remain relatively little studied. Important research needs in the context of this HCP/NCCP effort include 1) responses of vernal pool plant communities to various management regimes, including grazing, burning, and mowing. Research efforts should focus on the temporal and spatial dimensions and intensity of these management regimes. 2) For most vernal pool plant species, we have too little information on population dynamics, taxonomy, species interactions, and connections to regional habitats to carefully quantify the probability of long-term persistence. 3) The extent to which vernal pool plant communities can be restored is still unknown. Most efforts to restore vernal pool ecosystems have failed to mimic natural systems (e.g., DeWeese 1998), although research is underway at Travis AFB that will contribute to our understanding of the factors that influence success or failure of restoration efforts (Collinge, *unpublished data*).

3.6 RESEARCH NEEDS FOR TIDAL WETLAND COMMUNITIES

The tidal marshes of Solano County are poorly understood in terms of modern and historic plant species composition, vegetation community dynamics, and the interactions between vegetation and geomorphic and hydrologic processes. There are substantial gaps in the scientific data and understanding of the ecosystems and individual species. Research that would support conservation planning for this ecosystem includes 1) Suisun thistle: basic biological research on the life history characteristics, population dynamics, species interactions, and response to management (hydrology, water quality) regimes; 2) Endangered plant – invasive plant interactions and control methods. *Lepidium latifolium* invasions threaten several endangered wetland plant and animal species, and will compromise wetland restoration efforts in Solano County. Applied research on the species and community consequences of potential control measures are needed. 3) research directed toward the restoration of biogeochemical function is paramount to the restoration of tidal marsh communities, as most tidal wetland restoration efforts have failed in this regard; and 4) a complete classification and description of wetland types considering landscape position, hydrogeomorphology, biogeochemistry, and vegetation (see Ferren et al. 1996) is needed to understand and conserve Solano County wetland diversity.

3.7 RESEARCH NEEDS FOR ANADROMOUS SALMONIDS

Steelhead and fall-run/late-fall-run chinook salmon in Solano County are near the boundaries of the coastal and Central Valley ESUs for both species. It would be useful to clarify the genetic relationships of anadromous salmonids in Solano County streams to those ESUs—i.e., to determine if the fish belong primarily to one or another of the currently defined ESUs. Studies also are needed to document the temporal changes in population composition of steelhead-rainbow trout vis-à-vis the steelhead and rainbow trout phenotypes. Potential causal relationships between changes in population phenotypic composition and environmental factors need to be clarified. Also, the extent to which juvenile steelhead-rainbow trout and juvenile chinook salmon utilize non-natal streams for rearing should be determined. Factors that affect the survival and growth rate of juvenile salmonids in those streams should be evaluated.

3.8 RESEARCH NEEDS FOR AMPHIBIANS AND REPTILES

Information exists on metapopulation dynamics of the California tiger salamander for a hilly area along the California coast (Trenham, 1998), but comparative data for the ecosystem types in the Solano County planning area are lacking. It would be valuable to know how far salamanders move from breeding ponds, whether they return to breed in the natal ponds, and the ecosystem properties of the habitats they live in while they grow to maturity. Additional survey information on ponds and vernal pools that may be used for breeding is also necessary to understand more fully the genetic relationships among populations and distribution of the species. Finally, some management regimes may favor the small mammals upon which the species depends better than others, and data should be taken on the salamander and these small mammals as management regimes for vernal pool habitats in general are assessed.

For the California red-legged frog, few data exist on the dispersal patterns and utilized habitats of the frogs, especially the young, and this information may be critical for evaluating the adequacy of terrestrial habitat that surrounds and connects multiple breeding ponds required by the species.

For the foothill yellow-legged frog, western spadefoot toad, and giant garter snake, the most important current need is for more survey information on their distributions in Solano County as a first step in developing questions relating to means of enhancing populations.

3.9 RESEARCH NEEDS FOR VERNAL POOL CRUSTACEANS

Like the highly distinctive plant communities that inhabit the vernal pools of Solano County, relatively little is known for most areas (Jepson Prairie being a notable exception) beyond simple surveys focusing on the presence/absence of endangered and threatened species. In other similar systems through the Central Valley of California, local populations experience dramatic numerical fluctuations over annual and decadal

time frames, sometimes becoming locally extinct, and likely depending on colonization from other pools for re-establishment. As with vernal pool plant species, we have too little information on local and regional population dynamics, species interactions, and historical and recent connections among populations to be assured that any conservation plan will ensure long-term persistence of these species. Both genetic and demographic studies that include all potential habitat should be initiated in order to gain this information. In addition, experimental studies are needed to determine the value of vernal pool restoration and reconstruction as a means to re-establish historic connections among populations and to buffer existing populations against natural and anthropogenic disturbances. Some studies are underway at Travis AFB that target vernal pool plants (Collinge, unpublished data); similar long-term studies at both the population and community levels are needed for vernal pool crustaceans.

3.10 RESEARCH NEEDS FOR HYDROLOGY AND WATER AND SEDIMENT QUALITY

Despite pressures associated with urban, industrial, and agricultural development in the County, the hydrological regime and status of sediment and water quality has not exceeded the tolerance of many key species to the point of extirpation. In that context, careful planning that includes a combination of one-time scientific evaluations and ongoing research and monitoring should be incorporated into the conservation goals. The following research needs have been determined with direct regard to hydrology and sediment/ water quality but these should not be considered holistic or separate from other recommendations:

1. An assessment of historic fauna and flora of Suisun, Green Valley, Alamo and Ulatis Creeks should be done to determine the true baseline. This information should then be used to help determine how, if at all each of these creeks could be restored or maintained. This should rightfully include community consultation to determine what the community wants out of their watersheds. We recommend using the “historical ecology methodology” (Grossinger 2001).

2. Assessments should be done to determine appropriate dry season environmental flows for species of concern (particularly steelhead trout) especially in Suisun and Green Valley Creeks but also in Alamo and Ulatis Creeks. This assessment should ideally utilize an assessment of historical flow regime and land use change to determine what is potentially feasible versus what might be wishful thinking. We recommend using the “historical ecology methodology” (Grossinger 2001) in conjunction with channel habitat assessments and fish population assessment.

If flora and fauna studies, flow regime studies, channel habitat assessments, and fish population assessments demonstrate that beneficial uses are impaired by water quality and/ or quantity, or sediment quality, the following scientific assessments are recommended:

1. A scientific study should be conducted to determine the relative magnitude sources of non-point contaminants so that appropriate management techniques can be selected.

2. Studies should be undertaken to determine the relative sediment supply from various sediment sources (hillslopes, bank and bed erosion, faming, and urban runoff) so that appropriate management techniques can be applied. SFEI is experienced in both of these types of studies and could be approached to take the lead research role or an oversight role.

4.0 SPECIFIC HABITAT TYPES AND AREAS OF HIGH CONSERVATION CONCERN

4.1 VERNAL POOL ECOSYSTEMS

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 clay layer, support a unique biota capable of withstanding and responding to extreme variation in physical conditions. For example, California's vernal pools harbor more than 60 known endemic species of plants and invertebrates (Baskin 1994). Vernal pools were once widespread along the Pacific coast and Central Valley of California (Barbour et al. 1993). 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. In addition to direct habitat loss, many vernal pool ecosystems have been degraded by the invasion of exotic plant species, which contributes to further declines of vernal pool plant species.

Vernal pool ecosystems in Solano County consist of seasonally inundated pool basins and swales embedded in a matrix of undulating grasslands. Critical ecological processes link the pool basins to the adjacent mounds. For example, mounds adjacent to vernal pools provide important upland habitat for solitary bees, which are frequent flower visitors and pollinators of many vernal pool plants. Upland areas also provide refuges for amphibious animals such as spadefoot toads and California tiger salamanders, as well as terrestrial species such as pocket gophers and California jackrabbits. The burrowing activities of gophers during the dry season produce microtopographic variation within pool basins. This fine-scale heterogeneity allows for a greater variety of plant species to thrive in a single pool basin than would be found in a pool with more homogeneous topography. Jackrabbits forage throughout the grasslands and basins and contribute to seed dispersal of vernal pool plant species (e.g., Zedler and Black 1992, Collinge, *unpublished data*).

Historically, vernal pool complexes were widespread in Solano County (LSA Associates 2002), but currently exist primarily at Travis AFB, in the Jepson Prairie Preserve, and in the area between Travis and Jepson. There are smaller pool complexes at several sites north and west of Fairfield, which support populations of the endangered plant, *Lasthenia conjugens* (Contra Costa Goldfields, see Section 5.1) and perhaps relictual populations of several species of crustaceans.

The vernal pool complexes found in different parts of the county differ tremendously in plant and animal species composition. Because Travis and Jepson lie in two different watershed basins (Suisun vs. Montezuma Hills), they exhibit different drainage patterns, different soils, and different levels of exposure to tidal conditions. Plant and animal species composition reflects these differences in abiotic conditions. For example, of the plant species of special concern for this HCP/NCCP, one (*Lasthenia conjugens*) occurs at Travis but not at Jepson, and two others (*Tuctoria mucronata* and *Neostapfia colusana*) are known to occur at Jepson but not at Travis. Because of the high level of spatial variation in vernal pool plant and animal communities across the county, conservation efforts must include representatives of these different plant and animal communities in order to prevent further degradation of biological diversity.

4.2 GRASSLANDS

As discussed in the background material prepared by LSA, the upland grassland community was formerly characterized by bunch grasses, but now is generally dominated by non-native annual grasses and forbs as a result of grazing and other land uses. Nonetheless, small pockets of native-dominated grasslands still remain in few hilly areas, such as portions of the Sky Valley and in the Pleasant Valley. We recommend that the NCCP/HCP identify areas of native grasslands, include them in the reserve designs, and propose strategies for restoring non-native grasslands back to native grasslands, where possible.

4.3 RIPARIAN HABITAT

Riparian habitat borders the edges of rivers, streams, lakes and ponds, forming the transitional ecotone between the stream (or water body) and adjacent upland habitats. Natural riparian habitats are characterized by gradients of light and moisture, lush vegetation, and high biological diversity. Along streams and rivers, riparian habitat functions as an important corridor between coastal (or bayshore) marsh habitats, floodplains, and upland grasslands and oak woodlands. It also provides a diversity of wildlife with food, cover, and breeding sites in close proximity to water. In the San Francisco Bay area, the dramatic decline in riparian habitat area (only 16% of historic riparian habitat area remains; Goals Project [1999]) is correlated with declines in nearly all riparian dependent migratory and resident bird species, many amphibians, and resident and anadromous fishes that formerly used the many streams draining into the San Francisco Bay (Moyle 2002, Goals Project 1999).

Solano County contains all or portions of seven watersheds. Among those that drain into the Suisun Bay (the eastern portion of the San Francisco Bay estuary), the American Canyon Creek, Green Valley Creek, and Suisun Creek drainages are small, low-elevations watersheds. Many of the smaller tributary streams are ephemeral, flowing only during the wet winter and spring seasons. Riparian habitat along the streams of these drainages, while severely degraded in some areas, still functions as an important corridor and some of the streams still support small runs of anadromous salmonids (chinook salmon and steelhead), assemblages of resident fishes including hitch, California roach, prickly sculpin, three-spine stickleback, and Sacramento sucker, and amphibians, including foothill yellow-legged frog and perhaps California red-legged frog. These watersheds also provide important freshwater, sediment, and nutrient input to Suisun Marsh, the largest remaining tidal marsh complex in the San Francisco Bay estuary.

Sambucus mexicana, the food plant of the federally listed valley elderberry longhorn beetle, grows as an understory and edge species in the riparian woodland plant community, even in places where the shrub component of the woodland is not well-developed. Examples of this are in the hills in the northwestern portion of the county.

Many "riparian" habitats within and near cities and in agricultural portions of the county are very narrow (i.e., only 1 or 2 tree canopies wide) and are often characterized by non-native trees and shrubs. We suggest these areas be categorized and mapped as a separate habitat type, perhaps "degraded riparian" to distinguish it from the remnant riparian woodland (and riparian scrub) that has a greater diversity of native species and habitat values. In addition, levee setbacks and other measures should be considered to restore floodplains.

4.4 TRANSITIONAL HABITATS SOUTH OF HIGHWAY 12

There are few places in California where biologically significant habitats interdigitate in such a rich way as in the open lands east of Fairfield and south of Highway 12. Here, estuarine sloughs connect the rich salt marsh habitats of Grizzly Island with the dry grassland and vernal pool habitats in the vicinity of Travis Air Force Base and the Jepson Prairie. Two isolated hilly areas lie on either side of these sloughs. On the west, the Potrero Hills rise above grassland and marshes, and on the east lie the Montezuma Hills.

On the Potrero Hills' northwestern flank, a finger of estuarine marsh extends eastward from marshes of Hill Slough. North of these hills and south of Highway 12 lies an extensive zone of mima mounds, small vernal pools and swales, and two larger pools, at least one of which supports a breeding population of the California tiger salamander. Conservancy fairy shrimp, vernal pool tadpole shrimp, and several special-status vernal pool plants have also been recorded in this area. It contains designated critical habitat for Contra Costa goldfields, Conservancy fairy shrimp, and vernal pool fairy shrimp. Naturalists have observed California ground squirrels and burrows of the American badger. The hills themselves are covered with non-native grasslands, which support wintering raptors as well as a resident fauna.

From the eastern edge of Fairfield east to Shiloh Road, significant wetlands occur on both sides of Highway 12, and the area represents the transition zone from brackish to freshwater pools. Each pool and slough is significant in its potential to support unique species, and records exist for many special-status plants and animals. For example, critical habitats for vernal pool fairy shrimp and vernal pool tadpole shrimp occur on both sides of the highway in this area, and these critical habitats also extend north and south of the road further east, north of the Montezuma Hills. The presence of this transition is itself of great scientific importance because it allows for study of the tolerance limits and relationships of species. Currently, Highway 12 disrupts these patterns, and further development of this highway would remove any possibility of reestablishing natural hydrological contiguity of habitats and the back and forth movement of organisms.

East of Shiloh Road, and principally south of Highway 12, lie the topographically unique Montezuma Hills. Numerous small, gentle hills rise above a network of small swales, most of which support marsh vegetation. A record for bearded popcorn flower exists in one such area. Native wetland grasses have also been noted in these swales. The hills themselves support dryland farming. They are tilled from top to bottom to grow grain crops, and they also support sheep grazing. These hills harbor significant populations of wintering raptors, including the red-tailed hawk, ferruginous hawk, rough-legged hawk, kestrel, peregrine falcon, and prairie falcon. Importantly, there are seven records for burrowing owls. Grizzly Island to the west is known to birders as a hotspot for wintering raptors, and the Montezuma Hills extend the range and foraging opportunities for these birds.

At the base of the Montezuma Hills, flat lands filled with vernal pools and estuarine marshes extend down into the Montezuma Slough and up to the levee of the Sacramento River. Here, there are records for vernal pool tadpole shrimp and three special-status, vernal pool plants. It contains critical habitat for both the Conservancy fairy shrimp and vernal pool tadpole shrimp. Records exist for fragrant fritillary and Carquinez goldenbush in the upland margins of this habitat. Land here is used for hunting, cattle grazing, farming and other human uses, but retains some natural value to support native ecosystems.

4.5 SUISUN MARSH TIDAL WETLANDS

Physical environmental parameters such as landscape position, hydrogeomorphology, and biogeochemistry are often considered in the classification of wetland types (Cowardin 1979, Ferren et al. 1996). We recommend the Plan include a description of Solano County wetlands following Ferren et al. (1996) that groups wetlands with similar ecosystem affiliation and structure and is organized by hydrogeomorphic units or habitats such as estuaries, pools, ponds, streambanks, seeps, springs, and others. This approach will reveal a considerably more diverse assemblage of estuarine, palustrine, and riverine wetlands in the Solano Project area than has been conveyed in the background material. The consultants followed a descriptive approach that conveys dominant wetland vegetation, but does not provide enough information about the type of wetland system to which the vegetation belongs and thus the types of ecosystem functions it supports.

Conservation efforts should consider this diversity of wetland types to facilitate the conservation and recovery of historic biodiversity.

As discussed in the background material (Marshes and other Wetlands) prepared by LSA, more than 90% of the Solano estuarine wetlands have been filled for development or replaced by diked marshes that do not support full historic functions and values. Northern coastal salt marsh (i.e., Holland 1986) is more accurately described as estuarine emergent wetland. Estuarine wetlands occur between non-storm extreme high tide and extreme low tide. They are inundated by tidewater and may be exposed at low tide. Solano estuarine wetlands are bounded by non-tidal palustrine, riverine, or upland habitats above high tide or the influence of ocean-derived salts and estuarine deepwater habitats below low tide. Palustrine emergent wetlands of Solano are found at the edges of ponds, streams, and at fault-associated seeps and springs. These communities are found above the reach of tidal flows at estuarine wetland edges in Suisun Marsh. There are also palustrine seep and spring wetlands within estuarine areas.

Solano estuarine wetlands characterized by vegetation dominated by vascular plants occur in the classes Aquatic Bed Wetland (including rooted and floating vascular types), Emergent Wetland (including nonpersistent annual and persistent perennial types generally considered "salt marsh and brackish marsh"), and Scrub-Shrub Wetland.

Estuarine wetland vegetation is often related directly to the geologic origin, hydrogeomorphic processes, or landscape context in which it occurs. The Southampton and southwestern Grizzly Bay shorelines with adjacent subtidal habitat, mud flats, and low elevation emergent (i.e., salt marsh) vegetation are characterized by a *Spartina foliosa* series. *Spartina foliosa* occupies mudflats at the water's edge at along the Solano shoreline of the Napa River, through the Carquinez Straits to Southampton Bay and the Suisun Reserve Fleet shoreline at Grizzly Bay. Eastward of this point, Solano shorelines are colonized by mixed stands of *Scirpus californicus* and *Scirpus acutus*.

Estuarine emergent marshes with more substantial riverine inflow or at river mouths with perennial flows (i.e. Suisun Slough, Montezuma Slough, interior Suisun tidal channels) are characterized by emergent (i.e., brackish marsh) vegetation below mean water elevation characterized by *Scirpus americanus, S. californicus, Scirpus acutus, S. maritimus,* and/or *Typha domingensis.* Plant species at and above mean high water include those with high salinity tolerance. Significant tidal ranges influence Solano wetland communities more than 80 kilometers inland from the Golden Gate. The interior areas of Suisun Marsh experience only dampened effects of summer coastal fog. The inland reach of the tidal prism, coupled with high evapotranspiration rates of hot, dry Solano summers results in high soil salinity conditions at and above high tidal elevations in Solano that exceed soil salinity conditions observed on the outer coast. *Salicornia virginica, Arthrocnemem* (Salicornia) *subterminale, Cressa truxellensis,* and *Frankenia salina* occupy the high salinity edges. Below this extreme elevation, *Distichlis spicata* has been historically dominant in Suisun wetlands (Mason 1972), but *Jaumea carnosa, Cuscuta salina, Atriplex triangularis, Euthamis occidentalis, Triglochin maritima, Limonium californicum,* and *Grindelia stricta* var. *angustifolia* are all common. The

extreme environmental gradients present within Solano estuarine wetlands support a rich wetland flora with a range of adaptations to flooding and salinity stress. We recommend the review of Baye et al. (2000) for a complete floristic description of the estuarine wetlands.

The invasions of *Spartina alterniflora* and *Spartina densiflora* described in the background material are inaccurate and are not relevant to this Plan, as both are still restricted to Central and South San Francisco Bay and are not present in Solano County (Bossard et al. 2000). *Spartina patens* (not *S. alterniflora* as reported) is at Southampton Bay, Benicia State Recreation Area. This is the only non-native *Spartina* invasion in Solano County to date.

5.0 TARGET SPECIES

The current background materials and species list rely heavily on the California Natural Diversity Data Base (NDDB), which is incomplete and, in some cases, may include species that do not currently exist in the planning area. File records from the Sacramento Field Office of the U.S. Fish and Wildlife Service are sometimes more complete than the NDDB for federally listed species (e.g., clapper rail). We recommend considering the global/state ranking of species, which is available on-line from NatureServe (http://www.natureserve.org/explorer/) in addition to California and federal legal status (which are more politically biased) and California Native Plant Society status (which does not necessarily provide a global perspective).

Based on our collective knowledge of the species of conservation interest, combined with information from the background materials provided to us by LSA, we screened the "Draft List of Special-Status Species and Associated Habitats" and arrived at the following list of species which we believe require species-level conservation measures in the Solano County NCCP/HCP. These species are very rare, highly vulnerable, and/or of high ecological significance in the planning region. There may be a need to add some plants, especially tidal plant species, to this preliminary list (see later discussion of tidal marsh plants):

- Suisun Thistle
- Hispid Bird's beak
- Soft Bird's beak (good indicator species)
- Contra Costa Goldfields
- Colusa Grass
- Solano Grass
- Swainson's Hawk
- California Black Rail
- California Clapper Rail
- Burrowing Owl
- California Tiger Salamander
- California Red-legged Frog

- Giant Garter Snake
- Salt Marsh Harvest Mouse
- Conservancy Fairy Shrimp
- Vernal Pool Fairy Shrimp
- Vernal Pool Tadpole Shrimp
- Mid Valley Fairy Shrimp
- Delta Green Ground Beetle
- Ricksecker's Water Scavenger Beetle
- Valley Elderberry Longhorn Beetle
- Calippe Silverspot Butterfly
- Steelhead
- Spadefoot toad

In addition, the California ground squirrel may serve as a keystone species, and may need individual attention. Pollinators may also be keystone species, and should be identified by species. We recommend the consultants check with Robin Thorp for assistance.

The following are accounts of most of the individual species from the list above, along with a few others, about which individuals in our group are familiar and can offer specific advice:

5.1 PLANTS

Contra Costa Goldfields

Lasthenia conjugens (Contra Costa Goldfields) historically occurred in seven counties in California, ranging as far south as Santa Barbara and as far north as Mendocino, but currently it is known from only 13 populations in four counties (Federal Register 1997). Because of population declines caused by habitat loss, *L. conjugens* was recently listed as endangered under the federal Endangered Species Act (Federal Register 1997). Nine of the 13 known LASCON populations occur in Solano County. The population at Travis AFB is the only population in Solano County that occurs on public land, and eight other populations in Solano County occur within the urban growth boundary of Fairfield (Dains 1995, Federal Register 1997, Vollmar Consulting 1997). Goldfield populations may decline due to direct habitat loss, but also due to habitat degradation, such as chronic disking of sites or other mechanical damage due to heavy machinery. Moderate levels of mowing or grazing in late spring appear to be useful for controlling invasions of exotic plant species into vernal pool basins (Collinge, *unpublished data*).

Vernal pools in Solano County that contain *L. conjugens* are exposed to a variety of soil moisture and salinity conditions. Seedlings grown from seeds collected from different populations may differ substantially in their responses to moisture and salinity conditions, suggesting that these populations may be ecologically unique (Collinge et al., *in review*). These ecological differences may reflect genetic differences among populations. This fine-scale variation in *L. conjugens* characteristics suggests that conservation efforts should consider potential differences among populations within the species range.

L. conjugens is self-incompatible, meaning that it requires insect flower visitors for successful pollination and reproduction. It is also an annual plant, meaning that seed production is the only means of establishing new individuals in the population. Solitary bees in the family Andrenidae specialize on *Lasthenia* flowers (Thorpe and Leong 1998). These bees actively forage during the flowering period of the vernal pool plants, usually April-May, and provision nests that they construct mounds adjacent to vernal pools. Mounds are critical nesting habitat because they do not flood during the winter wet season. Hence, sites that contain pool basins but no adjacent upland habitats may not support viable bee populations. *L. conjugens* seeds are very small (< 5/16" long) and lack structures to enhance long-distance dispersal by wind or water. Jackrabbits, which live in grasslands adjacent to vernal pools and forage in vernal pool basins during the dry season, may contribute significantly to long-distance dispersal by *L. conjugens* and other vernal pool plants (Zedler and Black 1992, Collinge, *unpublished data*). Because of *L. conjugens'* apparently reduced dispersal ability, long distances between vernal pools may effectively isolate populations.

Colusa Grass

Neostapfia colusana (Colusa grass) occurs in Solano County on and near the Jepson Prairie Preserve. The genus *Neostapfia* contains just this species, making this species highly unusual from an evolutionary perspective (Crampton 1976). Little is known about this species except that it tends to occur in large or deep vernal pools and shallow playas under saline/alkaline conditions. Because only two populations are known to occur in Solano County and because Colusa grass is threatened by conversion of habitat to agricultural uses, development, over-grazing, and non-native plants, conservation efforts should emphasize protection of both remaining populations in the county.

Solano Grass

Tuctoria mucronata (Solano grass) is endemic to Solano and Yolo counties (California Native Plant Society 2001) and occurs in similar types of vernal pools as Colusa grass (above). Because both of these species occur in large, deep pools that dry later in the season than do smaller, shallower pools, they grow, develop, and set seed much later in the season than other native plant species in the vernal pool ecosystem. For this reason, they may provide key food resources to native animals. Solano grass is known from only two populations in Solano County, and given its rarity, conservation efforts should emphasize strict protection of both remaining populations. Further research is recommended for both of these unusual grass species to learn more about their distribution and abundance in relation to vernal pool characteristics throughout Solano County.

Suisun Thistle

The Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) is an important target species for the plan because it is a Solano County endemic that is vulnerable to extinction. Suisun

thistle was historically abundant along tidal creeks of the Suisun Marsh (Greene 1892). It is threatened by habitat fragmentation and loss, conversion of historic tidal wetlands to managed seasonal waterfowl habitat, and secondary impacts from urban development (U.S. Fish and Wildlife Service 1995). We are concerned that the species account for Suisun thistle in the background information is incomplete. There are several information sources with more detailed information for conservation planning, including the endangered species listing records in the Federal Register, USFWS Endangered Species program files, and a variety of biological resource reports of the San Francisco Estuary (Department of Water Resources 1994, U.S. Fish and Wildlife Service 1995, Baye et al. 2000).

The primary ecological process necessary for the conservation and recovery of Suisun thistle is maintenance of landscape-level tidal hydrologic networks that include a gradient of first-order tidal creeks to larger tidal sloughs and bays (Fiedler and Zebell 1995). Tidal wetland restoration approaches that include simple levee breaches or set-back levees for fringing tidal marsh will not contribute to the recovery of this species. Historic sedimentation processes that include some mineral soil deposition on tidal creek banks benefit the species, but increased sediment loads from urban runoff and associated invasive species expansions are a threat.

Variation in climate-associated estuarine salinity and tidal regimes appears to enhance the survival of this species. The closed canopy of the dominants in the plant community precludes seedling establishment and survival in wet years, but shifts in community structure in the more open halophyte community during extended droughts and times of higher channel salinity result in greater seedling establishment and population growth. USFWS recovery planning for this species recognizes that continued development in the Fairfield-Suisun area will result in increased urban runoff, freshwater discharges from stormwater and wastewater treatment outflows, and adverse hydrologic impacts resulting from additional flood-control public works projects that could result in extinction of the species.

Maintenance of ecological processes essential to Suisun thistle will benefit other sensitive species. Suisun thistle grows in close association with *Cicuta maculata* var. *bolanderi* (Bolander's spotted water hemlock) reported in early floras as abundant along tidal creeks of Suisun, but now rare (Grewell, unpublished data). *Senecio hydrophilus* is another formerly abundant, but locally rare angiosperm found with Suisun thistle. The tidal creekside vegetation community occupied by Suisun thistle is also utilized as cover and foraging habitat for endangered California clapper rails, threatened California black rails, and Suisun song sparrow.

There is only one population of Suisun thistle remaining in Suisun Marsh (Grewell, unpublished data). This population is spread over a number of occupied patches in the Cutoff Slough tidal marsh of Solano Land Trust Rush Ranch Open Space Reserve and the small tidal marsh on the DFG Joice Island Unit of the Department of Fish and Game's Grizzly Island Wildlife Management Area. The majority of the population is on the Rush Ranch portion of this contiguous tidal marsh. This single remaining population of Suisun

thistle included thousands of individuals during the drought period of the early 1990s (Grewell, unpublished data) The population has undergone a significant decline with a return to normal and above normal rainfall and Delta outflow years. The population has also been directly impacted by the spread of invasive perennial pepperweed (*Lepidium latifolium*), USDA introduction of exotic *Rhinocyllus conicus* (thistle weevil) for biological control of invasive thistles, and destruction of seedlings by recently introduced feral hogs (Grewell, unpublished data). Suisun thistle has been trampled by cattle that regularly break through fences and graze DFG and Rush Ranch tidal wetlands. The population formerly known to the DFG Peytonia Slough Ecological Reserve was impacted when children from the adjacent subdivision in Suisun City set the marsh on fire in June 2001, a secondary impact of urbanization. This fire burned off all wetland vegetation including Suisun thistle, salt marsh harvest mouse habitat and, resulted in the mortality of hundreds of snakes, and destroyed nest sites of sensitive bird species in the tidal marsh. Common emergent macrophytes resprouted from rhizomes quickly after this fire. To date, Suisun thistle recovery has not been observed. The Plan should address the secondary impacts of human pressure on sensitive habitats at the fringe of urban development.

Soft Bird's Beak

Soft bird's beak (*Cordylanthus mollis* ssp. *mollis*) is suggested as a target species for the Plan because it is a San Francisco Estuary endemic vulnerable to extinction (U.S. Fish and Wildlife Service 1995), and current research suggests it plays an ecologically significant role in tidal wetlands (Grewell et al. in preparation). However, the most current and relevant information for conservation planning for this species is not included in the background materials (LSA Associates 2002).

Although soft bird's beak has received protection under the federal ESA, a recovery plan has not been implemented and populations continue to decline on reserve and private lands (Grewell, unpublished data). Soft bird's beak was historically known from tidal marshes throughout the Estuary but is now limited to twelve population sites in Solano, Contra Costa, and Napa Counties (Ruygt 1994, California Natural Diversity Data Base 2002). This hemiparasite occupies a narrow elevation band above mean high water, and maintenance of tidal hydrologic processes is prerequisite for its survival. The species has declined with the fragmentation and fill of more than 90% of regional historic tidal marsh, with the greatest losses at the high marsh – upland ecotone. The majority of extant populations, and the largest known population are in Solano County tidal wetlands, with a few populations in Napa and Contra Costa Counties. Other historic populations in Petaluma Marsh, Suisun Marsh, Carquinez Strait, and the Napa Marsh are believed extinct. The species now occupies approximately half of its historic range. It is threatened by invasive plants (*Lepidium latifolium* and introduced winter annuals), feral hogs, and trampling by cattle (Grewell et al., in preparation). Secondary impacts from urban development include changes in tidal regimes, artificial freshening of tidal water from urban runoff and wastewater treatment discharges, changes in watershed runoff from seasonal to perennial flow, changes in pollinator communities, and increased recreation pressure.

Soft bird's beak is linked to other sensitive tidal marsh species. Threatened California black rails and endangered salt marsh harvest mice have been detected within extant Solano populations, and California clapper rails have nested just down-gradient of soft bird's beak populations in Suisun Marsh (Grewell, unpublished data).

We are concerned that the Plan may dismiss the need for conservation attention for this and other species, as the background information suggests that "most of the large marshes are now parts of preserves or in highly restricted development zones" (LSA Associates 2002) The background material alludes to protection of these areas, which in fact have had little or no funds or management priority for active stewardship. Most of the extant populations of soft bird's beak are in decline due to continued degradation of open space lands. Habitat degradation from the spread of invasive species and secondary impacts of urban development can jeopardize the sustainability of endangered species. Resource managers were directly responsible for the extirpation of the Beldon's Landing *Cordylanthus mollis* population in Suisun Marsh, and have directed the destruction of habitat (fill) of other rare plant populations (*Mason's lilaeopsis* and *Lasthenia conjugens*) in Solano County (Grewell, personal observation, Grewell and Fiedler, personal observation). Apparently, endangered species conservation has not been a priority to all public land managers. Hence, preserve status does not currently ensure adequate protection for sensitive resources on all Solano County open space lands.

Extensive research on the population biology, ecology, and restoration requirements of this species has been conducted by ecologists at UC Davis in cooperation with CALFED (Grewell et al. in preparation). Information on germination requirements, demographic evaluation of critical life stages, host plant community characteristics, important biological interactions, and experimental reintroduction techniques is available for conservation planning. Additional research suggests soft bird's beak plays a significant functional role in the tidal marsh community. The physiological link between soft bird's beak and perennial halophyte hosts results in amelioration of flooding and salinity stress, enhances biogeochemical cycling, and modifies species interactions leading to greater biological diversity.

Hispid Bird's Beak

Hispid bird's beak (*Cordylanthus mollis* ssp. *hispidus*) is a California endemic recommended as a target species because it is known from only one location in Solano County and a total of four sites in California. This annual, hemiparasitic angiosperm grows in saline and alkali soils at the edges of vernal pools, playas, and seasonal ponds, and within alkali sinks. Hispid bird's beak conservation will benefit burrowing owls, as they co-occur in Solano County.

The species account for this plant (LSA Associates 2002) is not accurate. Trampling by cattle, grazing, and disking north of Creed Road to protect grazing land from fire have negatively impacted the only Solano population (Grewell, unpublished data). Disking has directly eliminated large population patches. Conservation of this species must include

maintenance of critical biological interactions, including appropriate host plant and pollinator communities. The closest congener (*Cordylanthus mollis* ssp. *mollis*), and other *Cordylanthus* hemiparasites use a variety of available hosts through haustorial attachment to host plant roots (Chuang and Heckard 1971). Significant seedling mortality of this plant has been observed at the Solano site when hispid bird's beak is closely associated with *Cotula coronipfolia* and exotic annual grasses. If parasite seedlings form host attachments with exotic winter annuals, the host plants die before the parasite seedlings transition to reproductive stage, and the hemiparasites do not survive harsh field conditions or complete their reproductive cycle without host subsidies of water and carbon compounds.

The exotic winter annuals are most common in wetlands with grazing disturbance. There is speculation that hispid bird's beak is not more widespread in the seasonal alkaline wetlands of Solano because of grazing pressure, but the cause of rarity for this species is unknown. Some pond-edge species appear to benefit from grazing, while others may decline. It may be useful to designate grazed and cattle-free or low intensity grazing reserves for multiple species conservation.

Tidal Marsh Plants

Historic floras and herbaria records indicate significant changes in the distribution and abundance of the following tidal marsh plant species:

Cicuta maculata var. *bolanderi* – formerly common tidal creek banks
Glaux maritime – formerly common high to mid-elevation tidal marsh
Pluchea odorata – formerly common tidal creek and slough banks
Rumex occidentalis – formerly common at wetland borders
Senecio hydrophilus – formerly common small tidal creeks

These species, although not considered target species, are now rare in Solano County tidal wetlands, and most are not included on CNPS or NDDB lists of rare species (Baye et al. 2000). These species are locally more rare than other plants that are state-listed as rare or were recognized as former federal candidate species for listing, including: *Lilaeopsis masonii, Aster lentus*, and *Lathyrus jepsonii ssp. jepsonii*. Moreover, these tidal marsh plants are linked with the conservation of California clapper rails, black rails, and Suisun thistle.

5.2 BIRDS

California Clapper Rail

The endangered California clapper rail (*Rallus longirostris obsoletus*) is an appropriate target species because it is vulnerable to extinction and shares tidal marsh habitat with other sensitive species. This rare wetland bird historically occupied tidal wetlands from Humboldt Bay to Morro Bay, but its range is now restricted to the San Francisco Estuary. Populations were so abundant at the turn of the century that hunters boasted of shooting

200 in a day, and San Francisco restaurants hung strings of clapper rails in their windows (Steinhart 1990). A San Mateo newspaper account reported 5,000 clapper rails killed during a single week in the South Bay (Gill 1979). Severely depleted populations showed some recovery after rail hunting was prohibited in 1913 (U.S. Fish and Wildlife Service 1984). Small, fragmented populations of clapper rails at the extreme edge of the modern species range in Solano County may be especially important to the long-term viability of this species. Conservation of clapper rails is linked to the sustainability of other sensitive species such as Suisun thistle. Clapper rails forage and nest along small tidal creeks occupied by this endangered plant. Clapper rails also forage along tidally exposed mudflats within channels of larger tidal sloughs, close to basking sites of western pond turtles. Clapper rails have taken endangered salt marsh harvest mice as prey, and conservation of mixed halophyte communities will protect both species.

The species account provided for this rare bird is extensive, but the information sources are more relevant to clapper rail behavior and occurrence in San Francisco Bay. Small populations of clapper rails have been detected in Solano County every year for the past 24 years, but very incomplete census information for this species is available before this time. Within Solano County, clapper rails utilize cordgrass-dominated communities along the Suisun Bay shoreline near the Reserve Fleet and interior bulrush-dominated tidal creeks and bayshores. Rail foraging and refugial habitat encompasses the entire intertidal zone and the adjacent upland. Within Solano County, clapper rails build cup-shaped nests on the ground in *Scirpus maritimus* and *Salicornia virginica* (Evens and Collins 1992, Collins et al. 1993). Non-native red fox, rats, and feral cats pose a significant threat to the recovery of clapper rails (Foerster et al. 1990). Red fox invaded south San Francisco Bay in the mid-1980s (Foerster et al. 1990), and has now spread throughout Suisun Marsh with the eastern most detection in the estuarine wetlands near Shiloh Road (Solano Mosquito Abatement District, unpublished data).

The background information for the Plan (LSA Associates 2002) does not mention that feral hogs pose a direct threat to clapper rails in Solano. Feral hogs, which prey on eggs of rails and other birds, have been directly linked with local extinctions of several ground-nesting birds throughout the world, including other species of clapper rails. Feral hogs are now present in Solano marshes occupied by clapper rails. Clapper rails also are preyed upon by barn owls that are not native to tidal marsh. Barn owls have been released to Solano tidal marshes by wildlife rescue groups, and reserve mangers have allowed placement of barn owl nesting boxes and open outbuildings at the edge of occupied clapper rail habitat. Barn owls have been observed with clapper rail carcasses in Solano County.

The Breeding distribution of clapper rails is associated with areas that are at least marginally saline. Discharges that alter natural salinity levels in tidal channels adversely affect clapper rail habitat quality, as artificial freshening of channel salinity can degrade the physical environment for salt-tolerant plant species used by these birds (Zedler 1983, Beare and Zedler 1987). Wastewater treatment plant discharges have contributed to measurable levels of toxic contamination in clapper rail eggs (Lonzarich et al. 1992). Emergent vegetation changes associated with wastewater treatment discharges into the

White Slough Wildlife Area of the Napa River at Vallejo are suspected as a cause for decline of clapper rails in this marsh (Evens, personal communication). Clapper rails have abandoned the Southampton Marsh at Benicia State Recreation Area, where freshwater runoff and human recreation pressure have increased with the development of the surrounding uplands (Baumgratz, personal communication). A significant portion of halophytic vegetation formerly supporting clapper rails, salt marsh harvest mouse, and soft bird's beak has now been displaced by freshwater emergent macrophytes and invasive *Lepidium latifolium*.

Breeding populations of clapper rails at the Rush Ranch Open Space Preserve tidal marsh near Suisun City are still detected each year, but the population has declined by at least 80% in the past ten years. Invasive species and public visitation pressure have also increased during the same time period. Clapper rails were known in Peytonia Slough Ecological Reserve near Suisun City, and the 2001 fire in this tidal wetland occurred during the nesting season of clapper rails, Suisun song sparrows, and black rails.

Clapper rails are secretive and sensitive to disturbance. Clapper rails temporarily abandoned the Suisun Reserve Fleet shoreline marsh near Benicia during construction of a new bridge, but a few individuals were detected after construction (Grewell, unpublished data) The U.S. Fish and Wildlife Service restricted levee repair activities during breeding season in the immediate vicinity of clapper rail occupied habitat, but there have been significant violations of these restrictions. Clapper rails are impacted by fragmentation of habitat by trails and boardwalks, and disturbance from increased public access to sensitive habitat.

We recommend that the Plan address the need for regional recreation opportunities on open space lands, while limiting human activities around and within sensitive reserves for protection of target species. We suggest the Plan identify sanctuary areas closed to all human activities and establish transitional zones with increasing levels of human use with distance from core areas. These measures are especially important for protection of clapper rails, but apply to many of the target species for this Plan.

<u>California Black Rail</u>

The species account provided for California black rail (*Laterallus jamaicensis coturniculus*) in the background materials (LSA Associates 2002) is quite comprehensive. We suggest this rail be included as a target species. While this species is more widespread than some recommended targets, the remaining tidal marshes of Solano and Napa Counties support the highest breeding populations of California black rails. These secretive rails are linked to the survival of other tidal marsh species and co-occur with endangered soft bird's beak, Suisun thistle, salt marsh harvest mice, and California clapper rails. Maintenance and restoration of historic tidal hydrology and mixed halophyte communities will enhance the conservation success of the Plan.

We recommend the additional consideration of the threats to this species posed by invasive *Lepidium latifolium*. This exotic perennial pepperweed is displacing tidal

creekside vegetation and Salicornia plains. California black rails are also threatened by the recent introduction of feral hogs to Solano wetlands.

Swainson's Hawk

Swainson's hawks (*Buteo swainsoni*) are highly adapted for foraging in specific agricultural crops with particular management activities. Flood-irrigated alfalfa is a key agricultural component, large tracts of which support large numbers of nesting Swainson's hawks (Schmutz 1987, Bradbury 2002). Although it may be considered an umbrella species for the protection of riparian corridors and savanna, it is no longer a grassland species, and thus cannot be protected through the conservation and preservation of grasslands, vernal pool, or other natural habitats. Nesting density, a strong indicator of an area's carrying capacity, is as much as 6 times greater on cultivated agricultural lands than on grasslands. Even if Swainson's hawks adapted back to grasslands, that habitat would not now support a large enough population to assure recovery of the species (Bradbury 2002).

Agriculture is an extremely important economic activity in Solano County. If guarantees can be made that a large percentage of agricultural lands will remain with appropriate crop types (alfalfa, tomatoes, other specific row crops) in reasonable proximity to nest sites, it is likely that the Swainson's hawk population will remain at its current population level, and may increase to a level which meets recovery standards. A map with Swainson's hawk nest sites overlaid on current agricultural land use is needed to identify the most important agricultural lands to preserve.

Burrowing Owls

Unlike Swainson's hawks, burrowing owls (*Athene cunicularia*) are highly impacted by human development, both urban and agricultural (Holroyd et al. 2001). As is evident from the mapped species locations, there is significant partitioning between areas of Swainson's hawk use and that of burrowing owls. Burrowing owls rely on large tracts of uncultivated grasslands with sufficient burrowing/grazing animals to provide burrows, community safe-guards, and good visibility in the grassland setting. Artificial mounds (levees) have become important for the above reasons and appear to afford the owls less compacted soils for easier digging. California populations have been compressed into marginal habitat resulting in the questionable viability of the species in most areas (Barclay et al. 1998).

In Solano County, burrowing owls continue to decline with the increased cultivation of grasslands for dry land farming; these lands are poor habitat for Swainson's hawks as well. For burrowing owls to survive in the County, they will require the preservation and restoration of large, contiguous tracts of natural grasslands with terrain modifications for burrows, and managed for burrowing mammal use. Maintaining abundant populations of California ground squirrels is likely critical to burrowing owl viability. Moderately intensive cattle grazing may also be beneficial. There is an opportunity to fold burrowing

owl needs into the vernal pool and grassland preservation areas with minor management adjustments.

5.3 REPTILES AND AMPHIBIANS

Giant Garter Snake

Giant Garter Snake (*Thamnophis gigas*) is associated with natural and artificial lowland streams, sloughs, and marshes. The species is not distributed widely throughout these habitats in Solano County, however, but has been found in only a few specific areas. These lie generally northeast of the Jepson Prairie south of Dixon near the Solano County/Yolo County line (LSA Associates 2002). Any enhancement of wetlands in this area would probably benefit this species.

California Tiger Salamander

California Tiger Salamander (*Ambystoma californiense*) has three recorded breeding areas in the grassland/vernal pool ecosystems of Solano County, but others may exist. The key elements for the species' conservation are: (1) assuring that the uplands the salamanders need for their terrestrial existence are not irrigated and remain untilled; (2) retaining larger vernal pools where the salamander breeds; and (3) assuring that populations are linked with contiguous habitat. Grazing is compatible with their existence, and, at proper levels, may even enhance populations of the California ground squirrel, which is one of the principle species that provides subterranean habitat for the salamander. Individuals routinely use uplands within 200 meters of a breeding pool and occasionally use habitat even further away. They can move more than a kilometer between pools. (Comprehensive literature summaries available in Center for Biological Diversity 2001 and LSA Associates 2002.)

The most pressing issue in the Solano County NCCP/HCP is that salamander populations south of Highway 12 and north of the Potrero Hills face the risk of becoming completely isolated from other populations as traffic on Highway 12 increases. Construction of a freeway in this zone could lead eventually to the extinction of this breeding population if it is completely removed from a source of immigrants from the north.

Western Spadefoot Toad

The western spadefoot toad (*Spea hammondii*) may occur in Solano County. Provisions to protect such species as the California tiger salamander and burrowing owl should be sufficient to protect the western spadefoot toad. A life history summary for this species appears in Zeiner et al. (1988).

California Red-legged Frog

Breeding populations of this species are found in hilly areas of western Solano County, primarily south of Highway 12 and west of Interstate 680. Red-legged frogs spend most

of their lives in water, but do move onto land occasionally, either for aestivation in times of drought or possibly for feeding. Some subterranean habitat, such as the burrows of ground squirrels or cavities under rocks and logs is essential for long-term survival. In addition, individuals often migrate more than a mile from one breeding area to another, and multiple breeding populations are essential for long term survival (LSA Associates 2002, U.S. Fish and Wildlife Service 2002).

Keeping unobstructed corridors of natural habitat between pools is thus essential. A final element for the conservation of this species is to protect breeding areas from invasion by the non-native bullfrog (*Rana catesbeiana).* Even though the two frog species can sometimes coexist, protection from bullfrogs is still important. Therefore, any new development or agricultural activity adjacent to the red-legged frog habitat should remain free of artificial ponds and streams that could be invaded by the bullfrog.

Detailed conservation plans for California red-legged frog (*Rana aurora draytonii*) are described in the Recovery Plan just finalized by the U.S. Fish and Wildlife Service. The NCCP/HCP should be consistent with these plans.

Foothill Yellow-legged Frog

Foothill yellow-legged frog (*Rana boylei*) inhabits clearwater streams at mid to upper elevations, and has perhaps been confined to these regions by the extensive channelization of low-elevation streams for flood control (LSA Associates 2002). Measures to protect and enhance natural streams in the western parts of Solano County will also aid this species. Additional protective measures may not be needed.

5.4 FISHES

Steelhead Trout

Steelhead (*Oncorhynchus mykiss*) need to receive directed management attention because of their importance in the recreational fishery, relatively high visibility to the public (primarily as the freshwater form, rainbow trout), and their listed status under state and federal endangered species law(s). Their presence in a stream is also a good indicator of habitat and water quality. A number of stakeholder groups support conservation measures for this species, including recreational fishing groups, environmental groups, and professional fishery biologists both within and outside government agencies, among others. Steelhead are a ceremonial icon to at least one Native Californian group—the Esselen band on the Carmel River—and have cultural significance to other tribes in the Klamath River system on the California north coast. The decline in steelhead abundance in California during the past two decades has been widespread and precipitous (Busby et al. 1996, McEwan 2001). Conservation of steelhead under the NCCP/HCP may serve as testament to the commitment within Solano County to preserve natural resources of cultural, economic, and ecological value. Conservation management efforts directed toward steelhead also will benefit associated species in stream and riparian habitats.

Steelhead conservation within the NCCP/HCP area will require the protection of specific habitat areas and maintenance of appropriate environmental conditions in those watersheds that contain reproducing populations segments of steelhead, viz., Green Valley and Wooden Valley watersheds. Specific measures include facilitation of migratory passage over artificial barriers and the provision of adequate stream flows and physical habitat features required by the fish. Some streams may be used only temporarily by steelhead and rainbow trout for rearing, especially in years of favorable precipitation and streamflows. Physical habitat conditions in the stream channel and riparian areas should be maintained in those streams so that steelhead and rainbow trout, as well as salmon, may periodically use them during years of normal to wet weather.

However, unlike many targeted species that have more localized or endemic populations within the NCCP/HCP area in Solano County as a whole, steelhead are wide-ranging and have substantial life-history variability. Therefore, steelhead require a broad and flexible management perspective. Steelhead are the anadromous (sea-run) phenotype and rainbow trout are the freshwater phenotype of the same species. The two forms probably compose a single genetic population when they co-occur within the same stream (McEwan 2001). Hence, it is vital that requisite environmental conditions be maintained in streams that may presently contain only rainbow trout if those streams historically contained steelhead, including migratory pathways in the lower reaches of streams and in brackish water.

Because the habitats for steelhead and rainbow trout occur in small, low-elevation watersheds within the NCCP/HCP area, it is likely that the steelhead phenotype may not occur every year even while rainbow trout continue to persist. Over periods of several decades, even the rainbow trout population is likely subject to occasional extirpation due to extended droughts or other natural factors. Artificial factors (reduction of flows by dams, creation of new barriers to migration, etc.) can increase the frequency of extirpation. The reestablishment of those local populations probably occurs by colonization from other parts of the coastal or Central Valley steelhead ESUs. The long-term persistence of steelhead and rainbow trout through multidecadal periods, even if intermittently, would truly reflect the effectiveness of conservation efforts within the area of concern.

An appropriate framework for conservation management of steelhead would include the concept of a metapopulation comprising source and sink subpopulations, as outlined by the National Marine Fisheries Service (NMFS white paper: "Viable salmonid populations and the recovery of evolutionarily significant units," January 6, 2000; www.nwfsc.noaa.gov/pubs/). Within that conceptual framework, local subpopulations may occasionally be extirpated by severe challenges during the course of natural environmental cycles, but they would subsequently be reestablished by colonists from other subpopulations.

Annual monitoring of selected streams (Green Valley and Wooden Valley watersheds) over several decades should be conducted to determine the temporal patterns of population variability of steelhead and rainbow trout as well as chinook salmon and other

native fishes. Other creeks (e.g., Alamo and Ulatis creeks) also should be sampled at least periodically to determine their use by steelhead, rainbow trout, and salmon during years of favorable streamflows.

Central Valley Fall-run/Late-fall-run Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) were not identified as a target species by our team of science advisors because the salmon population within Solano County is part of the much larger Central Valley fall/late-fall run ESU currently not listed under state or federal endangered species laws. However, chinook salmon are one of several high-profile species and warrant some comment.

Fall/late-fall-run chinook salmon will likely benefit from protective measures directed mainly toward steelhead such as maintenance of streamflows and appropriate physical habitats. Salmon evidently spawn in some streams within the Solano County NCPP/HCP area, viz., Green Valley and Wooden Valley watersheds. There is evidence that salmon fry are washed into Suisun Marsh from upstream areas and may use the Marsh as a rearing area, and they possibly also enter the Green Valley and Wooden Valley watersheds for rearing. To the extent that chinook salmon in the NCPP/HCP area and adjacent areas form part of a self-perpetuating natural population, they should be recognized as contributing to the natural production of the Central Valley fall/late-fall ESU. That ESU is currently heavily subsidized by hatchery production.

The spawning population within an individual watershed may be relatively small and probably subject to periodic extirpation, so it would be appropriate to view the local populations as part of a larger metapopulation. Recolonizations following periodic extirpations may occur by straying of spawners from nearby streams within Solano County and from elsewhere in the Central Valley ESU range. Salmon within the NCPP/HCP area provide important ecological links with other, contiguous areas—particularly Suisun Marsh and the mainstem Sacramento River. Small streams also may provide feeding and rearing habitats for juvenile salmon even if those streams are not used for spawning, as has been shown with small intermittent streams in the upper Sacramento River basin, the Cosumnes River in the San Joaquin River basin and in other regions (e.g., Scrivener et al. 1994). Thus, juvenile salmon migrating from the Sacramento-San Joaquin Delta, Suisun Marsh and Sacramento River may enter the Green Valley or Wooden Valley watersheds and rear there for some period. Salmon also provide significant marine-derived nutrient and energy influxes to freshwater habitats because all the adults die after spawning and the carcasses fertilize stream and streamside ecosystems (e.g., Bilby et al. 1996, Willson et al. 1998, Helfield et al. 2001).

Delta Smelt

The delta smelt (*Hypomesus transpacificus*) is a small osmerid fish endemic to the San Francisco Bay estuary (also called the Sacramento-San Joaquin estuary). The fish are small, delicate planktivores typically found in shallow (<2-4 m deep) open waters (Moyle 2002). Delta smelt occur in the estuary from Isleton on the Sacramento River and below Mossdale on the San Joaquin River to San Pablo Bay and the lower reaches of the Napa

and Petaluma Rivers. Within the estuary, their distribution is controlled largely by salinity, with the population concentrated in waters with salinities ranging from 0 ppt (freshwater) to <10 ppt. The species occurs seasonally in Suisun Bay and the larger sloughs and channels of Suisun Marsh.

Although delta smelt are listed as threatened under the federal Endangered Species Act and part of their critical habitat is within Solano County (principally Suisun Marsh and Barker Slough), the species was not identified as a target species by our team of science advisors because its use of areas within the Solano County NCCP/HCP was minimal and generally not dependent on local habitat management.

Splittail

The splittail (*Pogonichthys macrolepidotus*) is a large cyprinid endemic to California and found mainly in the sloughs, lakes, and rivers of the Sacramento-San Joaquin watershed. The species is adapted for living in estuaries with fluctuating conditions and, with the exception of the springtime spawning period, the fish spend most of the lives in the estuarine waters of the Sacramento-San Joaquin Delta, Suisun Bay, Suisun Marsh and San Pablo Bay (Moyle 2002). Splittail are floodplain spawners: following high flow events in the spring (February-May), adult fish move upstream onto seasonally inundated floodplains to spawn and then return to the estuary. Newly hatched young rear on the highly productive floodplains, only moving downstream to the estuary as the floodplain drains. The population decline observed in the splittail during the past several decades is apparently related to reductions in the frequency and timing of floodplain inundation and the resultant reduced spawning success.

Although splittail were listed under the federal Endangered Species Act in 1999 and part of their critical habitat is within Solano County (principally Suisun Marsh and the lower portions of the American Canyon, Green Valley and Suisun Creeks), the species was not identified as a target species by our team of science advisors because its use of areas within the Solano County NCCP/HCP was minimal and generally not dependent on local habitat management. However, conservation and/or restoration of floodplains (e.g., levee setbacks) and of seasonally appropriate hydrographs of Solano County creeks would benefit the species.

5.5 INSECTS

Delta Green Ground Beetle

Ground beetles are often found in habitats where they are strongly associated with a particular soil type. The delta green ground beetle (DGGB) is associated with the playa-type vernal pools that form on Pescadero clay soils (U.S. Fish & Wildlife Service 1985). Adults and larvae primarily live at the shorelines of these playas where they feed primarily on Collembola. The preferred habitat is sparsely-vegetated or barren at the time of adult activity, but vegetative cover increases as the playas dry and the shoreline and upland species germinate and grow (Arnold 1989).

The species account prepared by LSA Associates, Inc. (2002) notes that the Biological Opinion for renewal of the Solano Water project states that adult activity may occur in the fall or evening (U.S. Fish & Wildlife Service 1999), yet existing records indicate that activity is diurnal and occurs between February and May (California Natural Diversity Data Base 2002, Buggy Data Base 2002, U.S. Fish & Wildlife Service 1985). Most other taxa of *Elaphrus* are active between May and September (Goulet 1983), so the seasonal shift in the activity period of the DGGB is probably due to its association with the vernal pool habitat.

Adults disperse by flying between playas and often land on patches of barren ground, such as trails or balds (Arnold, personal observation). Their dispersal is between and among playas within the vernal pool-grassland matrix rather than migratory.

Within Solano County, the DGGB is known from the playas in the Jepson Prairie, i.e., between Hwy. 113 and Travis Air Force Base (California Natural Diversity Data Base 2002, Buggy Data Base 2002, U.S. Fish & Wildlife Service 1985). It may also occur in association with the playas that are located on private properties on either side of Hwy. 12, but I am not aware that adequate surveys have been done in this portion of the county.

This beetle has a very limited geographic range and within that range, its preferred habitat, the shorelines of playa pools, is also quite limited. Some shorelines are mini-cliffs that are too steep for DGGB use, while some flatter or gently sloped shorelines are too densely vegetated (Arnold 1989). Although a significant portion of the beetle's geographic range has been protected, the habitat needs to be managed appropriately to benefit the beetle.

The primary threats are invasive plants, both in the pools and adjacent uplands, and incompatible grazing practices. Invasives colonize the shorelines of the playa pools favored by the DGGB, which reduces the amount of bare ground for hunting. Grazing may be a useful management technique, when appropriately timed to control the exotics and favor the natives. Fire, mowing, and possibly herbicides may also be necessary to adequately control exotics at some locations.

Ricksecker's Water Scavenger Beetle

This beetle has been found in a variety of aquatic habitats, usually characterized by standing water, including a reservoir, pond, and playa pool. The winter and spring activity period (January through June), based on collection records, suggests that it may be associated with seasonally-ponded wetlands. Related species are generally associated with aquatic habitats characterized by standing water (Smetana 1980).

As mentioned in the LSA account, this beetle is known from a limited number of specimens and locations in the greater San Francisco Bay area (California Natural Diversity Data Base 2002, Buggy Data Base 2002). For this reason, specific details about its biology and habitat requirements are poorly known at this time. Within Solano

County, the beetle is known only from the Jepson Prairie, and in particular, from Olcott Lake. Based on its occurrence there, I anticipate that this beetle may eventually be found at other playas within and near the Jepson Prairie.

Valley Elderberry Longhorn Beetle

This beetle is known from as far north as the Shasta-Tehama county line and as far south as Lake Isabella in Kern County (Barr 1991, California Natural Diversity Data Base 2002, Buggy Data Base 2002, Halsted and Oldham 2000, U.S. Fish & Wildlife Service 1984). It also occurs in the foothills of the Sierra Nevada up to approximately 3,000 feet between Kern and Placer counties (Arnold, personal observation). In the Central Valley, it is limited to riparian remnants of the formerly more extensive riparian woodland and scrub habitats that were associated with many drainages, where its larval food plant, blue elderberry (*Sambucus mexicana*), grows. In the foothills, elderberry grows in riparian habitats, as well as at rock outcrops and in the understories of oak woodland-scrub habitats, so the beetle also occurs in these habitats.

The amount of riparian habitats in Solano County, as throughout most of the Central Valley, has declined significantly during the past century. Within Solano County, the beetle or its exit holes have been observed in riparian habitats at various locations along Putah Creek, Cold Creek, Dudley Creek, Ledgewood Creek, Gordon Valley Creek, Pleasant Valley Creek, Alamo Creek, and Ulatis Creek (Barr 1991, California Natural Diversity Data Base 2002, Buggy Data Base 2002, U.S. Fish & Wildlife Service 1984). It has been found next to urban and agricultural lands, including orchards and grazing land, as well as more natural habitats. Other than the Dudley Creek location (east of Dixon), all of the observations are located near Fairfield and Vacaville, and in the Vaca Mountains north and west of these towns. Additional drainages in the north central and northwestern portions of the county are likely to still support the beetle, as well as portions of the Sky Valley, but these areas have not been as well surveyed as other portions of the county. Elderberry occurrences along drainages in the southern and eastern portions of the county are generally too sparse to support populations of this beetle.

More recent studies indicate that the beetle prefers to bore in the wood of younger stems of elderberry (Arnold 2002). Grazing cattle often eat or trample young elderberry stems, which can reduce habitat quality for the beetle even in protected areas. Also, remnant riparian habitats in the county generally occur as small, widely-separated patches, rather than more continuous riparian corridors. Adult beetles are actually strong fliers, but probably disperse primarily along riparian corridors rather than between drainages. The current distances between remnant riparian patches associated with most drainages in the County are probably greater than the distances adult beetles would normally disperse. Restoration efforts should focus on establishing elderberries of all age classes and, where practical, the creation of continuous riparian corridors.

Callippe Silverspot Butterfly

This butterfly lives primarily in grassland habitats where there are hilltops (which are used for mate location), its larval food plant, *Viola pedunculata*, and nectar plants (*Aesculus*, *Monardella*, and various introduced thistles) (Arnold 1981). These habitat requirements do not have to coincide.

The native grassland habitat was characterized by bunchgrasses, but these have been converted to primarily annual grasses due to past and current grazing practices. Grazing could be used to manage the vegetation to favor the bunchgrasses and larval food plant of the butterfly. However, the timing and intensity of grazing activities needs to be coordinated with the growth and flowering times of the natives to favor them rather than the non-natives that have become so prevalent. Ironically, the butterfly utilizes several introduced species of thistle (*Cirsium*, *Silybum*, etc.) for nectar (Arnold 1981), so its numbers may decline somewhat if these nectar plants are controlled or eliminated as part of the vegetation management.

Within Solano County the butterfly is known to occur in the hills between Vallejo and Cordelia (i.e., vicinity of Lake Herman, Columbus Parkway, and Sky Valley) and northward into Jamison Canyon (California Natural Diversity Data Base 2002, Buggy Data Base 2002). Although the larval food plant grows at various locations in the Montezuma Hills, the butterfly has not been observed there. Similarly, the larval food plant also grows at the Jepson Prairie, which lacks the hills necessary for mate location, as well as some of the favored nectar plants.

The species account prepared by LSA Associates, Inc. (2002) refers to the phenotypic variation that occurs in the western Solano County area and taxonomic status of this subspecies, *Speyeria callippe callippe*. Most species in the genus *Speyeria* exhibit considerable phenotypic variability which has resulted in the recognition of numerous subspecies. Western Solano County and southeastern Napa County is an area where individuals with markings of three subspecies of *Speyeria callippe* co-occur, namely *callippe callippe*, *callippe comstocki*, and *callippe liliana*. Butterflies, like all insects are ectothermic, thus populations that occur in foggy areas (such as southwestern Solano County) often tend to be darker in color, which not only enables them to warm up more quickly on foggy days, but is also a distinguishing morphological characteristic of this endangered subspecies. Although the frequency of individuals that resemble *callippe callippe* from southwestern Solano County is lower than those from San Bruno Mountain (San Mateo County), at most locations in Solano County, this frequency is higher than either of the other subspecies, which explains why USFWS treats these populations as the listed subspecies. For similar reasons, USFWS is also treating populations from the Pleasanton area (Alameda County) as the listed subspecies.

By definition, hybrids occur between species not subspecies. Western Solano County is an area of overlap and intergradation of the characteristics that distinguish the three subspecies of *Speyeria callippe* that co-occur there.

5.6 CRUSTACEANS

Fairy and Tadpole Shrimp

The consultant's report (LSA Associates 2002) highlights five species of highly specialized crustaceans that inhabit vernal pool ecosystems in various parts of California, and that continue to occupy pools in Solano County. These species include four species of fairy shrimp, *Branchinecta lynchi, B. mesovallyenensis, B. conservatio,* and *Linderiella occidentalis*, and one species of tadpole shrimp, *Lepidurus packardi*. The species accounts provided by LSA Associates (2002) accurately identify habitat destruction and fragmentation, along with alteration of water supply and agricultural conversion that destroys natural topography, as the primary threats to these species. These activities have 1) eliminated many populations; 2) isolated formerly connected populations; and 3) reduced the potential for recolonization following natural and anthropogenic disturbances. All of these species potentially experience dramatic fluctuations in population size, and all are threatened with local and regional extinction. *B. mesovallyenensis* and *Linderiella occidentalis* are listed as Species of Special Concern, *B. lynchi* is listed as federally Threatened, and *L. packardi* and *B. mesovalleyensis* are listed as federally Endangered.

In Solano County, these taxa are associated primarily with vernal pools, playas, and grassy swales. In addition, a few species have been found in man-made seasonally-ponded wetlands, such as ditches, detention basins, depressions, roadside puddles, and crop furrows at locations in close proximity to their natural habitats. The majority of locations that support these taxa occur from south and southeast of Fairfield, Travis Air Force Base, particularly near the Potrero Hills and vicinity, and the Jepson Prairie. Other locations occur southeast of Dixon and near Montezuma Hills (California Natural Diversity Data Base 2002, Buggy Data Base 2002). The consultant's report generally identifies habitats that support these five species, although in several cases, it fails to identify the specific locations in Solano County inhabited by a particular species (e.g., *L. occidentalis*, for which there is no summary of their distribution within the county). There is no quantitative information in the consultant's report about abundances, patterns of co-existence with other species, and changes in population numbers through time for any of the species mentioned in the documents that were given to this panel. In addition, the consultant's report does not include information about sampling locations, in particular, potentially suitable habitat that was not sampled. Consequently, the information available to us provides an incomplete picture of distribution, abundance, and population fluctuations.

There is growing evidence that a critical feature of populations of many of these species, one that governed their evolution and ecology and explains much of their unique biology, is that due to drought, flooding, and other climatic and geomorphological variables, they periodically become locally extinct on annual, decadal, or even longer periods (Wilcox, in review). All of these species have very limited intrinsic dispersal capability, relying on transport by water, animal vectors (e.g., waterfowl, cattle), and perhaps wind to move on scales more extensive than a few meters. To some extent, their persistence relies on their

ability to produce dormant stages that survive summer heat and desiccation. In addition, their local and regional survival hinges on re-colonization by dispersal from other local populations, which themselves may become extinct in different years. Therefore, the number of pools that exist in a region, their proximity to each other, and their hydrologic integrity (as a result of runoff and flooding) are additional critical factors that determine whether most species of vernal pool crustacean will survive or become extinct.

It appears that it is impossible to generalize from species to species about the scales over which extinction/recolonization processes operate in the target species identified in Section 5.0. A recent study by Wilcox (in review) indicates that the spatial and temporal scales over which extinction and re-colonization processes operate differ from species to species. For example, the maintenance of viable populations of *Branchinecta lynchi* appears to require dense complexes of pools with minimal spacing. In contrast, *Linderiella occidentalis* requires widely dispersed networks of large pools. In addition, none of the species is truly a habitat generalist, found in all types of pools and playas. For instance, the preferred habitat of *Lepidurus packardi* and *Branchinecta conservatio* is playa pools with turbid water (Eriksen and Belk 1999, Helm 1998). Life history studies have demonstrated that both of these taxa develop more slowly than the other freshwater shrimp of Solano County and remain active later in the season; thus they tend to be restricted to deeper pools and playas that have longer hydroperiods than smaller vernal wetlands (Helm 1998). *Branchinecta lynchi*, *B. mesovalleyensis*, and *Linderiella occidentalis* generally live in smaller vernal pools and grassy swales, but can also be found in playas. Consequently, conservation planning that protects this group of vernal pool crustaceans cannot focus on a single species and will necessarily encompass a broad range of pool sizes, densities, and spacing.

Finally, it is worth noting that there is growing information that at least some of the nominal species listed above actually represent sibling species complexes. For example, *Branchinecta mesovalleynesis* was only recently described as a new species, distinct from other Central Valley congeners (Belk and Fugate 2000). Similarly, what was once thought to be a single species of *Lepidurus* (*L. packardi*) likely encompasses several genetically and ecologically distinct species (King and Hanner 1998, Rogers 2001). Beyond these potentially important taxonomic distinctions, and the ecological and genetic diversity harbored in so-called “cryptic” species, there is limited genetic information from Solano County and other regions in California, suggesting that at least some of the target species of branchiopods have remained sufficiently isolated for enough time to accumulate detectable genetic and ecological differences (*e.g.*, King and Hanner 1998). This, and the fact that many of these species have evolved *in situ* in a relatively short geological time frame, suggests that there is the potential for local adaptation to evolve in at least some populations of endemic crustaceans that inhabit the vernal pools of Solano County. Moreover, pools vary enormously in their biological and physical parameters across pool, pool complex, landscape, and regional scales. At this point, we have no idea how common local adaptation is, and over what spatial scales it occurs. To the extent that it does occur, translocation and restoration efforts should be considered highly risky.

5.7 OTHER TAXA

In addition to the target species discussed above, we recommend that the NCCP/HCP provide some consideration to ecologically pivotal species that have been extirpated from the County or which currently persist at population densities below historic levels. These species include the following:

Carnivores

California grizzly bear: extinct. Grizzly bears were most abundant in tule marshes, willow and cottonwood riparian corridors, and Coast Range chaparral (Jameson and Peeters 1988). Slaughter for sport and livestock protection with $500 bounties drove the species to extinction (Grinnell et al. 1937). Grizzly Bears commonly crossed the shallow bay between Mount Diablo and from Coast Range foothills into Suisun Marsh to forage on California rosehips, blackberries, and fish (Frost 1970s, Arnold 1996). The largest island and its adjacent bay in Solano County were named for these bears.

Black bear: widespread elsewhere, rare in Solano County

Gray wolf: extinct throughout California by 1920s. The ecological role of the wolf, for example in potentially regulating populations of ungulates, is unknown in California.

Coyotes: widespread in the County, but misguided shooting reduces populations

Native predators should be targeted for conservation as indicators of intact food webs and as potential keystone species (i.e., species whose impact on the ecosystem is disproportionately large for their abundance)

Ungulates

Chronicles by early settlers describe deer, tule elk, and pronghorn antelope in herds of thousands near Benicia and throughout Solano County (Fraser 1879, Harvey et al. 1992). Tule elk, Roosevelt elk, and pronghorn antelope were exploited by market hunters to supply meat and hides for the Gold Rush (Harvey et al. 1992).

Tule elk: This was the only species to escape local extinction, but only a few elk remained in the County by 1874 (Harvey et al 1992). Tule elk are now limited in the County to one controlled herd on Grizzly Island Wildlife Management Area.

Roosevelt Elk: locally extinct, extant North Coast. Formerly mingled with tule elk throughout its historic range, which included Marin, Sonoma, Napa, and Solano counties and north along the coast range through Oregon (Harper et al. 1967).

Pronghorn antelope: extinct (extant elsewhere). Antelope densities were greater in the San Joaquin Valley than anywhere in North America, and accounts of early explorers

confirm their historic presence in Solano grasslands, oak and riparian woodlands, and chaparral (Harvey et al. 1992).

Cattle have replaced native ungulates as the dominant herbivores on Solano open space lands**.** While cattle and native ungulates coexist on grazing lands, the conservation plan should consider open spaces reserves where native herbivores are released from competition with cattle. There is some evidence that low-intensity grazing helps to control non-native invasives, especially grasses. It is not unlikely that native ungulates might serve this management role as well or better than livestock.

6.0 THREATS, MANAGEMENT ISSUES, AND OPPORTUNITIES

In this section we summarize some dominant threats to biodiversity in the planning region and offer recommendations for countering these threats in the NCCP/HCP.

6.1 HYDROLOGICAL MODIFICATION

The impacts of the urban and agricultural environment on hydrology of streams can be divided into four main categories:

1. Impacts to the flood discharge peaks and the lag time from peak rain mass to peak runoff;
2. Increases in the total discharge volume;
3. Changes in the seasonal distribution of runoff;
4. Changes to the extent of the inundation of the floodplain during floods.

The principal impact of urbanization is on the peak discharge (Waananen et al. 1977). In urban areas of Solano County, runoff volumes are probably transmitted to receiving waters much more quickly (lag time has decreased) than historically because of increased velocities on impervious catchment surfaces, increased velocities in hydraulically more efficient drainage channels and storm sewer networks, greater connectivity of the catchment surfaces to the drainage network, and because floodplains in the lower parts of the watersheds are deliberately isolated from the channel network by structural controls. The location of the urbanization influences the magnitude of the effect, but it is probably fair to say that increasing urban land use in the watersheds of Solano County will increase the peak discharge in the future.

In addition, annual runoff volumes have probably increased over natural conditions because of a decrease in infiltration in areas with impervious surfaces (roofs, roads, and parking lots). During pre-urban conditions, runoff during the dry season, early wet season floods, drier years, and successive dry years would have been minimal. This is because soil infiltration during these dry times exceeds rainfall intensity. Most of the volume increase associated with urbanization has probably occurred during drier times and during smaller floods, not only changing the total annual volume of runoff but changing the seasonality as well.

Decreases in infiltration affect ground water recharge with subsequent effects on base flow during times when there is no rainfall. Dams and managed releases, retention basins, and withdrawal for irrigation also deliberately impact seasonality. Lake Curry on Suisun Creek and Lake Frey and Lake Madigan in the Green Valley watershed are managed by the City of Vallejo for water supply. In addition, there is extensive spray irrigation on row crops in the Valleys of these watersheds. Less deliberate hydrological changes probably include legal or illegal pumping and point source and releases, return flows from irrigation, watering lawns, and washing cars.

The period and magnitude of floodplain inundation under natural conditions is the product of a number of factors including antecedent soil moistures conditions, the condition of the riparian vegetation, the recent history of channel sedimentation and erosion, the tidal phase, and the magnitude and duration of the storm event. Urban and agricultural land use typically influences all of these parameters and therefore influences floodplain inundation. Typically, flood control channels are designed to transmit water more efficiently and often disconnect the channel from the floodplain. However, if channels are under-designed or not maintained, a large flood can escape the channel either by overtopping or by breaching a constructed levee. When this happens, water, sediment, and contaminants are delivered to sensitive areas outside of the channel and water flows back into the channel can be limited due to levees further downstream. In this way, flooding of the floodplain would typically occur less often than under natural conditions, but when it does occur, the magnitude and duration can be larger.

Implications for habitat and species conservation in Solano County

A number and plants and animals that were identified in the background information provided to us are either directly or indirectly impacted by changes to hydrology beyond normal seasonal and interannual variations expected under natural conditions. Here we concentrate on species that were deemed to be particularly important in the context of the Suisun NCCP/ HCP (i.e., some of the target species discussed in the preceding section). The salinity regime in tidal areas of the County is partly or whole influenced by local runoff as well as diurnal tides, discharge in the Sacramento River and geometry, and connection of tidal channels and sloughs.

If land management plans in Solano County significantly change peak flows in the future, total runoff volume, and flow seasonality, species that are reliant on a certain salinity regime may be forced to gradually migrate spatially or be extirpated. Plant species in Solano County that may be impacted include Suisun thistle and soft bird’s-beak. Changes in hydrology of local watersheds may impact the California black rail, California clapper rail, and the salt marsh harvest mouse. For example, California black rails often conceal their nests in the upper limits of the tidal zone and are therefore particularly vulnerable to hydrological change.

Changes in seasonal hydrology as well as changes in stream cross-sectional geometry to accommodate a new discharge regime can influence the species composition and/ or

stability of the banks and near-bank riparian vegetation. Bank erosion can be a significant portion of the total sediment supply to Bay Area streams (McKee and Pearce 2002). In addition, if increased flow energy has caused net sediment supply to the stream from bed erosion, a further consequence is a net lowering of the channel bed and intersection of ground water at a lower level. This may cause the water table to lower. Other changes to hydrology in watersheds include withdrawal of groundwater and stream water for crop irrigation, reservoir management, and changes in infiltration associated with changes in vegetation cover (for example, native versus non-native grasses for grazing) and urban impervious surfaces.

Based on a SFEI reconnaissance, the riparian zones of Alamo, Ulatis, Suisun and Green Valley Creeks are largely intact upstream of Hwy 80 although the structure and species composition was not assessed (McKee, October 14, 2002). Valley elderberry longhorn beetle in the riparian vegetation of Alamo, Ulatis, and Green Valley Creeks may be associated with stressed elderberry trees. In that context, and ironically, changes to hydrology and associated declines in riparian health may in the short term improve populations; however, in the longer term, loss or fragmentation of the riparian forests is likely to be detrimental.

Steelhead are highly impacted by changes to seasonal hydrology, stream simplification associated with urban drainage design, and loss of riparian habitat. Loss of summer flows associated with changes to the groundwater regime because of surface or groundwater withdrawal for irrigation, reduced groundwater storage because of less infiltration in urban areas, or changed evapotranspiration in agricultural areas may be contributing factors. Although fish such as steelhead are tenacious and can survive in largely unsuitable conditions, moderate to severe modifications to stream hydrology, geometry and complexity, and riparian structure associated with urban and agricultural development will undoubtedly lead to extirpation.

Changes in the extent or period of time the floodplain is inundated could have deleterious consequences for a number of floodplain species. These include hispid bird's-beak, Contra Costa goldfields, Colusa grass, Solano grass, splittail, conservancy fairy shrimp, vernal pool fairy shrimp, vernal pool tadpole shrimp, midvalley fairy shrimp, and Delta green ground beetle.

Recommendations

1. Future developments in urban and agricultural areas should be carried out in a way that minimizes changes in peak runoff, total runoff volume, and seasonality of runoff as a solution to reducing changes to the salinity regimes of tidal areas.

2. Future developments should either maintain or enhance groundwater infiltration as one solution for maintenance of crucial dry season / dry year flows and as a contributing factor for maintenance of the riparian zone along creeks.

3. Assessments should be done to determine appropriate dry season environmental flows especially in Suisun and Green Valley Creeks but also in Alamo and Ulatis Creeks, and then steps should be taken to ensure that these are met. As noted earlier, this assessment should ideally utilize an assessment of historical flow regime and land use change to determine what is potentially feasible versus what might be wishful thinking.

4. An assessment of historic fauna and flora of Suisun, Green Valley, Alamo and Ulatis Creeks should be done to determine the true baseline. This information should then be used to help determine how, if at all each of these creeks could be restored. This should rightfully include community consultation.

5. Care must be taken to preserve some areas of the floodplain with natural or near natural inundation frequency and magnitude. Floodplain inundation is a necessary ecological dispersion mechanism for some species and has the added benefit of reducing flooding in downstream areas.

6.2 WATER QUALITY

The impacts of urban and agricultural development on water quality and sediment quality of streams in the planning area can be divided into the following main categories:

1. Runoff of nutrients and pathogens;
2. Eutrophication in drainage networks and receiving waters;
3. Runoff of trace contaminants;
4. Increased sediment supply to the stream channels;
5. Increased turbidity and sediment loads in drainage networks;
6. Increased sedimentation in stream channels;
7. Possible increases in flooding associated with changes in channel geometry to accommodate excess sediment.

Water quality is typically impacted by land-use changes associated with increasing human populations. For example, nitrogen and phosphorus are key plant nutrients, and concentrations and exports have been shown to increase with increasing human populations (e.g. Cole et al. 1993, Caraco 1995) and increasing agricultural applications (e.g. McKee and Eyre 2000). Sediment loads also show the same general trends (e.g. Letcher et al. 1999). The population of Solano County increased by 16% in the period 1990-2000 (ABAG 2002). It seems likely that water and environmental health will continue to degrade unless vigilance is exercised during land-use planning and development.

Land and water management associated with urbanization and agriculture also incorporates the application of a number of multi-spectrum and species specific herbicides and insecticides. In the Bay Area, there are a number of watersheds listed as impaired by the State (Clean Water Act. 303(d)) for nutrients, pathogens, sediments, and diazinon. In addition, there are watersheds listed for mercury (associated with mining),

trace metals, and dissolved oxygen. The Suisun Bay is listed for chlordane, copper, DDT, diazinon, dieldrin, dioxin compounds, furan compounds, mercury, nickel, PCBs, selenium, and exotic species, and many of these may be associated with diffuse sources in adjacent watersheds. Suisun Marsh sloughs are listed for trace metals, organic enrichment, low dissolved oxygen, and salinity.

The plant nutrients, nitrogen (N) and phosphorus (P), have been described by the EPA as the number one water-quality problem in the USA. Both N and P are found naturally in the environment. However, excess supply of nutrients to aquatic environments can cause increased aquatic plant biomass (algae and macrophytes) termed eutrophication. Euptrophication is often associated with increased soil erosion, application of inorganic fertilizers in agricultural and urban areas, golf courses and parks, irrigation return flow, increased loads associated with farmed animals and urban pets, and aerial dry- and wet-fall deposition associated with atmospheric pollution.

Pathogens are typically associated with warm-blooded animals. Feces from animals in the agricultural and urban environments as well as leaking sewers are most commonly the cause of localized high pathogen counts in water bodies. During the Science Advisors field trip (August 19th 2002), reeds and tall grasses were observed choking at least several agricultural/ flood control drainage lines in the areas east of Fairfield perhaps indicating excessive fine sediments, nutrients and certainly a decrease in channel capacity. During a SFEI reconnaissance (McKee, October 14, 2002), excessive algae and macrophytes were observed in locations on Alamo, Ulatis, Suisun, and Green Valley Creeks upstream from Hwy 80 where riparian vegetation was insufficient to shade the creeks.

Trace contaminants of concern include current-use pesticides and herbicides, and historic-use pesticides (e.g. DDT). These chemicals, since their introduction in the 40s, have been applied in the urban and agricultural environments for reduction of insect borne diseases, weed, and insect control, and mosquito abatement. Depending on the properties of the chemical and the method of application, these contaminants are transported in the environment attached to soil particles, on wind-blown dust, as an aerosol, in agricultural return flows, and in surface and ground water flow. In general, all of these trace chemicals will be present in land and water habitats in Solano County if they have been applied locally and some will be present even if not locally applied sourced from allochthonous aerial deposition. (might be good to cite Luoma and other contaminant studies done in the estuary here)

Increased sediment supply to urban and agricultural drainages, increases in turbidity, reductions in substrate quality (D_{50}), increased channel sediment storage, and increases in sediment loads entering a receiving water body are typical problems associated with urban and agricultural development. Sediment processes naturally differ substantially between watersheds depending on factors such as rainfall, geology, vegetation cover, topography, soils, and drainage shape. The animals and plants that live in each watershed will be those that are suited to the hydrological and sedimentological conditions that prevail. However, development often increases sediment supply to the channel through factors such as changes in hydrology and drainage density, changes in vegetation cover

and type, erosion of soils from agricultural and horticultural fields, construction sites, and road drains. Subsequently, the aquatic habitats will modify to accommodate changes in sediment and water supply and the fauna and flora that live there will be stressed or extirpated.

During the Science Advisors field trip (August 19th 2002), we observed a number of areas where soils were exposed either due to grazing practices and intensive animal traffic, management of crop areas for minimal ground cover, or management of roadsides, road drains, agricultural drains, or flood control drains for minimal vegetation cover. Some agricultural drains and flood-control channels appeared highly turbid.

During a SFEI reconnaissance (McKee, October 14, 2002) high turbidity was observed in parts of Alamo Creek upstream from Vacaville likely associated with cattle in the creek. Turbid water was also observed in many locations upstream from Hwy 80 in Ulatis Creek and one location on Green Valley Creek. Very fine sediment was observed in pools and fine sediment in bars in all locations (n=8) in Alamo and Ulatis Creeks. Fine to very fine sediment was also observed in pools and bars at five locations on Suisun Creek. In general, Green Valley Creek did not appear to be as impaired with regard to fine sediments in pools and bars.

In general, hillslope erosion was observed in watersheds of Alamo and Ulatis Creeks, and Suisun Creek (particularly Wooden Valley). Bank erosion was only observed in Alamo Creek and in Wooden Valley Creek (tributary to Suisun Creek). Areas of exposed soil were observed in all four watersheds associated with grazing practices, zero cover management under grape vines, tree crops, and between rows in ground crops. Exposed soils were also observed on horse ranches and around stables and yards and apparently purposely managed for aesthetic value along farm and rural-residential driveways.

Implications for habitat and species conservation Solano County

A number of species that were deemed by the Science Advisors to be particularly important in the context of the Solano County NCCP/ HCP are susceptible to changes to water and sediment quality. Swainson's Hawk can be adversely impacted by poisoning of prey animals, organophosphate and carbamate insecticide contamination in agricultural fields during times of the year when insects are the main prey, and potential bioconcentration of contaminants up the food chain. Western burrowing owls may also be impacted by chemical spraying in fields both by ingestion of contaminated prey and adverse effects of pesticides from spraying and drift. Black rails can be adversely impacted by contamination from industrial operations that lead to poor water quality. Clapper rails can be adversely impacted by pollution from urban and industrial runoff and sewage discharge. Although known sites for the California red-legged frog occur in hills west of urbanized areas, additional surveys could detect the species lower in watersheds where urban effects are likely. Were this the case, the species could be adversely impacted by changes in hydrology associated with urbanization and by changes in water quality such as sediments containing organic matter, as well as by pesticides,

fertilizers, heavy metals, hydrocarbons, and other toxic effluents. Other species that may be threatened by changes in water quality include the giant garter snake, salt marsh harvest mouse, conservancy fairy shrimp, vernal pool fairy shrimp, vernal pool tadpole shrimp, midvalley fairy shrimp, valley elderberry longhorn beetle, and callippe silverspot butterfly.

Steelhead trout are highly impacted by water and sediment quality in habitat streams. Water quality problems include sub-optimal water temperatures associated with low summer flow and loss of riparian trees, ammonia in toxic concentrations under certain pH conditions associated with animal and human effluents, low dissolved oxygen concentrations due to high water temperature and decaying plant biomass, and turbidity associated with increased sediment supply. Increased fine sediment supply to and storage in channel lags and pools reduces the quality of steelhead spawning habitat by reducing the flow of water and oxygen. Fine sediment stored in pools reduces the area and volume of water suitable for rearing habitat. During the SFEI reconnaissance (McKee, October 14, 2002), these types of problems were observed in Alamo, Ulatis, Suisun, and Green Valley Creeks, although Suisun and Green Valley were certainly less impacted and appear to be the most valuable habitats for steelhead presently.

Recommendations

1. A scientific study should be conducted to determine the relative magnitude sources of non-point contaminants so that appropriate management techniques can be selected.

2. Should studies or existing data deem it necessary, measures should be considered to reduce the runoff of sediment and contaminants from existing urban and industrial areas and new developments. Measures to be considered include maximizing infiltration, grass swales, retention ponds, and levee setbacks.

3. Should studies or existing data deem it necessary, measures should be considered to implement public education programs on the impacts/ use and/ or correct disposal of pet feces, lawn clippings and garden waste, detergents, and garden fertilizers.

4. Measures should be considered to improve farm management of sediment and contaminants. The current regime of minimum vegetation cover in rangeland, row crop, tree crop farming and vineyards is certainly contributing to the supply of fine sediment to creek channels. Studies should be undertaken immediately to determine the relative sediment supply from various sediment sources so that appropriate management techniques can be applied.

6.3 IMPACTS TO THE SUISUN MARSH

We commend the applicants for including sensitive species of Suisun Marsh, but we are concerned that the sensitive tidal wetlands of Suisun Marsh may be under-represented in

the Plan. Although we received fairly detailed maps of Suisun Marsh after our workshop, the context and implications of these maps were not addressed in the background materials. Maps delineating the 52,000+ acres of diked wetlands from the fragmented historic tidal marsh and adjacent uplands will be useful for impact assessment and conservation planning. More than 90% of the historic tidal wetlands in this basin have been diked or filled. Many of the target species are dependent on the relict undiked tidal wetlands of Suisun. An examination of detailed habitat maps will reveal that these fragmented natural habitats primarily ring the Potrero Hills and are contiguous with incorporated areas of Suisun City. The remaining tidal wetlands are impacted by secondary effects of development (e.g., increased fire frequency, chemicals, domestic animals), and are extremely vulnerable to additional secondary effects. The San Francisco Estuary EcoAtlas provides a starting point for this information:
http://www.sfei.org/ecoatlas/Habitat/maps/subregion/hsuis.html
http://www.sfei.org/ecoatlas/Habitat/maps/subregion/msuis.html

The Plan should directly address opportunities for partnerships with other overlapping conservation planning efforts in the region. Provided background information indicates the Suisun Marsh is already protected by the Suisun Preservation Act and Suisun Marsh Plan of Protection. However, the primary and secondary protection areas envisioned by these agreements have been compromised in the past by annexation of buffer lands to Suisun City for development. The protection plans for Suisun were developed 20 to 30 years ago with the single goal of protecting waterfowl habitat and private hunting lands. As such, they are inadequate for ecosystem-focused resource management and conservation planning in the Suisun Marsh. The Solano County NCCP/HCP applicants should address overlap, integration and potential participation in other ongoing regional planning efforts related to Suisun Marsh.

6.4 THREATS TO RIPARIAN HABITAT

The ecological and physical function of Solano County streams have been severely impaired and continue to be threatened by a variety of human activities, principally:

- channelization, straightening the stream channel and confining it within levees, most of which are regularly cleared to remove riparian vegetation;
- water diversion, reducing and/or altering natural hydrographs;
- installation of dams and weirs, structures usually associated with water diversions and which present barriers to upstream and downstream movement of fishes; and
- impaired water quality resulting from urban and agricultural runoff.

These alterations have resulted in the rapid reduction in riparian vegetation and associated habitat. However, because of the high ecological and biological diversity value of these riparian habitats and because many of the these streams retain some ecological and physical function, they represent important conservation and restoration opportunities within Solano County. Reserve design and management objectives should include:

- incorporation of setback levees into flood control planning to restore and maintain riparian and floodplain habitat;
- conservation and/or restoration of natural seasonal hydrographs to allow natural stream processes to maintain channel form, provide flood flow passage and maintain riparian vegetation;
- removal of barriers to fish passage and/or installation of fish passage structures (e.g., fish ladders); and
- control and/or removal of non-native invasive vegetation (e.g., eucalyptus, giant reed).

6.5 INVASIVE SPECIES

Invasive exotic species are recognized as second only to direct habitat destruction as a threat to imperiled plants and animals nationwide (Wilcove et al. 1998). Although exotic species most commonly invade via disturbed linear corridors, such as roadsides, under some conditions movement of exotics may also be facilitated by conservation measures to connect wildlands. We recommend an aggressive invasive species control program to eradicate feral hogs and invasive plants and animals, accompanied by an education program for resource managers and the general public that demonstrates the threats and consequences of exotic species introductions. This education program will be essential to preserve and protect conservation reserves.

It is believed feral hogs were introduced to Suisun Marsh by a private hunting club. It is well documented that red fox was introduced to San Francisco Estuary by a private hunting club. Red fox is directly linked to clapper rail and shorebird declines. Private hunting club members openly admit to shooting coyotes, as they are perceived as a threat to nesting waterfowl. Coyotes out-compete exotic red fox in territory establishment, and red fox are far more effective predators of nesting birds than coyotes. In the recent past, the Solano Resource Conservation District distributed exotic, invasive plants (tamarisk, pampas grass, and others) for planting within diked wetlands of the County. These plants have invaded adjacent sensitive habitat, and now significant resources will be required to eradicate these intentional introductions.

The California Department of Fish and Game and private pheasant hunting clubs continue to introduce ring-necked pheasants to Solano open space lands. These non-native birds have invaded adjacent reserves where hunting is prohibited and are now the most common species on point-count surveys in tidal marsh. Male pheasants have displayed aggressive behavior towards clapper rails. The California Department of Fish and Game has introduced non-native wild turkeys, which are spreading in Solano upland reserves and altering local food webs. Unless these species are actively controlled (or, ideally, eradicated), habitat corridors between reserve lands could result in threats to new reserves.

6.6 RESERVE DESIGN ISSUES

Landscape ecology is often ignored in reserve design (Noss et al. 1997). The natural environmental gradients and habitat mosaics across the planning region should serve as the ideal model for design of a conservation reserve network. We recommend that the Plan identify and implement opportunities for conservation of unfragmented habitat gradients at local and regional scales. In particular, the Plan should consider opportunities for connections between open space reserves in the Vaca Mountains, Coast Range, and the Suisun Marsh. Historic movement of large mammals between these uplands and the Suisun Marsh is now constrained by urbanization and highways. Observations of black bear, mountain lion, coastal black-tailed deer, and coyote movement between County upland areas and the Suisun Marsh indicate continued movement of mammals between these habitat areas, but wildlife under/overpasses and connected reserves would facilitate a partial return to historic ecological food webs throughout the region. We recommend the development of design standards, such as elevated roadways, to accommodate wildlife movement across roads. We strongly encourage planners to work with Caltrans to implement these standards. Without effective highway crossings, for example along Highway 12 west of Fairfield, increased traffic and highway upgrades threaten to permanently isolate populations of many species south and north of the highway.

We suggest that reserve designs conserve and restore historic gradients between wetland and upland habitats. In particular, reserve planning should include opportunities for conservation and restoration of historic gradients of tidal marsh to vernal pool and native grasslands. Habitat linkage between Suisun tidal wetlands, low terrace – Suisun region vernal pools, and the Greater Jepson Prairie Ecosystem should be considered. Historic stands of *Leymus triticoides* can still be found at low gradient tidal marsh ecotones, and this native grass provides a very different high-tide refugial habitat structure for threatened birds and small mammals than the more common exotic Mediterranean grasses.

Reserve planning should balance the local desire for agricultural open space with planned restoration of native grasslands and reintroductions of large native herbivores. A substantial portion of existing upland reserve lands surrounding Suisun Marsh are exotic grasslands grazed by cattle. Reserve managers such as the Solano Land Trust partially rely on grazing leases for operation expenses and are guided by a Board that largely represents agricultural interests. The agricultural community in Solano County values preservation of historic agricultural grazing. As less grazing lands are available in the region due to increasing urbanization, open space reserves are impacted by intensive grazing pressure. Offsite impacts include increases in nutrient loading and sedimentation from erosion into receiving waters. Vernal pool ecologists acknowledge that cattle disturbance at pool edges preserves some ecological functions previously provided by large native mammals. The reintroduced tule elk herd occupying diked wetlands and uplands of Grizzly Island was intended to provide animals for regional reintroductions, and tule elk have been successfully reintroduced to Concord Naval Weapons Station buffer lands on the south shore of Suisun Bay. Conservation and restoration of native

grasslands and reintroductions of tule elk could enhance conservation reserves in Solano County.

6.7 CONSIDERATION OF ECOLOGICAL PROCESSES AND SECONDARY IMPACTS

Urbanization alters local tidal regimes, increases estuarine pollution, and introduces perennial freshwater into brackish and saline aquatic systems. Tidal marsh exists at the interface between terrestrial habitats and open water of Suisun Bay. These brackish and salt marshes exist where disturbance from water motion is moderate enough to allow the accumulation of sediment and growth of wetland angiosperms. Ecological processes important in maintaining the structure and function of theses marshes include the frequency and magnitude of tidal inundation, soil and water salinity, nutrient availability, and maintenance of historic interactions between species within the marsh. Endemic species in these marshes have narrow habitat requirements and can be impacted by subtle changes in tidal elevations and seasonal changes in historic freshwater runoff patterns. We are concerned that the species accounts provided for the Plan do not adequately make the connection between species life history, habitat needs, and essential ecological processes.

At a landscape scale, maintenance of estuarine salinity variability is important for maintenance of historic habitats and species. Increased urban demand for freshwater supply has led to management for predictability of water quality over time. The desire to keep Delta and Suisun Marsh channels as fresh as possible each year to support urban water supply diversions and artificial waterfowl habitat has been detrimental to many endemic species. The State Water Quality Control Board (SWRCB) established historic water salinity standards for Suisun Marsh channels that did not previously consider the ecological benefits of natural climate-related salinity variations in brackish tidal marshes. These standards are now being revaluated by the SWRCB in light of broader ecological considerations. Local drainages into Suisun channels from Solano County are largely ephemeral streams. We suggest the Plan specifically address the impacts of perennial freshwater discharge from urban and agricultural drains, and expanded wastewater treatment discharges into tidal channels.

Increased runoff from impermeable urban surfaces carries pollutants into sensitive habitats. We suggest the applicants limit the discharge and diversion of water to and from ecologically significant watersheds to protect conservation reserves. The plan should limit irrigation and urban runoff into sensitive habitat and protected areas

Tidal marshes can improve water quality by reducing turbidity, temporarily or permanently retaining pollutants into wetland vegetation and sediments, and converting some chemicals to less harmful forms. However, relying on sensitive wetlands for these water quality improvements can also pose threats to sensitive species due to aquatic toxicity and magnification through the food web. We suggest that the Plan specifically address mitigation of secondary impacts from increased capacity and discharge by the Fairfield-Suisun Regional Wastewater Treatment Plant, and other project area wastewater

treatment facilities. Current discharge of freshwater into brackish and saline receiving waters of Suisun Marsh and the Napa River change habitat structure and threaten native species. We recommend consideration of the historic seasonality of discharges, where freshwater discharges were limited to the November-March period. Moreover, we recommend an evaluation of the use of constructed freshwater wetlands for wastewater treatment to eliminate or reduce the negative impacts of freshwater discharge into Suisun tidal sloughs.

We suggest that the Plan evaluate how secondary impacts from expansion of landfill facilities will affect sensitive species and habitats. Expansion of the Potrero Hills Landfill has resulted in the need for wetland mitigation, and the existing mitigation project has caused direct loss of federally endangered species on adjacent property. There are other examples of mitigation projects in Solano County that have resulted in impacts to non-target sensitive species. We suggest the Plan applicants anticipate these threats and address them in the conservation plan.

Construction of new housing developments will alter hydrologic regimes, rerouting requisite water to sensitive wetland habitat. Increased sediment loads from development-associated runoff may increase wetland elevations and change community structure. Recent development in the Cordelia - Green Valley area of Solano County increased sediment loads and changed habitat conditions in Cordelia Slough and associated tidal wetlands. We suggest the Plan address future offsite impacts, and include an urban runoff pollution elimination or reduction program.

6.8 STEWARDSHIP ON SOLANO RESERVE LANDS

The Jepson Prairie Preserve serves as a model for Solano open space lands with active management, stewardship, and applied conservation ecology research through joint cooperation between Solano Land Trust and the University of California Natural Reserve System. Many Solano public lands, including other SLT lands, are not adequately funded for active stewardship, or have not placed sensitive species conservation and recovery at a high priority. We recommend that the Plan develop mechanisms for correcting this deficiency.

The Suisun thistle provides an example of a species that requires active management under modern conditions. This is a documented case of a formerly abundant plant, known historically to Solano County and nowhere else in the world, which has experienced a precipitous decline that has accelerated while the last populations of this species are on "protected reserve lands." We recommend that the Plan fully address the long-term funding needs for scientific research in support of conservation-based management decisions and stewardship of existing and future open space reserves in the County. It is pointless to delineate conservation reserves on a map, if habitat degradation continues on reserve lands.

Several habitat conservation plans are being developed in Solano County as independent efforts. The CALFED Charter program for conservation planning in Suisun Marsh is a

direct response to conflicts among Solano stakeholders and endangered species recovery planning. CALTRANS and other agencies also have projects planned for the County that require environmental compliance and mitigation. The lack of coordination and planning of conservation reserves could undermine the success of this NCCP/HCP.

The scientific integrity of this Plan will be compromised if institutional coordination is not improved. In the past ten years, there have been examples of wetland mitigation projects in Solano County that have resulted in significant negative impacts to sensitive species and habitat on adjacent lands. Some mitigation projects currently underway in the County have eliminated endangered species populations. This trend threatens the future success of regional conservation planning to offset the environmental costs of development. We recommend the Plan clearly define a mechanism for coordination between the multitude of conservation and mitigation efforts within Solano County, with actions identified to protect sensitive resources at local and landscape scales.

We suggest that the Plan clearly identify an oversight management authority for Solano conservation reserves and an institutional mechanism for implementation of adaptive management. The existing Solano Land Trust could be a good choice for this role, if the SLT Board of Directors is restructured to represent a balance of agricultural and wildland conservation interests. In addition, we recommend the Plan clearly identify scientific standards and criteria for making decisions about conservation of species and authorization of incidental take under the ESA.

LITERATURE CITED

ABAG 2002. Human population data obtained from the Association of Bay Area Governments (ABAG) website at: http://www.abag.ca.gov/abag/overview/datacenter/popdemo/poplist.html

Arnold, A. 1996. Suisun Marsh history: hunting and saving a wetland. Monterey Pacific Publishing Company, Marina, CA.

Arnold, R.A. 1981. Distribution, life history, and status of three California Lepidoptera proposed as endangered or threatened species. Final report for California Department of Fish and Game. 39 pp.

Arnold, R.A. 1989. Evaluation of habitat quality for the threatened Delta green ground beetle in the vicinity of the Jepson Prairie Preserve for PGT and PG&E's gasline expansion project. Report prepared for Pacific Gas & Electric Co. by Entomological Consulting Services. 25 pp.

Arnold, R.A. 2002. 2002 monitoring report on the Valley elderberry longhorn beetle for PG&E's gasline expansion project. Report prepared for Pacific Gas and Electric Co. by Entomological Consulting Services. 28 pp. & figures.

Atwater, B.F., S.G. Conard, J.N. Dowden, C.W. Hedel, R.L. MacDonald, and W. Savage. 1979. History, landforms, and vegetation of the estuary's tidal marshes. Pages 347–386 in T.J. Conomos, editor. San Francisco Bay: the urbanized estuary. Pacific Division, American Association for the Advancement of Science, San Francisco.

Barbour, M., B. Pavlik, F. Drysdale, and S. Lindstrom. 1993. California's changing landscapes. California Native Plant Society, Sacramento, California, USA.

Barclay, J., C. Bean, D. Plumpton, and B. Walton. 1998. Burrowing owl conservation in California: issues and challenges. California Burrowing Owl Consortium paper, Second International Burrowing Owl Symposium, Ogden, UT. Unpublished.

Barr, C. 1991. The distribution, habitat, and status of the Valley elderberry longhorn Beetle. U.S. Fish and Wildlife Service. Sacramento, CA. 133 pp.

Baskin, Y. 1994. California's ephemeral vernal pools may be a good model for speciation. BioScience 44:384-388.

Bates, L.A., W.E. Dollarhide, G.R. Kliewer, G.J. Staidl, and C.B. Goudey. 1977. Soil Survey of Solano County, California. U.S. Govt. Printing Office, Washington, DC.

Baye, P.B., P.M. Faber, and B.J.Grewell. 2000. Tidal marsh plants of the San Francisco Estuary. Pages 9-32 in P.R. Olofson, editor. Goals Project Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. San Francisco Bay Area Wetlands Ecosystem Goals Project. San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Beare, P.A. and J.B. Zedler. 1987. Cattail invasion and persistence in a coastal salt marsh: the role of salinity reduction. Estuaries 10:165-170.

Belk D. Fugate M. 2000. Two new Branchinecta Crustacea: Anostraca) from the southwestern United States. Southwestern Naturalist 45(2):111-117.

Bilby, R. E., B. R. Fransen and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon in the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bossard, C.C., J.M. Randall, and M.C. Hoshovsky. 2000. Invasive plants of California's wild lands. University of California Press, Berkeley.

Bradbury, M.A. 2002. Swainson's hawk adaptation to, and dependence on, specific agricultural practices and crop types in California's Central Valley. Swainson's Hawk Technical Advisory Committee paper, North American Ornithological Conference, New Orleans, LA. Unpublished.

Buggy Data Base. 2002. Report of occurrences for Solano County and special-status invertebrates. Data base maintained by Entomological Consulting Services, Ltd. Pleasant Hill, CA.

Burcham, L.T. 1957. California Rangeland. Calf. Department of Natural Resources, Division of Forestry. 261 pp.

Busby, P. J., T. C. Wainwright, G J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Seattle.

California Native Plant Society (CNPS). 2001. Inventory of Rare and Endangered Plants of California (Sixth edition).Rare Plant Scientific Advisory Committee, D.P. Tibor, convening editor. California Native Plant Society. Sacramento, CA. x + 388 pp.

California Natural Diversity Data Base. 2002. Report of occurrences for Solano County and special-status invertebrates. Data base maintained by California Dept. of Fish and Game. Sacramento, CA.

Caraco, N.F., 1995. Influence of human populations on P transfers to aquatic ecosystems: A regional scale study using large rivers. Pages 235-244 in H. Tiessen, editor. Phosphorus in the global environment. John Wiley and Sons.

Center for Biological Diversity. 2001. Petition to the State of California Fish and Game Commission supporting information for the California tiger salamander (*Ambystoma californiense*). Available online at www.biologicaldiversity.org.

Chaplin, S.J., R.A. Gerrard, H.M. Watson, L.L. Master, and S.R. Flack. 2000. The geography of imperilment: targeting conservation toward critical biodiversity areas. Pages 159-199 in B.A. Stein, L.S. Kutner, and J.S. Adams, editors. Precious heritage: the status of biodiversity in the United States. Oxford University Press, Oxford, U.K.

Chuang, T.I. and L.R. Heckard. 1971. Observations of root-parasitism in *Cordylanthus* (Scrophulariaceae). American Journal of Botany 58:218-228.

Cole, J.J., Peierls, B.L., Caraco, N.F., and Pace, M.L., 1993. Nitrogen loading of rivers a human driven process. Pages 141-157 in M.J. McDonnell and S.T.A. Pickett, editors. Humans as components of ecosystems: the ecology of subtle human effects and populated areas. Springer-Verlag, New York.

Collins, J.N., J.G.Evens, and B.J. Grewell. 1993. A synoptic survey of the distribution and abundance of the California clapper rail (*Rallus longirostris obsoletus*) in the

northern reaches of the San Francisco Estuary during the 1992 and 1993 breeding seasons. Final Report to California Department of Fish and Game, Yountville.
Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe.1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. USFWS Biological Services, Washington, D.C. 103 pp.
Crampton, B. 1976. Rare grasses in a vanishing habitat. Fremontia 4:22-23.
Dains, V. 1995. A study of Contra Costa goldfields (*Lasthenia conjugens*) at Potrero Hills and other locations in Solano County. Unpublished report submitted to Global Environmental, Sacramento, CA.
Department of Water Resources. 1994. Summary of sensitive plant and wildlife resources in Suisun Marsh during water years 1984 – 1994. California Department of Water Resources, Environmental Services Office report to State Water Resources Control Board in support of the Bay-Delta Water Quality Control Plan.
De Weese, J.M. 1998. Vernal pool construction monitoring methods and habitat replacement evaluation. Pages 217-223 in C.W. Witham, editor. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, CA.
Eriksen, C.H. and Belk, D. 1999. Fairy shrimps of California's puddles, pools, and playas. Mad River Press, Inc. Eureka, CA. 196 pp.
Evens, J.G. and J.N. Collins. 1992. Distribution, abundance and habitat affinities of the California clapper rail (*Rallus longirostris obsoletus*) in the northern reaches of the San Francisco Estuary during the 1992 breeding season. Avocet Research Associates final report to California Department of Fish and Game, Yountville.
Evens, J.G., G.W. Page, L.E. Stenzel, S.A. Laymon, And R.W. Stallcup. 1989. Distributions, relative abundance, habitat use, and status of the California black rail in western North America. Point Reyes Bird Observatory Contribution 502.
Federal Register. 1997. Endangered and threatened wildlife and plants; endangered status for four plants from vernal pools and mesic areas in northern California. Federal Register 62:33029-33038.
Ferren, W R. Jr, P.L. Fiedler, and R.A. Leidy. 1996. Wetlands of the Central and southern California Coast and Coastal Watersheds: a methodology for their classification and description. Final report to United States EPA Region IX San Francisco. (http://ucpeps.berkeley.edu/wetlands/titlepag.html)
Fiedler, P.L and R.K. Zebell. 1995. Rare plant resource mitigation and restoration plan for the Montezuma Wetlands Project. San Francisco State University, Dept. of Biology report to Levine-Fricke. June 1995.
Foerster, K.S., J.E. Takekawa, and J.D. Albertson. 1990. Breeding density, nesting habitat, and predators of the California clapper rail. San Francisco Bay National Wildlife Refuge Report SFBNWR-11640-90-1. Newark, CA.
Fraser, J.P Munro. 1879. The history of Solano County. Wood, Alley, & Co. Limited First Edition Reprint, 1994. James Stevenson Publisher. Fairfield, CA. 566 pp.
Frost, J. 1970s (no date). A pictorial history of Grizzly Island. Self-published.
Gill, R.E. 1979. Status and distribution of California clapper rail (*Rallus longirostris obsoletus*). California Fish and Game 65(1):36-49.

Goals Project, 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. 209pp + appendices.

Goulet, H. 1983. General of Holarctic Elaphrini and species of *Elaphrus* (Fabricius) (Coleoptera: Carabidae): classification, phylogeny, and zoogeography. Quest. Entomology 19:291-482.

Greene, E.L. 1892. Ecologae botanicae. I. New or noteworthy thistles. Proceedings of the Academy of Natural Sciences, Philadelphia 44:352-363.

Grewell, B.J., M.A. DaPrato, P.R. Hyde, and E. Rejmankova. In preparation. Experimental reintroduction of endangered soft bird's beak to restored habitat in Suisun Marsh. Project 99-N05 Final Report to CALFED Ecosystem Restoration Program. University of California, Davis.

Grinnell, J., J.S. Dixon, and J.M. Linsdale. 1937. Fur-bearing mammals of California: their natural history, systematic status and relations to man. 2 Vols. University of California Press, Berkeley. 777 pp.

Grossinger, R. 2001. Documenting Local Landscape Change: The Bay Area Historical Ecology Project. In D. Egan, and E. Howell, editors. The historical ecology handbook: a restorationist's guide to reference ecosystems. Island Press, Washington, D.C.

Halsted, J. and Oldham, J. 2000. New distribution records for the Elderberry Longhorn beetle, *Desmocerus californicus* Horn (Coleoptera: Cerambycidae). Pan-Pacific Entomologist 76:74-76.

Harper, J.A., J.H. Harn, W.W. Bentley, and C.F. Yocum. 1967. The status and ecology of the Roosevelt elk in California. Wildlife Monographs 16: 49 pp.

Harvey, T.E., K.J. Miller, R.L. Hothem, M.J. Rauzon, G.W. Page, and R.A. Keck. 1992. Status and trends report on wildlife of the San Francisco Estuary. US Fish and Wildlife Service, Sacramento.

Hedgpeth, J.W. 1979. San Francisco Bay – the unsuspected estuary: a history of researches. Pages 9-29 in R.J. Conomos, editor. San Francisco Bay – the urbanized estuary. Pacific Division, American Association for the Advancement of Science. San Francisco.

Helfield, J. M. and R. J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. Ecology 82: 2403-2409.

Helm, B.P. 1998. Biogeography of eight large branchiopods endemic to California. Pages 124-139 in C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. Proceedings from a 1996 conference. California Native Plant Society. Sacramento, CA. 283 pp.

Holland, R.F. 1986. Preliminary descriptions of the terrestrial natural communities of California. Unpublished report. California Department of Fish and Game, Sacramento, CA.

Holland, R.F. 1998. Great Valley vernal pool distribution, photorevised 1996. Pages 38-49 in C.W. Witham, editor. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, CA.

Holroyd, G.L., R. Rodriguez-Estrella, and S.R. Sheffield. 2001. Conservation of the

burrowing owl in western North America: issues, challenges, and recommendations. Journal of Raptor Research 35(4):399-407.
Jameson, E.W., Jr. and H.J. Peeters. 1988. California mammals. University of California Press, Berkeley. 403 pp.
Keeley, J. E., and P. H. Zedler. 1998. Characterization and global distribution of vernal pools. Pages 1-14 in C. W. Witham, editor. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California, USA.
King, J. L., and R. Hanner. 1998. Cryptic species in a "living fossil" lineage: taxonomic and phylogenetic relationships within the genus *Lepidurus* (Crustacea: Notostraca) in North America. Molecular Phylogenetics and Evolution 10(1):23-36.
Letcher, R., L.J. McKee, W. Merritt, T. Jakeman, and B. Eyre. 1999. Review paper on techniques to estimate catchment pollutant export. NSW Environment Protection Authority Technical Report 99/73, Sydney.
Lonzarich, D.G., T.E. Harvey, and J.E. Takekawa. 1992. Trace element and organochlorine concentrations in California clapper rail (*Rallus longirostrus obsoletus*) eggs. Arch. Environ. Contam. Toxicol. 23:147-153.
LSA Associates, Inc. 2002. Biological Resources. Solano NCP/NCCP, Solano County Water Agency.
Mason, H. L. 1972. Vascular marsh plant communities of Part II study area: benthic and palustrine plant communities of the shorelines of San Francisco, San Pablo, and Suisun Bays. In C.L. Newcombe and H.L. Mason, editors. An environmental inventory of the north San Francisco Bay-Stockton ship channel area. San Francisco Bay Marine Research Center, Inc. Lafayette, CA.
McEwan, D. 2001. Central Valley steelhead. Contributions to the Biology of Central Valley Salmonids. Vol. 1. California Department of Fish and Game, Fish Bulletin 179: 1-43.
McKee, L.J., and Eyre, B.D., 2000. Nitrogen and phosphorus budgets for the sub-tropical Richmond River catchment, Australia. Biogeochemistry 50:207-239.
McKee, L., and S. Pearce. 2002. Sediment Processes. Chapter 3 in L. McKee, J. Leatherbarrow, J. Davis, and S. Pearce, editors. A review of urban runoff processes in the Bay Area: existing knowledge, conceptual models, and monitoring recommendations. Report prepared for the Sources Pathways and Loadings Workgroup (SPLWG). San Francisco Bay Regional Monitoring Program for Trace Substances (RMP), San Francisco Estuary Institute, Oakland CA, Draft July 2002.
Moyle, P.B. 2002. Inland fishes of California. University of California Press, Ltd.: London, England.
Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.
Noss, R.F., M.A. O'Connell, and D.D. Murphy. 1997. The science of conservation planning: habitat conservation under the Endangered Species Act. Island Press, Washington, D.C.

Rantz, S.E., 1971. Precipitation depth-duration-frequency relations for the San Francisco Bay region, California. U.S. Geological Survey Professional Paper 750-C, C237-C241.

Rantz, S.E., 1972. Runoff characteristics of California streams. U.S. Geological Survey Water-supply Paper 2009-A. 38pp + map.

Rogers, C.D. 2001. Revision of the Nearctic *Lepidurus* (Notostraca). Journal of Crustacean Biology 21(4):991-1006.

Ruygt, J. 1994. Ecological studies and demographic monitoring of soft bird's beak (*Cordylanthus mollis* ssp. *mollis*) a California listed rare plant species. Unpublished report the California Department of Fish and Game. Yountville, CA.

Schmutz, J.K. 1987. The effect of agriculture on ferruginous and Swainson's Hawks. Journal of Range Management 40(5):438-440.

Scrivener, J. C., T. G. Brown and B. C. Andersen. 1994. Juvenile chinook salmon (*Oncorhynchus tshawytscha*) utilization of Hawks Creek, a small and nonnatal tributary of the upper Fraser River. Canadian Journal of Fisheries and Aquatic Sciences 51:1139-1146.

Smetana, A. 1980. Revision of the genus *Hydrochara* Berth (Coleoptera: Hydrophilidae). Memoirs of the Entomological Society of Canada 3:1-85 plus figures.

Sorenson, A.A., R.P. Greene, and K. Russ. 1997. Farming on the edge. American Farmland Trust, Washington, DC.

Steinhart, P. 1990. California's wild heritage: threatened and endangered animals in the golden state. California Department of Fish and Game Publication, Sacramento. 108 pp.

Thorpe, R.W. and J.M. Leong. 1998. Specialist bee pollinators of showy vernal pool flowers. Pages 169-179 in C.W. Witham, editor. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, CA.

Trenham, P. C. Jr. 1998. Demography, migration, and metapopulation structure of pond breeding salamanders. Unpublished Ph.D. dissertation, University of California, Davis.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Valley elderberry longhorn beetle. Portland, OR. 62 pp. (prepared by Richard A. Arnold).

U.S. Fish and Wildlife Service. 1985. Delta green ground beetle and Solano grass recovery plan. Portland, OR. 68 pp. (prepared by Richard A. Arnold and Robert F. Holland).

U.S. Fish and Wildlife Service. 1995. Endangered and threatened wildlife and plants, proposed Endangered status for two tidal marsh plants: the Suisun thistle and soft bird's beak from the San Francisco Bay Area; Proposed Rule. June 12, 1995. Federal Register 60(112):30999-31006.

U.S. Fish and Wildlife Service. 1999. Biological opinion for the Solano project water service contract renewal. 107 pp. & append.

U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California red-legged frog (*Rana aurora draytonii*). Region 1, U.S.F.W.S., Portland, OR. May 28, 2002. 173 p.

Vollmar Consulting. 1997. Draft biological assessment for the proposed Meyer Business Park, Fairfield, Solano County, California. Report submitted to the U.S. Army Corps of Engineers, San Francisco, CA.

Waananen, A.O., J.T. Limerinos, W.J. Kockelman, W.E. Spangle, and M.L. Blair. 1977. Flood-prone areas and land-use planning - Selected examples from the San Francisco Bay region, California. U.S. Geological Survey Professional Paper 942.

Wagner, D.L., C.W. Jennings, T.L. Bedrossian, and E.J Fortugno. 1981. Geologic Map of the Sacramento Quadrangle, California, 1:250,000. Map No. 1A. California Division of Mines and Geology, Sacramento, CA.

Wagner, D.L. and E.J. Bortugno. 1982. Geologic map of the Santa Rosa Quadrangle, California, 1:250,000. Map. No 2A. California Division of Mines and Geology, Sacramento, CA.

Wells, L.E. 1995. Environmental setting and quaternary history of the San Francisco Estuary. In: Sanguines, E.M. and D. Anderson (eds) Geology and hydrogeology of the south San Francisco Bay Region. Pacific Section, SEPM.

Whittig, L.D. and P. Janitsky. 1963. Mechanisms of formation of sodium carbonate in soils. I. Manifestations of biological conversions.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.

Wilcox, C. In review. Spatial structure in two fairy shrimp metapopulations (Branchiopoda: Anostraca, Branchinecta lynchi and Linderiellaoccidentalis): potential mechanisms and implications for reserve design. Submitted to Journal of Animal Ecology.

Willson, M. F., S. M. Gende and B. H. Marston. 1998. Fishes and the forest: expanding perspectives on fish-wildlife interactions. Bioscience 48: 455-462.

Zedler, J.B. 1983. Freshwater impacts in normally hypersaline marshes. Estuaries 6:346-355.

Zedler, P.H. and C. Black. 1992. Seed dispersal by a generalized herbivore: rabbits as dispersal vectors in a semiarid California vernal pool landscape. American Midland Naturalist 128:1-10.

Zeiner, D. C., W. F. Laudenslayer, and K. E. Meyer. 1988. California's Wildlife, Vol. 1, Amphibians and Reptiles-California Statewide Wildlife Habitat Relationships System, California Dept. of Fish and Game.

APPENDIX A: Solano County NCCP/HCP Science Questions Organized by Issue

To help focus the science advisor's input, and to ensure the full range of pertinent scientific issues are addressed, a draft list of science questions has been developed. The list of questions provided below is the first step to developing the framework for the agenda and discussions the Science Advisor Group will undertake during their workshop scheduled for August 19, 20, 2002. Each section, e.g., species/habitats or reserve design, follows broad categories and acts as a guide for the advisor's discussion. More specific questions related to each section will be added according to stakeholder input. It should be noted that questions sent to the Science Advisor group must be limited to those that can be addressed using scientific knowledge and tools but cannot pertain to non-scientific issues such as societal values, economics, or environmental laws.

Vance Russell and Bruce DiGennaro of Kleinschmidt will act as the facilitators for the Science Advisor Group. They will also serve as liaisons between the Science Advisor Group and Stakeholders, NCCP/HCP Consultants, the Resource Agencies (DFG, USFWS and NMFS) and Solano County Water Agency. **If you have any comments or questions to add to this list, please send them to Vance Russell at Vance.Russell@KleinschmidtUSA.com.**

A. Species/Habitats

- Discuss and develop principles for conservation of target species and habitats.
- What are the specific, current and 30-50 year threats to species and habitats?
- Review species and communities list and discuss the following (be as inclusive as possible, do not presume coverage of species or activities):

    - Determine species with sufficient information and baseline data to make conservation decisions;
    - Identify species which require substantial additional data or additional conservation measures;
    - What prior and existing data gaps exist? If significant data gaps exist, what methods/models are recommended for overcoming this lack of information? If models are recommended, which models, assumptions, parameters and testing are recommended?
    - Suggest additional species for consideration; and
    - Discuss appropriateness of community designations/distinctions.

- What are the important community and guild relationships to conserve in Solano County?
- What important species-habitat relationships exist (for example, *Lasthenia conjugens* range is restricted to habitat with residual alkalinity)?
- How does genetic diversity affect population viability for the given target species?
- Are there genetic bottlenecks that should be considered?
- Are there genetically vulnerable populations that exist in the area and what actions may be taken to reduce this vulnerability?
- How vulnerable are the species and habitats of concern in Solano County to non-native invasive species?
- Are invasives an existing problem or a future threat? What are some future scenarios for potential invasions and possible invasion corridors?

- What specific management/control strategies should be considered, and how do these strategies impact the reserve design?
- Should buffers be considered as a means of protecting against invasives, and what would be an adequate buffer width for the potential invasives of concern?
- What are the potential impacts of invasive species to listed species genetic diversity?

B. Reserve Design

- Determine and prioritize reserve design principles applicable to the Solano County HCP/NCCP.
- What is the size of required habitat for focal species?
- Using existing information and knowledge indicate species- and habitat-specific characteristics of potential reserves. Prioritize the most important sites for reserves.
- What key areas could serve as corridors for various species?
- What objective methods are recommended for designing a necessary and sufficient reserve system to meet plan goals?
- Are explicit reserve selection algorithms, e.g., SITES or MARXAN, recommended, and is existing data sufficient for their application? How can scientifically justifiable goals be set for such methods?
- Identify any areas critical to reserve design, e.g., biodiversity "hotspots", crucial linkages, rare microhabitats, genetically unique population areas and source populations.
- How can reserve design principles effectively be applied to the linear aquatic habitats of streams?
- Using general indicators to species and habitat such as threats or population status, discuss and prioritize sensitive or unique resources including both those impacted and not impacted by future development or adverse environmental conditions (e.g., non-point source pollution, or human induced habitat destruction).
- How much human access and activity should be allowed in reserve areas?

C. Monitoring/Performance

- Discuss and suggest principles and a framework for adaptive management applicable to the Solano County HCP/NCCP. If possible, include conceptual models showing relationships between species, community, and landscape level conservation.
- What are the current data gaps in Solano County? What key research questions related to the HCP/NCCP still need to be addressed? What uncertainties, hypotheses and conservation assumptions are being made relative to the HCP/NCCP?
- How do you measure conservation success once the plan is approved and implemented?
- Which species, habitat and ecosystem indicators can serve to monitor species viability and other ecological characteristics important to the HCP/NCCP?
- Discuss and suggest protocols for implementing monitoring.

D. Ecosystem Function

- What specific ecological processes (e.g., fire or hydrology) are important to the habitats and species of concern in Solano County? What is the current status of these processes?
- What long-term processes or cycles, such as population dynamics, disturbance cycles, and migration, need to be considered?

- How do these processes relate to and affect the function and structure of specific habitats and target/listed species?
- Are there existing or potential foreseeable threats to important ecological processes that could adversely impact the goals of the plan? Discuss specific threats and stressors and how they affect, or may affect, ecosystem processes.
- How can key processes be protected or restored? Are there specific reserve design features such as size or shape that would aid or facilitate maintenance of key processes?

E. Water and Air Quality / Urban Runoff

- What are the potential impacts of non-point source pollution on target species?
- Are existing non-point source standards adequate for protection of target species? Suggest appropriate standards for consideration.
- Are there guidelines regarding the effectiveness of passive and active treatments, e.g., bio-filtration or nuisance flows reductions, which might be suggested?