Report of Independent Science Advisors for Yolo County Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP)

Prepared For
Yolo County Habitat/Natural Community Conservation Plan Joint Powers Agency

Prepared By
The Independent Science Advisors:

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With Contributions From
Stanley Gregory

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Attachments

Executive Summary

This report summarizes recommendations from a group of independent science advisors for the Yolo County Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP). This scientific input is provided early in the planning process, before preparation of a draft plan, to help ensure that the plan is developed using best available science. To ensure objectivity, the advisors operate independent of the Yolo County Habitat/Natural Community Conservation Plan Joint Powers Agency (JPA), its consultants, or any other entities involved in the NCCP/HCP. Our recommendations are advisory only and are not binding on NCCP/HCP participants.

In some cases our advice may extend beyond what was expected by the JPA, relative to the current scope of the NCCP/HCP. For example, although the JPA is not seeking permit coverage for aquatic species or flood-control projects through the plan, we offer recommendations concerning these issues (1) in case the plan is ever expanded to address them, (2) because even development projects in terrestrial habitats can affect aquatic species, and (3) because the plan has potential to contribute to the recovery of aquatic resources in coordination with other planning or regulatory mechanisms. For example, throughout this document we offer suggestions for where the NCCP/HCP may complement the goals of such other planning efforts as the County's Integrated Regional Water Management Plan.

Our recommendations are organized by the following major topics: (1) the scope of the plan, (2) review of existing information, (3) conservation design approaches, (4) conservation analyses, and (5) adaptive management and monitoring.

Scope of the Plan

The scope of an NCCP/HCP includes its biological goals, geographic area, plan duration, species to be addressed, and actions to be permitted. The plan area (all of Yolo County) and duration (50 years) are appropriate and we offer no further comments on them. However, the biological goals of the plan are not fully articulated, and the lists of species and actions to be addressed continue to evolve. We therefore make the following recommendations about goals, species, and covered actions.

Biological Goals

The advisors recommend creating an explicit, hierarchical framework of goals and objectives to provide a transparent and logical format for planning, implementing, and monitoring an NCCP/HCP. The framework should tier off of the overarching goals of the NCCP program, which are "to sustain and restore those species and their habitats… that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape" and "to conserve, protect, restore, and enhance natural communities." Based on these broad goals, we recommend defining measurable objectives tailored to the specific ecological setting, species, habitats, and conditions of concern in the planning area. These objectives, in turn, should be used to develop explicit, resource-specific criteria to guide plan development and to define monitoring and adaptive management actions. Text Box 1 illustrates this hierarchical approach.

Box 1. *One example of how goals, objectives, and criteria can be placed in a hierarchical structure to support plan development and define monitoring criteria:*

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Goal 1 (based on language in SB 107). Conserve, restore, and manage representative samples of all natural and semi-natural landscapes in Yolo County in a manner that sustains their natural ecological functions, biological diversity, and viable populations of covered species.

Goal 1a. Conserve representative samples of each native vegetation community type in a size and configuration sufficient to support viable populations or metapopulations of associated target species.

Objective 1a1. Conserve at least xx% of remaining grasslands and manage to sustain native biodiversity, guided by the following criteria:

- Conserve the largest contiguous blocks of grassland in an arrangement that allows for continued use by the most area-dependent grassland species (e.g., American badger).
- Conserve all remaining grasslands that support vernal pools with sufficient buffering to maintain natural vernal pool hydrology.
- Conserve all remaining grasslands on serpentine soils.
- Manage grasslands (e.g., with grazing and fire) to maximize native species richness and control buildup of nonnative grasses and thatch.
- Etc.

Objective 1a2. Conserve all remaining alkali sinks (or provide for no net loss) and manage to sustain and enhance populations of all target species associated with them.

- Conserve all remaining populations of alkali-associated narrow endemic plants in Yolo County.
- Etc.

Goal 1b. Retain and manage large areas of non-natural or semi-natural "working landscapes" to sustain and enhance their contributions to biodiversity and viable focal species populations.

Objective 1b1. Increase the carrying capacity of the valley floor agricultural landscape for nesting Swainson's hawks, guided by the following criteria:

- Retain suitable nesting trees within the agricultural landscape, and plant additional oak trees within suitable foraging areas where nest-tree availability is limiting.
- Retain high-quality foraging land covers (e.g., alfalfa, row crops) within 1 mile of suitable nesting trees to support nesting Swainson's hawks.

Goal 2 (based on language in SB 107). Conserve a range of environmental gradients (such as slope, elevation, aspect, and coastal or inland characteristics) and high habitat diversity to provide for shifting species distributions due to changed circumstances.

Goal 2a. Conserve habitat areas across the full elevational range of Yolo County.

Objective 2a1. Conserve at least xxx acres (or xx%) of remaining natural habitats within each 1,000-foot elevational band in the study area.

Goal 2b. Etc.

Two broad issues concerning plan goals resonate throughout the rest of the report:

1. The plan should explicitly reflect that man-modified habitats (especially agricultural lands) support many species of concern in the planning area, and that maintaining these lands in agricultural uses is critical to conserving biological resources in Yolo County, even though these areas may not be "natural."
2. The plan should contribute to, or at least be consistent with, other planning efforts that are addressing flood risks in the region. We recognize that flood-control planning and the management of water resources are largely outside the regulatory purview of this NCCP/HCP. However, the advisors believe that the NCCP/HCP can work synergistically with other planning processes (such as CALFED and the county's Integrated Regional Water Management Plan) to achieve conservation and mitigation solutions that benefit both natural and human communities.

Species Addressed

The advisors recommend that the list of species addressed in the plan not be overly focused on threatened or endangered species. NCCPs are not strictly endangered-species permitting plans, but are required to sustain and enhance the state's natural communities and their constituent species. This may entail selecting "focal species" that are not necessarily rare or declining, but that are indicators of habitat conditions, ecological processes, populations of more difficult to monitor species, or of biodiversity in general. Thus, we recommend creating *two* lists of species: those to be analyzed for coverage under state and federal take authorizations (including listed or likely to be listed species), and additional focal species that may otherwise help achieve the plan's biological goals.

To create these species lists, we recommend a systematic approach that considers the different types of factors that limit the distribution or viability of species populations, broken down by each of several major landscape types in the County (e.g., native uplands, agricultural landscapes, riparian communities, and aquatic communities). The species limiting-factor categories (*area-limited, dispersal-limited, resource-limited,* and *process-limited* species) are based on the focal species approach first recommended by Lambeck (1997). To these categories we also added *keystone species* (which have disproportionately positive effects on biodiversity) and *problem exotic species* (which have disproportionately negative impacts on biodiversity). The matrix created using these categories and landscape types (see Table ES-1 for examples) should first be filled with species that are high priorities for permit coverage (e.g., threatened or endangered species), but supplemented as necessary with other, non-listed species to ensure that all landscape types and limiting factors are adequately addressed.

Some species or species groups we explicitly recommend adding to the list included in the Ecological Baseline Report (H.T. Harvey & Associates et al. 2005) and to be addressed by the plan include:

- A variety of rare ants, bees, and butterflies that are important components of biodiversity and provide valuable ecological services, such as crop and native plant pollination.
- Wintering waterfowl, due to their economic importance in the region and their value to maintaining wildlife habitat through management.

Table ES-1. Partially completed example matrix for defining focal species based on functional categories and major community types. The matrix should first be filled with high-priority species proposed for permit coverage (indicated with *), and supplemented with other species as necessary to address all functional categories and community types.

	Major Community Type			
Functional Category	**Native Upland**	**Agricultural Landscape**	**Riparian/Wetland**	**Aquatic**
Area limited	American badger, mountain lion, golden eagle	*Swainson's hawk, northern harrier	*yellow-billed cuckoo, white-tailed kite, ringtail	green sturgeon
Dispersal limited	mountain lion, grasshopper sparrow	*giant garter snake	*giant garter snake, salamanders, *valley elderberry long-horned beetle	*chinook
Resource limited	serpentine-dependent plants, yellow-billed magpie, cavity-nesting birds	*tiger salamander, *burrowing owl, waterfowl, shorebirds, vernal pool endemics	heron rookeries, cavity-nesting birds	aquatic insects, tri-colored blackbird
Process limited	manzanita spp.	wintering waterfowl	valley oak, cottonwood	Sacramento splittail, *chinook
Keystone	California ground squirrel, acorn woodpecker	California ground squirrel, acorn woodpecker, native pollinators	valley oak, coast live oak, acorn woodpecker	great blue heron, black-crowned night heron
Problem exotic	Barb goatgrass, yellow starthistle	yellow starthistle, European starling	perennial pepperweed, black locust, tamarisk, Arundo	bass, sunfish, bullfrog

- Grasshopper sparrow, which is a sensitive indicator of unfragmented grasslands.
- Heron rookeries, which are uncommon and localized and may serve as management indicators within anthropogenic landscapes.
- Yellow-billed magpies, which appear to be suffering high mortality rates from West Nile virus and may deserve special monitoring and management attention.
- American badger, which is highly sensitive to habitat fragmentation and roadkill and therefore useful to reserve design and analysis.

- Ringtail, which is an uncommon species and a potential indicator of healthy riparian habitats in the Central Valley.
- Cougar, which is an area-limited and dispersal limited species that contributes to ecosystem health via its role as a top carnivore.
- Valley oak woodland, which is an uncommon and declining natural community of the valley floor that is beneficial to other species (e.g., Swainson's hawk).
- Blue oak woodland and savanna, which are compromised by non-native species and disruption of natural fire and grazing regimes.

We explicitly recommend addressing some native fishes in the plan, including Chinook salmon, steelhead, delta smelt, Sacramento splittail, green sturgeon, hardhead, and river lamprey. We understand that the JPA has not decided to seek take authorizations for aquatic species, and that other planning efforts and regulatory tools may better address water resource issues. Nevertheless, we note that (1) actions permitted by the NCCP/HCP are likely to at least indirectly affect aquatic species (and may require mitigation); (2) it is not possible for purposes of assessing plan impacts to totally divorce terrestrial from aquatic communities; and (3) the plan has potential to contribute to the recovery of aquatic resources in coordination with other planning or regulatory mechanisms.

Finally, the advisors urge that species not be removed from the list simply due to lack of recent observations in the county. Survey coverage is too incomplete to prove absence for many species, and species distributions are dynamic over time. Therefore, and in light of shifting distributions with climate change, we urge reasonable caution in interpreting which species may occur within the study area over the next 50 or 100 years.

Covered Actions

The NCCP/HCP should comprehensively analyze the likely spatial patterns of future development projects and associated infrastructure, and how this will affect habitat fragmentation, wildlife movement, and conservation of biological resources. The plan should specifically analyze likely effects of future road improvements on wildlife movements and ecological connectivity. Where impacts to wildlife movement are likely, we recommend using Before-After/Control-Impact studies of road crossings and roadkill to identify strategic locations for improving connectivity, such as where roads cross major streams.

The plan should also review where its conservation and mitigation actions can contribute to goals of other programs, such as those designed to reduce risks of flooding. For example, the advisors strongly recommend investigating opportunities for restoration of natural floodplain functions, river meanders, and riparian vegetation inside of newer set-back levees that may be recommended or designed by other planning efforts. Thus, this NCCP/HCP may offer mechanisms for mitigating the potential negative effects of flood-control projects on native species.

Finally, we recommend that the plan investigate to what degree conversion of open-water irrigation ditches to piped conveyances might occur in the plan area, and consider appropriate mitigation actions where such conversion threatens to remove movement corridors for giant garter snakes or to significantly reduce habitat for target species. The plan could also address alternatives to piping, including alternative forms of canal maintenance. For example, vegetating canal banks with native plants can reduce maintenance costs and soil erosion into canals, while creating some native habitat value.

Review of Existing Information

The advisors reviewed various maps, reports, and other information provided by the JPA and consultants for the NCCP/HCP, including the *Ecological Baseline Report* (EBR) prepared by H.T. Harvey & Associates et al. (2005). We offer some comments on improving or supplementing this information for future planning phases.

Maps

Although the biological and mapped information compiled by the plan to date provides a useful foundation for planning, we recommend improving some map coverages, including with finer resolution (0.25 to 1.0-acre minimum mapping units) mapping of vernal pools, oak woodlands, and wetland communities. We also urge recognition that static maps of a dynamic agricultural landscape (with crops changing over time) should be interpreted with caution when projecting future conditions for wildlife.

We recommend mapping and characterizing watersheds using criteria that reflect their ecological integrity and functionality to assist with identifying high-priority conservation areas, modeling species distributions, and analyzing plan effects. Relevant characteristics to consider include the watershed's geology and climate, the nature and extent of its aquatic and riparian communities, the nature and extent of upland buffers adjacent to wetlands, and location and degree of human alterations within the watershed.

Characterizing Stream-flow Regimes

If the plan addresses aquatic species, we recommend characterizing stream-flow regimes and the nature and location of stream passage barriers to better understand fish distributions and the potential to improve conditions for fish. Flow regimes can be characterized using physical habitat simulation (PHABSIM) and Instream Incremental Flow Methodology (IFIM). If not already being done by other entities, we recommend mapping fish passage barriers to support plans to improve passage for anadromous fishes (whether by the NCCP/HCP or by other applicable plans).

Species Distribution Mapping

Adequate data on the distribution and abundance of target species is a major information gap for this plan, as it is for essentially all NCCP/HCPs. Since comprehensive survey coverage is not feasible for most species, we recommend judicious use of habitat suitability models to help fill this gap. However, while the GIS overlay model presented in the EBR is a useful first step for exploring species-habitat relationships, it is not a reliable method for mapping habitat values or predicting species distributions. We therefore recommend developing rigorous statistical distribution models or expert-opinion models for those species where existing data are adequate to support model development. Our report provides detailed recommendations concerning the types of models to consider, necessary sample sizes, and appropriate uses and interpretations of environmental variables in models.

We also make specific recommendations concerning how best to fill data gaps for certain groups of species, including those for which we do not recommend using habitat suitability models. For example, species restricted to vernal pools should be assumed present in all vernal pools until proven absent by repeated field surveys, rather than attempting to predict which vernal pools are suitable using models. Similar recommendations apply to other narrow endemic species, such as alkali sink and serpentine soil endemics, as well as rare salamanders, frogs, toads, or fish. For such species, available GIS data are insufficient to discriminate habitat quality.

Because Yolo County is very important to nesting Swainson's hawks, and because survey data appear to be biased to areas closer to cities, we recommend more comprehensive surveys to document the distribution of Swainson's hawk nesting territories throughout the planning area. We also recommend additional data compilation, and surveys where feasible, for other species, including tri-colored blackbird, burrowing owl, short-eared owl, northern harrier, black tern, bank swallow, yellow-billed cuckoo, San Joaquin pocket mouse, American badger, and roosting bats.

Other Data Gaps and Mapping

To better understand and analyze species distributions, existing and potential ecological conditions, and plan effects on biological resources, we recommend collecting and using additional data on environmental conditions, including groundwater depth and water quality. Indirect indicators of groundwater depth, such as volunteer growth of woody vegetation, can often be used to identify areas suitable for wetland restoration. Such indirect indicators could be confirmed by hand-auguring to document water-table depth during late summer or fall.

We recommend investigating to what degree point and non-point pollutant sources have been mapped, and where they may affect NCCP/HCP decisions about conservation and restoration options. We understand that wetland restoration in areas with mercury contamination is problematic, because restored wetlands may actually increase mercury-contamination by converting mercury to methyl mercury, which can accumulate in food chains. Remedies for this problem require further research.

We recommend updating and refining the protected-area database for Yolo County. All existing "green space" (including for example, agricultural easements, mitigation banks, and public parks) should be mapped. We further recommend refining definitions of reserve status to indicate their degree of protection and management for biological resources (e.g., similar to those used in the GAP program; Scott et al. 1993). We also recommend mapping existing, proposed, and suitable areas for ecological restoration and enhancement.

Conservation Design Principles

The advisors reviewed the approach for selecting reserve sites proposed by the consultants, and identified principles for designing a biological reserve network in the county. Although we generally support use of objective reserve-selection algorithms, such as the SITES model described in the EBR, we believe this approach is best applied only to the relatively natural upland habitats of the western hills, and not everywhere throughout the County. We therefore suggest subdividing the County into several major landscape units, which differ in their ecological settings and in the planning and implementation tools we recommend applying.

We first present some general conservation planning principles that apply throughout the county followed by principles that apply within each of four major landscape units: (1) the natural upland areas in the western portion of the county, (2) the largely agricultural valley floor, (3) major riparian corridors winding through the study area, and (4) the Yolo Bypass.

General Principles

- The NCCP/HCP reserve system should contain representative samples of all kinds of natural communities in the County, across their natural range of variation. Strive to conserve large open-space systems that comprise a full range of environmental gradients and community types within contiguous areas, as opposed to scattered reserves each supporting a small sample of the available variation.
- Maximize conservation of the rarest (and most irreplaceable) natural habitats in the plan area—with a goal of no further loss of vernal pools, natural wetlands, native fish habitat, oak woodlands, and rare soils or geological substrates that support rare endemic species.
- Connect reserves to one another and to reserves outside the county to allow for wildlife movement and shifting environmental conditions (e.g., with climate change). Build a conservation network that is adaptable and resilient to environmental as well as economic changes.
- Emphasize wildlife-friendly management of "working landscapes," with incentive-based programs for local landowners, to ensure long-term maintenance and enhancement of native wildlife that depend on agricultural ecosystems.
- Contribute to restoration and maintenance of healthy riverine/riparian corridors, with particular attention to restoring wide "nodes" of riparian habitat at strategic locations, maintaining and enhancing aquatic, hydrologic, and wetland connectivity, restoring natural habitat and flow conditions, and control of exotic species and chemical contamination.
- Concentrate future urban or exurban development close to existing urban areas and along existing roads, particularly in those areas with the lowest biodiversity values, the least likelihood of flooding, and the lowest need for investment in additional infrastructure (e.g., roads and flood-control systems).
- Managed conserved lands for viable populations of native species in natural patterns of abundance and distribution, and to sustain ecological and evolutionary processes within their natural or historic range of variability.

Native Upland Principles

The native upland region includes the largely undeveloped hilly areas in the west, including Blue Ridge, Little Blue Ridge, and the Capay and Dunnigan Hills. The advisors suggest that this region is well suited to conservation planning using traditional reserve-design and reserve-selection approaches (e.g., Noss et al. 1997:73-110; Margules and Pressey 2000). The approach should emphasize representation of all major vegetation communities within a reserve system that includes large biological core areas that are adequately linked and buffered to maintain the range of normal ecological processes. Some specific guidelines to apply:

- Minimize development within large blocks of intact habitats. Concentrate development near existing development and roads. Maximize infill, densification, and community aggregation strategies to reduce habitat fragmentation by exurban and low density housing.
- Maximally avoid impacts to serpentine soils.
- Avoid impacts within the grassland/oak woodlands interface, which is valuable to a variety of declining bird species and other wildlife.
- Concentrate reserve selection adjacent to existing reserves to increase the size, connectivity, and buffering of existing conservation investments. Along the county's western boundary, ensure connectivity with Berryessa/Blue Ridge conservation areas established by the Napa County Land Trust.
- Buffer natural open hillsides from intensive land uses with lower intensity agricultural uses.

Agricultural Landscape Principles

A large portion of the biological diversity and ecological value in Yolo County is supported by the extensive agricultural mosaic of the Sacramento Valley. These man-made habitats support a diversity of wildlife, including waterfowl, giant garter snakes, and Swainson's hawks, among many others. In this region, use zoning, incentive programs, easements, best management practices, restoration, and other means to maximize wildlife-friendly agricultural mosaics and practices, and to cluster development in areas with least impacts to biological integrity.

- Maintain contiguous and extensive agricultural mosaics that provide value to diverse native wildlife. Cluster urban/exurban development in limited areas, close to existing urbanized cities, out of flood-prone areas, and preferably in agricultural types having limited biodiversity value. For example, orchards support lower wildlife diversity than rice fields, and alfalfa and some row crops offer good foraging habitat for Swainson's hawks.
- Maintain and enhance aquatic and riparian connectivity through agricultural areas for giant garter snakes and numerous other species, and buffer major drainages with broad agricultural "greenbelts" to maximize their biodiversity value.
- Maintain and enhance all rare natural habitat types remaining within the agricultural landscape, such as alkali and saline playas, riparian habitats, ponds and emergent wetlands, vernal pools, and valley oak woodlands.
- Maintain and enhance wildlife-friendly habitat features, such as native-shrub hedgerows, berms, flooded agriculture (rice fields), vegetated ditches, ponds, and nest trees.
- Increase nesting habitat for Swainson's hawks by increasing nest-tree availability (especially valley oaks and coast live oaks) in suitable foraging areas where trees are sparse.
- Retain or increase high-quality Swainson's hawk foraging habitat (alfalfa and certain row crops) within 1 mile of existing or potential nest trees.
- Increase abundance of elderberry shrubs along drainages as habitat for valley elderberry longhorn beetle.

- Increase populations of native pollinators and seed dispersers that can benefit crops as well as wildlife by maintaining or restoring some native vegetation communities within the agricultural matrix.
- Increase use of wildlife-friendly best management practices to minimize unintentional killing of wildlife by mowing during nesting of ground-nesting birds or draining of wetlands before fledging of wetland species.
- Encourage use of organic farming methods to minimize use of pesticides, fuels, fertilizers, etc.

Riparian/Riverine Principles

Riparian/riverine corridors contribute greatly to biodiversity in the county, despite most streams being highly altered and constrained by human changes. In addition to their high intrinsic habitat value and wildlife diversity, riparian zones can serve as "backbones" for reserve networks, facilitate movement of species through less hospitable environments, and play a key role in linking reserves together. Emphasize restoration and maintenance of riparian/riverine corridors, with particular attention to restoring wide "nodes" of riparian habitat at strategic location, as well as continuous, naturally vegetated buffers adjacent to riparian corridors to protect aquatic and riparian habitat quality.

- Improve habitat connectivity, including aquatic continuity for fish passage.
- Increase the amount of naturally inundated floodplain in the planning area.
- Reduce exotic vegetation and enhance native riparian vegetation, especially by increasing native riparian trees and woodlands.
- Reduce and control invasive exotic animal species in aquatic habitats (e.g., New Zealand mud snail) and prevent future invasions.
- Prioritize conservation of upper watersheds.
- Provide scientifically justifiable buffers of upland vegetation adjacent to wetlands.
- Improve water quality by controlling runoff from roads and development, and invoking other best management practices.

The following types of locations deserve special attention in conservation and restoration planning in riparian areas:

- Confluences of riparian/riverine systems, such as the junctions where tributaries enter larger streams or rivers, which often serve as biodiversity hotspots.
- Mature riparian forest, or areas with potential to become mature forests over time.
- Wide (>100 m) riparian areas.
- Functional or potentially restorable floodplains, such as lands between old or degraded levees near streams and newer set-back levees, where breaching or removal of the older levee can restore some natural flooding processes, river meanders, and wide riparian vegetation.

Yolo Bypass Principles

The Yolo Bypass is a leveed floodplain managed for multiple benefits, including wildlife habitat, agriculture, and flood conveyance. Conservation guidelines here include many in common with riparian/riverine corridors (above). To these we add the following specific recommendations:

- Increase the amount of riparian forest habitats within the Yolo Bypass.
- Reduce water temperatures via restoration (e.g., increase shading vegetation) and management (control of water flows) to favor cool-water native fishes.
- Improve aquatic connectivity, including fish passage between the Bypass and the Sacramento River, Cache Creek, and Putah Creek.
- Increase frequency of inundated floodplain habitat, including during low-flow conditions.

Conservation Analyses

Analyzing the likely effects of a conservation plan on target resources is one of the most important yet underdeveloped tasks in most NCCP/HCPs. The advisors recommend robust and objective analyses of plan effects to bolster the plan's scientific and legal defensibility. At a minimum, the plan must fully and objectively analyze its likely effects on populations of covered species, which often requires assessing plan effects on physical or ecological processes. It also requires careful consideration of such uncertainties as the effects of global climate change or how land uses are likely to change within the plan area over the next 50 years, with or without plan implementation.

Conservation and Take of Covered Species

The plan should predict, as best possible with available knowledge and models, whether plan implementation will increase, decrease, or have no measurable effect on the population size, sustainability, or recovery of target species. Rather than advocating formal population viability analyses (PVA) for covered species (because the required data for quantitative PVAs are almost always lacking) we recommend using a form of informal PVA—or a systematic approach to evaluating the likely effects of the plan (and alternatives) on target species populations that uses available information to best effect. Although not fully quantitative, this approach forces thorough consideration of each known limiting factor for a species and how the plan is likely to affect that limiting factor (increase, decrease, or no measurable effect on the factor's influence on species populations). The strength of each factor should be weighed relative to the others in determining the overall, cumulative effects of the plan on species' populations. For example, a plan alternative may result in a slight decrease in the acreage of potential habitat for a species, but with improved quality of that habitat to support that species (due to improved management or habitat connectivity, for example). The assessment should carefully weigh whether the combined effect of these positive and negative changes is most likely to increase, decrease, or not measurably affect the species net population size and sustainability. The evidence used to make these decisions should be carefully documented in the plan analysis, including disclosure of key uncertainties bearing on them. These uncertainties should often become the targets of monitoring in the adaptive management program to reduce uncertainty over time, and to test whether the hypothesized net effect was correct.

Effects on Ecological Processes

Analyzing plan effects on target species requires assessing the plan's effect on ecological processes that influence species' habitat and populations, such as flooding, fire, migration, grazing, pollination, succession, competition, and predation. We do not recommend a comprehensive assessment of all natural and anthropogenic processes operating within the planning region. Rather, we recommend prioritizing and analyzing ecological process effects based on which processes are most influential in shaping natural communities or supporting target species during different seasons. Thus we recommend the following two-pronged approach to assessing ecological process effects:

1. Identify the dominant ecological processes that shape natural communities in the area, and estimate their natural or historic range of variability (Landres et al. 1999) relative to ecosystem health. For example, what is the natural range of variability in fire frequency that favors or disfavors oak regeneration, and how do current or predicted future conditions compare? What is the natural flood/scour/deposition cycle in riparian areas, and how do current or future conditions compare?
2. Identify those processes that may be limiting for focal species at particular times and places. For example, what are the seasonal water-flow requirements to support fish populations at various portions of their life cycle, and how do current or predicted conditions compare? What seasonal levels of grazing intensity best control exotic species that may limit rare plant populations?

Scenario Modeling

The advisors recommend a scenario modeling exercise designed to (1) project likely and alternative future changes and land use patterns in the county, (2) assess the consequences of those changes on target resources, and (3) explore effects of various conservation and mitigation policies relative to NCCP/HCP goals. We recommend developing a range of plausible future scenarios for the county based on stakeholder input, expert judgment, and/or natural resource models, to assess likely effects on target resources. These scenarios should consider major foreseeable changes, such as climate change, changes in water availability or costs, community growth patterns, or changes in agricultural practices. One benefit of scenario modeling is that it can project baseline changes in environmental attributes or resource levels with and without implementation of plan alternatives, thus facilitating a more objective evaluation of plan relative effects on target resources.

Alternative scenarios can be developed through stakeholder processes, professional or expert judgment, or simulation models. The stakeholder-driven approach increases citizen involvement, political plausibility, and the likelihood of institutional acceptance. Expert-judgment scenarios may allow for more quantifiable, statistical likelihood analyses, and some expert scenarios already exist for the study area through the work of Dr. Robert Johnston (UC Davis, Dept. Environmental Science & Policy) and the Sacramento Area Council of Governments (SACOG). Simulation modeling can define alternative futures by projecting the rules guiding how people make decisions across space and time. This approach allows rapid production of numerous alternatives that be used to predict the statistical likelihood of alternative futures, but this approach may not facilitate stakeholder buy-in as readily as others. Whichever approach or combination of approaches is used, the advisors believe a scenario modeling exercise may be useful in evaluating alternative planning approaches and for producing alternatives for the required NEPA and CEQA analyses.

Assessment of Aquatic Resources

If aquatic resources are to be addressed, we recommend using one or more commonly used assessment indices to assess current stream conditions, predict likely future conditions (perhaps as part of scenario modeling as described above), and measure changes over time during plan implementation as part of the adaptive management and monitoring program. Two general approaches are biological assessments and physical habitat assessments. Biological assessments include the EPT (Ephemeroptera-Plecoptera-Trichoptera) Index, Index of Biological Integrity (IBI), and ecological community models, such as RIVPAK. These biological assessments all use the abundance or presence of aquatic biota as indicators of a stream's ecological health.

Physical assessments measure physical aspects of the stream environment, especially water flow regimes. Standard-setting methods identify minimum flow standards that are required to maintain instream flow values that reflect fish habitat quality based on historical streamflow records or hydraulic field data. Incremental methods estimate changes in habitat relative to incremental changes in instream flows. The most widely used method in the U.S. is Instream Flow Incremental Methodology (IFIM) which can be used to evaluate the relative consequences of changes in instream flow on downstream habitats. An alternative method is known as Physical Habitat Simulation (PHABSIM), which requires detailed field survey data and is often used as part of IFIM to generate habitat-discharge relationships.

Representation Analysis

A representation analysis evaluates how well a reserve system *represents*, or samples, the range of variation within an area of interest, such as whether it includes significant examples of all vegetation types, species habitats, or geological substrates in the county. We recommend a representation analysis of physical (abiotic) habitats and natural vegetation within the plan area, assessing to what degree each type is represented in existing or potential reserves. Physical attributes to be evaluated include watershed attributes, climate variables, and geological substrates. For some resources, it may be useful to perform a resource-focused representation analysis--such as analyzing vernal pool distributions by geographic substrate to ensure that reserves capture the full range of pool types that may support different species.

Effects of Global Warming

Regional climate change models predict that both winter precipitation and temperatures will increase in much of California (Hayhoe et al. 2004), which will effect natural communities in ways that should be accounted for during plan development (e.g., using scenario analyses). For example, Pyke (2005b) found that current vernal pool protection favors vernal pool habitat in drier parts of the Central Valley, and that in the face of climate change, more pools need protection in the northern Sacramento Valley to ensure long-term viability of threatened and endangered vernal pool invertebrates.

Yolo County lies in an interesting location relative to climate change. Much of the county obtains its water from creeks draining the coast ranges, where most precipitation falls as rain. In contrast, the Sacramento River drains the Sierra Nevada, where snowfall is the predominant water input. The future shift toward warmer temperatures and increased rainfall will change runoff and flooding patterns from the Sierras (Hayhoe et al. 2004). Thus, different watersheds in the county may have distinctly different futures under climate change. We recommend reviewing the latest climate predictions for the region and incorporating them into alternative scenarios, to help assess plan effects and to shape the adaptive management and monitoring plan.

Adaptive Management and Monitoring

Adaptive management is a systematic process for continually improving management practices by learning from outcomes of previous actions. In other words, adaptive management treats management actions as experiments, the results of which can inform future actions. The adaptive management plan should contain direct feedback loops to inform land managers and those overseeing NCCP/HCP implementation. If possible, specific *a priori* management thresholds should be developed under each plan objective. Management thresholds tell the land manager when a change in management action is needed. Therefore, plan objectives and action plans should evolve as more is learned about the system being monitored.

Preliminary Management Recommendations

Although it is too early in the planning process to identify all necessary and sufficient management and monitoring guidelines, we offer the following preliminary recommendations for select topics.

- We recommend a comprehensive review of levee maintenance plans to synthesize a set of best management practices for levee maintenance that are cost effective but compatible with NCCP/HCP goals.
- Managed grazing and fire are essential tools for countering the adverse effects of annual grasses and thatch buildup on natural ecological processes and native species in grassland, vernal pool, and oak savannah habitats. Incorporate the latest research on managed fire and grazing into site-specific management plans.
- Management of permanent drains, ponds, or other wetland features may vary based on geographic context and the species they are being managed for. In some areas, it may be best to maintain permanent waters to provide habitat for giant garter snakes, western pond turtles, and a variety of wetland birds. However, periodically draining ponds during late summer can be used to control bullfrogs and other exotic species.
- Encourage native vegetation along roadsides and irrigation canals to reduce maintenance costs and use of herbicides while increasing habitat value.
- Grazing management in oak woodlands and savannas should discourage grazing during summer and strive to remove approximately half of the annual forage produced each year. Oaks should be planted more than ½ mile from stock water sources, and planted oaks or natural seedlings should be protected with cages until the trees are over 6 feet tall.
- Manage fire in oak woodlands to encourage oak recruitment, based on the latest available research.
- Riparian buffer zones (or setbacks) of 50 to 300 feet (depending on the stream size and local topography) should be established to prevent vegetation disturbance and ground compaction,

minimize bank erosion, and promote native floodplain vegetation and its associated ecological benefits (Kondolf et al 1996).

- Use best management practices (BMPs) to control peak discharge rates, volumes, and pollutant loads running off of existing or new developments. BMPs may include infiltration systems to capture and infiltrate runoff, detention and retention systems (such as agricultural tailwater ponds), constructed wetlands for biological uptake of pollutants, filtration systems to remove suspended materials, and conveyance systems that direct storm water from impervious surfaces to detention and filtration systems.
- Restore and manage for natural conditions wherever possible, including natural water-flow regimes and vegetation communities, and control problem exotic species.
- Manage irrigation and drainage canals in wildlife-friendly ways, such as avoiding maintenance during sensitive periods and retaining native vegetation to reduce weeds and maintenance costs.
- Consider creating small, isolated islands of elevated soil within rice fields to increase safe nesting sites for black terns (*Chlidonias niger*), which suffer high nest predation along canals.
- Create incentives to retain alfalfa within about 1 mile of Swainson's hawk nest trees.
- Encourage planting of oak trees within the agricultural matrix to provide future nesting sites for Swainson's hawks.

Preliminary Monitoring Recommendations

We recommend using the conceptual-model approach presented in Atkinson et al. (2004) to guide development of the monitoring program. This dovetails well with the hierarchical approach to setting goals, objectives, and criteria. Development of management-oriented conceptual models is especially useful for relating plan goals to management actions within an adaptive management program.

Monitoring effort for each covered species should be sufficient to understand its relative population status and trends, threats to the population, and responses to management, with reasonable certainty. However, it is not essential to obtain precise, statistical estimates of population size for all species or all years. For most species, relative indices of distribution and abundance may suffice, such as those derived from simple presence-absence surveys conducted periodically throughout reserves and corrected using detection probabilities (Azuma et al. 1990, MacKenzie et al. 2002). For other species, especially plants, yearly population density estimates would be useful and appropriate, particularly when populations are large, although more precise counts of individuals may be necessary when populations are very small.

Swainson's hawk should receive relatively intensive monitoring to estimate nesting populations and nest success annually. In addition to species monitoring, examples of attributes worthy of tracking with the adaptive monitoring program include invasive species, oak recruitment, roadkill incidence in select locations, biological and physical assessments of aquatic systems, fire histories, and wildlife disease outbreaks.

1 Introduction

This report summarizes recommendations from a group of independent science advisors for the Yolo County Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP). This statutorily required scientific input is provided early in the planning process, before preparation of a draft plan, to help ensure that the plan is developed using best available science. Attachment A provides brief biographies of the independent science advisors. To ensure objectivity, the advisors operate independent of the Yolo County Habitat/Natural Community Conservation Plan Joint Powers Agency (JPA), its consultants, or any other entities involved in the NCCP/HCP.

Contents of this report reflect the advisors' review of technical documents prepared by the NCCP/HCP consultants (particularly the *Ecological Baseline Report* [EBR] prepared by H.T. Harvey & Associates et al., 2005), results of a two-day science advisors' workshop, and subsequent research and discussions amongst the advisors. Advisors were also encouraged to seek expert input from other scientists. Dr. Stanley Gregory provided some written input concerning aquatic resources and analytical techniques, and other scientists provided personal communications as cited throughout this report.

The science advisors met August 15-16, 2005, to review information from Phase I of the NCCP/HCP planning process and offer recommendations for Phase II and beyond. The first morning was a field tour of the planning area, led by plan consultants and representatives of the participating counties and agencies, to acquaint the advisors with on-the-ground biological conditions and planning issues (see Attachment B). Most of the first afternoon was devoted to presentations on existing data by the plan consultants, followed by a question and answer period to ensure that advisors fully understood issues of concern in the planning area and the materials presented by consultants. This open session involved plan consultants and representatives from the U.S. Fish and Wildlife Service (USFWS; Craig Aubrey), California Department of Fish and Game (CDFG; Brenda Johnson), and Yolo NCCP/HCP JPA (Maria Wong) (See Workshop Attendance, Attachment C). The remainder of the first day and all of the second day involved closed-door discussions by the science advisors to begin formulating their recommendations, answering pertinent questions, identifying additional information needs, and outlining this report.

General questions that were addressed by advisors during their deliberations are included in Attachment D. These questions served as guidance only, to ensure that advisors addressed the full scope of issues pertinent to an NCCP/HCP. No attempt was made to format this report to explicitly answer each question, although answers are implicit to the contents. Additional and more detailed questions arose during the workshop and will continue to arise during the planning process. These questions will be answered as time allows in separate correspondence.

The Science Advisors recognize that our recommendations are advisory only and are not binding on NCCP/HCP participants. Nevertheless, we suggest that a constructive way for the JPA to respond to the advisors' comments is similar to what journal editors require of authors; i.e., by indicating how they addressed our comments, including which suggestions were followed and specifically why others were not followed.

Finally, we note that an important report on regional conservation challenges and strategies in California (Bunn et al. 2005) was released to the public during the drafting of this science advisors' report. That report, prepared by the Wildlife Health Center at UC Davis and released by CDFG, presents a comprehensive overview of conservation challenges and conservation strategies for all of California and by biogeographic regions, including the Central Valley and Bay-Delta Region. Although we have not attempted to comprehensively review and incorporate recommendations from that report into this one, its findings are highly concordant with recommendations herein, although broader in scope and scale. We urge the JPA and consultants to consider that report as supplemental to this Science Advisors' report, and to review the chapter covering the Central Valley and Bay-Delta Region for additional information sources, recommendations, or potential conflicts with the contents of this report.

2 Scope of the Plan

The scope of an NCCP/HCP includes its biological goals, geographic area, plan duration, species to be addressed, and actions to be permitted. As this particular NCCP/HCP has a long history of discussion and public involvement, certain aspects of its scope are already well defined. For example, the plan area (all of Yolo County) and duration (50 years) are appropriate and ecologically relevant. However, we recognize that the biological goals of the plan are not fully articulated, and that the list of species and actions to be addressed continue to evolve. We therefore make the following recommendations about goals, species, and covered actions.

2.1 Biological Goals

The NCCP Act (Sher 2001, Senate Bill No. 107) states that the purpose of NCCP planning is "to sustain and restore those species and their habitat… that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape" and that "it is the policy of the state to conserve, protect, restore, and enhance natural communities." Thus, although one objective of NCCPs and HCPs is to obtain authorizations (or permits) to "take" some habitat or individuals of listed or otherwise sensitive species, the broader goal is to sustain, restore, and enhance biological diversity and ecological functionality in general. The advisors therefore recommend that the JPA develop explicit hierarchical goals for the plan that consider measures of biological diversity and ecosystem function, in addition to species-specific goals for listed or otherwise sensitive species intended for permit coverage.

2.1.1 Hierarchical Structure

A hierarchical framework of goals and objectives should provide a transparent and logical format for planning, implementing, and monitoring an NCCP/HCP, as well as for adjusting management over time to reflect knowledge gained via monitoring (i.e., adaptive management). We therefore suggest that the JPA develop explicit plan goals (starting with the overarching goals of the NCCP Program), measurable objectives that tier off these goals, and explicit criteria to guide plan development and to define measurable goals and thresholds for monitoring and adaptive management. Box 1 illustrates one potential approach for structuring hierarchical goals, objectives, and criteria. This approach would help guide plan development and define monitoring and management criteria, but we encourage the JPA to consider alternative structures. For example, the commonly used "coarse filter/fine filter" approach to setting conservation goals (Noss 1987) has proven very useful to conservation planning. It focuses on conserving representative samples of ecosystems or ecological communities (the coarse filter) as well as individual species (fine filter) that might fall through the cracks of coarse-filter protection. A more recently proposed "mesofilter" approach (Hunter 2005) complements the coarse/fine approach by more explicitly addressing the conservation of critical ecosystem *elements* (for example, springs, pools, logs, or snags) and *processes* (such as fires and floods) that are essential at both the ecosystem and species levels.

Box 1. *One example of how goals, objectives, and criteria can be placed in a hierarchical structure to support plan development and define monitoring criteria:*

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Goal 1 (based on language in SB 107). Conserve, restore, and manage representative samples of all natural and semi-natural landscapes in Yolo County in a manner that sustains their natural ecological functions, biological diversity, and viable populations of covered species.

Goal 1a. Conserve representative samples of each native vegetation community type in a size and configuration sufficient to support viable populations or metapopulations of associated target species.

Objective 1a1. Conserve at least xx% of remaining grasslands and manage to sustain native biodiversity, guided by the following criteria:

- Conserve the largest contiguous blocks of grassland in an arrangement that allows for continued use by the most area-dependent grassland species (e.g., American badger).
- Conserve all remaining grasslands that support vernal pools with sufficient buffering to maintain natural vernal pool hydrology.
- Conserve all remaining grasslands on serpentine soils.
- Manage grasslands (e.g., with grazing and fire) to maximize native species richness and control buildup of nonnative grasses and thatch.
- Etc.

Objective 1a2. Conserve all remaining alkali sinks (or provide for no net loss) and manage to sustain and enhance populations of all target species associated with them.

- Conserve all remaining populations of alkali-associated narrow endemic plants in Yolo County.
- Etc.

Goal 1b. Retain and manage large areas of non-natural or semi-natural "working landscapes" to sustain and enhance their contributions to biodiversity and viable focal species populations.

Objective 1b1. Increase the carrying capacity of the valley floor agricultural landscape for nesting Swainson's hawks, guided by the following criteria:

- Retain suitable nesting trees within the agricultural landscape, and plant additional oak trees within suitable foraging areas where nest-tree availability is limiting.
- Retain high-quality foraging land covers (e.g., alfalfa, row crops) within 1 mile of suitable nesting trees to support nesting Swainson's hawks.

Goal 2 (based on language in SB 107). Conserve a range of environmental gradients (such as slope, elevation, aspect, and coastal or inland characteristics) and high habitat diversity to provide for shifting species distributions due to changed circumstances.

Goal 2a. Conserve habitat areas across the full elevational range of Yolo County.

Objective 2a1. Conserve at least xxx acres (or xx%) of remaining natural habitats within each 1,000-foot elevational band in the study area.

Goal 2b. Etc.

2.1.2 Example Goals

Whatever structure or approach is adopted for organizing goals and objectives, the advisors recommend that the following list of potential goals and objectives be incorporated (note that this is not an exhaustive list of all possible goals and objectives, but includes some examples to be considered):

- Maintain the full extant species richness in the county, and enhance biodiversity by increasing populations of rare species to viable levels.
- Conserve and restore representative samples of all natural ecological community types historically present within Yolo County, preferably as a natural mosaic of land-cover types rather than as independent units.
- Maintain biologically important anthropogenic landscapes (e.g., agricultural mosaics) that provide habitat or essential resources to target species.
- Sustain effective movement and interchange of organisms between habitat areas within the plan area and with adjacent plan areas.
- Contribute to regional recovery of federal and state listed threatened and endangered species.
- Protect and restore natural ecosystem processes (such as fire, flood, sediment transport, or grazing regimes) where feasible.
- Maintain and enhance the connectivity and ecological integrity of aquatic and riparian systems by restoring natural hydrologic regimes, including low and high flow events, reconnecting rivers to their floodplains, wetland buffering, riparian vegetation restoration, control of contaminants, and other methods.
- Increase riparian community diversity (e.g., plant and bird species richness).
- Contribute to biological goals of CALFED, as defined in CALFED Ecological Restoration Program (ERP) reports.
- Contribute to regional conservation goals and strategies as outlined in Bunn et al. (2005).

2.1.3 Additional Considerations

In closing this discussion of biological goals, we wish to emphasize two important issues that resonate through this report:

- Given the degree of conversion of natural habitats to agricultural uses in the plan area, plan goals and objectives should explicitly reflect that many target species in the area depend on anthropogenic habitats, including but not limited to Swainson's hawk, giant garter snake, tiger salamander, and wintering waterfowl. Thus, protecting the integrity of land uses that are conducive to species conservation, even if these land uses are "unnatural," is important to conserving biological resources in Yolo County.
- Although not explicitly a biological goal, the advisors urge that the plan should contribute to, or at least be consistent with, other planning efforts designed to reduce risks of flooding in human communities, while striving to conserve and restore natural habitats in flood-prone areas. As made clear recently in New Orleans, responsible land-use planning should

anticipate and prepare for natural disasters. Scientifically, it is certain that floods will happen in the Central Valley in the foreseeable future; ongoing climate change will likely increase risks of flooding; and, without major improvements to the current levee system, it is highly likely that levees will fail in Yolo County, with drastic economic consequences (Department of Water Resources 2005).

We recognize that addressing these flood-control issues is largely outside the regulatory scope of an NCCP/HCP, and that other planning efforts are underway to address them, such as CALFED and Yolo County's Integrated Regional Water Management Plan and General Plan update. Nevertheless, the advisors believe that the NCCP/HCP can contribute to the goals of these other planning processes through conservation and mitigation actions. For example, the conservation and restoration of natural wetlands can help buffer against the catastrophic effects of floods, and efforts to replace older or degraded levees with newer set-back levees create opportunities to restore natural, flood-dependent habitats and species. Throughout this report, the advisors therefore make recommendations where NCCP/HCP actions could work synergistically with other planning efforts to help reduce flood risks to human communities while furthering conservation of natural communities.

2.2 Species Addressed

Following on the discussion of biological goals, the advisors recommend that the list of species addressed in the plan not be overly focused on listed species and species likely to be listed in the future. Note that NCCPs are not strictly endangered-species permitting plans, but are required to sustain and enhance the state's natural communities and their constituent species. This may entail selecting "focal species" or "umbrella species" that are not necessarily rare or declining, but that are indicators of habitat conditions, ecological processes, populations of more difficult to monitor species, or of biodiversity in general. Note that not all focal species need to be *covered* by *take authorizations* (permits), or analyzed and documented as extensively as *covered species* (species for which take authorizations are issued under state and federal Endangered Species Acts and the NCCP Act). Thus, we recommend considering creation of *two* lists of species: those to be analyzed for coverage under take authorizations (including listed or likely to be listed species), and additional focal species that may otherwise help achieve the plan's biological goals and objectives, as developed above.

In addition, in answer to questions posed to the advisors, we explicitly recommend including appropriate aquatic species, such as native fishes, on both lists of species to be addressed. We understand that the JPA has not decided to seek take authorizations for aquatic species, and that other planning efforts and regulatory tools may exist for addressing take and conservation of aquatic species. Nevertheless, we note that actions permitted by the NCCP/HCP (even development projects in terrestrial habitats) are likely to at least indirectly affect aquatic species (and may require mitigation). Moreover, the plan has great potential to contribute to the recovery of aquatic resources in coordination with other planning or regulatory mechanisms. Finally, it is not possible for purposes of assessing plan impacts to divorce terrestrial from aquatic communities, considering how interdependent they are within the greater ecosystem. At the very least, we recommend that the plan assess its likely impacts on aquatic resources and how it may best contribute to their recovery in coordination with other planning efforts.

We expand on these general recommendations below.

2.2.1 Prioritizing Covered Species and Supplementing with Focal Species

We recognize that obtaining take authorizations for covered species is a critical goal of any NCCP/HCP, and that no plan can reasonably analyze and cover all species. We therefore [1]tentatively endorse the "stoplight analogy" approach described in the EBR for prioritizing the list of potentially covered species—with most or all "red-light" (threatened, endangered, and proposed) species, many "yellow-light" species (unlisted species of concern that are locally rare or declining), and few "green-light" (less sensitive) species being included on the list. However, we believe this approach should be supplemented using a more formal focal-species selection process, to ensure that all natural communities and limiting factors are adequately addressed by the plan. Specifically, we propose a method modified from Lambeck (1997), who suggested that conservationists identify groups of species whose vulnerability can be attributed to a common cause, such as loss of area or fragmentation of a particular habitat type or alteration of a disturbance regime, such as natural fires or floods. Species in each group then can be ranked in terms of their vulnerability to those threats. Some focal species may be habitat generalists, but in other cases different suites of focal species should be selected for different major habitat types.

Lambeck identified four functional categories of focal species. For each group the focal species are the species most demanding for the attribute that defines that group and which therefore serve as the umbrella species for that group. Two or more species might be selected within a group, and a single species may occur in more than one group. Together, these species tell us what patterns and processes in the landscape must be sustained in order to sustain biodiversity. Their collective needs define conditions and thresholds – such as patch size, connectivity, fire frequency, etc. – that must be met if the native biota is to be maintained (Lambeck 1997).

- *Area-limited species* have large home ranges, occur at low densities, or otherwise require large areas to maintain viable populations. Examples include large mammals (especially carnivores), large raptors, and species that are highly sensitive to the patch dynamics of their habitat (i.e., where suitable breeding habitat occurs only in a small portion of the overall habitat area in a given year).
- *Dispersal-limited species* are limited in their dispersal capacity (e.g., median or maximum dispersal distance), sensitive to particular movement barriers such as rivers or highways, or are vulnerable to mortality when trying to move through a human-dominated landscape. Examples include amphibians (especially salamanders), turtles, large snakes, flightless insects, large-seeded and/or ant-dispersed herbaceous plants, and most species sensitive to roadkill or human persecution or collecting.
- *Resource-limited species* require resources that are at least occasionally in critically short supply. Classic examples are nectarivores, some frugivores, mast-dependent birds and mammals, cavity-nesting birds, cliff-nesting birds, and plants or burrowing animals dependent on particular substrates or soils.

[1] Some advisors are uncomfortable with the stoplight analogy out of concern that "green light" may be interpreted as "go, go, go"—or in other words that unfettered impacts to green-light species are acceptable. Consider using a less graphic metaphor, such as Tier 1, 2, 3 or Priority 1, 2, 3.

- *Process-limited species* are sensitive to details of the disturbance regime (e.g., frequency, severity, seasonality, patch size) or other manifestations of natural processes, such as hydroperiod, fire-return intervals, or the flow velocity of streams. Examples include fire-dependent animals and plants, vernal pool endemics, stream fishes, and riparian plants like cottonwoods that establish following floods.

To this list of focal species types we add two additional categories:

- *Keystone species* (often called highly interactive species) are species that exert a disproportionately strong influence on community structure or function, such as the presence or abundance of other species (Power et al. 1996). Examples include top carnivores (like cougar) which provide top-down regulation of food webs, and burrowing animals (like ground squirrels) that provide microhabitats and homes for numerous other species. In most cases the influence of keystone species on diversity and ecosystem integrity is assumed to be positive.
- *Problem exotic species* are invasive non-native species that have strong impacts on species richness or composition, habitat structure, nutrient cycling, or other aspects of the ecosystem they have invaded. Because these species are often highly interactive, they may be thought of as "negative keystone species." Examples in the plan area include numerous weedy plants, zebra mussels, bullfrogs, and a variety of introduced fishes. Note that whereas objectives and criteria applying to species in other functional categories are usually set to sustain or increase them, objectives and criteria for problem exotic species are set to control or eliminate them.

Using these six functional categories and the major landscape types in the study area, the advisors recommend creating a matrix of focal species to be addressed by the plan to ensure that all key habitats, processes, and threats to biodiversity are addressed. Table 1 provides a partial example of such a matrix, with some but not all cells filled in with example species to illustrate the approach. For efficiency, the matrix should first be populated with appropriate high-priority species for coverage (i.e., red-light and yellow-light species that are also indicators of the functional categories and communities comprising the matrix). Where potential covered species do not adequately fill all cells in the matrix, fill them or supplement them with other species or species groups that serve as indicators of community health or ecosystem function. Note that even where high-priority covered species occupy a given cell, other species or species groups may be useful to include as biological indicators. For example, aquatic insect communities are sensitive indicators of stream quality for native salmonids and are relatively easy and inexpensive to monitor as Indices of Biological Integrity (IBI; Karr 1981)[2].

Note that the major community types listed in Table 1 can be (and probably should be) further subdivided to be more ecologically explicit, perhaps using Sawyer and Keeler-Wolf (1995) or (less preferably) Holland (1986). For example, native upland could be split to differentiate

[2] An IBI is made by combining several biological indicators into a summary index that reflects the overall ecological integrity or functionality of an ecological community. A well-constructed IBI allows scientists to (1) measure condition, (2) diagnose stressors, (3) define management approaches to protect and restore biological condition, and (4) evaluate performance of protection and restoration activities (Karr 1981, Naiman and Bilby 1998, Karr and Chu 1999, Simon 1999).

Table 1. Partially completed example matrix for defining focal species based on functional categories and major community types. The matrix should first be filled with high-priority species proposed for coverage (indicated with *), and supplemented with other species as necessary to address all functional categories and community types.

	Major Community Type			
Functional Category	**Native Upland**	**Agricultural Landscape**	**Riparian/Wetland**	**Aquatic**
Area limited	American badger, mountain lion, golden eagle	*Swainson's hawk, northern harrier	*yellow-billed cuckoo, white-tailed kite, ringtail	green sturgeon
Dispersal limited	mountain lion, grasshopper sparrow	*giant garter snake	*giant garter snake, salamanders, *valley elderberry long-horned beetle	*chinook
Resource limited	serpentine-dependent plants, yellow-billed magpie, cavity-nesting birds	*tiger salamander, *burrowing owl, waterfowl, shorebirds, vernal pool endemics	heron rookeries, cavity-nesting birds	aquatic insects, tri-colored blackbird
Process limited	manzanita spp.	wintering waterfowl	valley oak, cottonwood	Sacramento splittail, *chinook
Keystone	California ground squirrel, acorn woodpecker	California ground squirrel, acorn woodpecker, native pollinators	valley oak, coast live oak, acorn woodpecker	great blue heron, black-crowned night heron
Problem exotic	Barb goatgrass, yellow starthistle	yellow starthistle, European starling	perennial pepperweed, black locust, tamarisk, Arundo	bass, sunfish, bullfrog

woodlands, shrublands, and grasslands. Likewise, some of the functional categories could be subdivided to ensure adequate coverage of issues. For example, process-limited species might be separated into those limited by aquatic (e.g., hydrological) versus terrestrial (e.g., fire) processes.

2.2.2 Select Additional Species to Consider

Whether or not the JPA decides to use the above matrix approach for identifying focal species, we recommend at least considering the following species or species groups for inclusion in the plan, whether for coverage under state or federal take authorizations or in recognition of their economic or ecological importance in the plan area or their utility as biological indicators. Note that this list is preliminary and could be expanded as planning proceeds.

- *Native invertebrates* such as ants, bees, and butterflies are important components of biodiversity and provide invaluable ecological services, such as crop and native plant pollination. Much is known about the distribution and ecology of these species in Yolo County due to studies at UC Davis. The following uncommon or at-risk species should be considered for possible inclusion as covered species based on recommendations from UC Davis invertebrate experts (A. Shapiro, P. Ward, and R Thorp, personal communications to MS). Although we do not have specific demographic data on these species, host plant information is known for most, and these species should be considered when prioritizing habitats for protection:
    - Butterflies of local concern include *Battus philenor* (pipevine swallowtail, a riparian specialist with one known host-plant species), *Mitoura muiri*, *Erynnis brizo lacustra* (serpentine endemic), *Mitoura johnsoni* and *M. spinetorum* (rare, poorly understood, feed on digger pine mistletoe), *Phyciodes campestris* (field crescent, a marsh/riparian specialist that may be extinct in Yolo County) (A. Shapiro, personal communication).
    - Bees that are vernal pool plant specialists and thought to be at risk include *Andrena* (*Diandrena*) *blennospermatis* Thorp , *A.* (*Hesperandrena*) *baeriae* Timberlake, *A.* (*H.*) *dissona* Thorp and LaBerge, *A.* (*H.*) *duboisi* Timberlake, *A. (H.*) *escondida* Cockerell, *A.* (*H.*) *lativentris* Timberlake, *A.* (*H.*) *leucomystax* Thorp and LaBerge, *A.* (*H.*) *pulverea* Viereck (=*limnanthis* Timberlake) (R. Thorpe, UCD, personal communication).
    - Rare ants in the county include *Pyramica reliquia* (Ward), which is known globally from a single site in Yolo County (P. Ward personal communication), and *Proceratium californicum* Cook, which is known from a handful of localities, two of which are in Yolo County (P. Ward personal communication).
- *Native fishes*, including all sensitive species listed in EBR Table 5. Listed species that occur in the County include spring-run and winter-run Chinook salmon, steelhead, and delta smelt. Other species of special concern include Sacramento splittail, green sturgeon, hardhead (Cache Creek), and river lamprey. Other native fishes include sculpin, rainbow trout, California roach, hitch, speckled dace, three spine stickleback, white sturgeon, and pike minnow. Native fish are important indicators of watershed health as their populations and distributions reflect both land and water impacts. In addition, water is the most limited and limiting resource for both the natural and human economy in the state. Sturgeon can be used to define minimum requirements for fish passage, because they are weaker swimmers than salmon or other migrating fish. The advisors consider the assemblages of native fishes found in Putah and Cache Creeks of special interest, because few Central Valley streams still support the historic native fish assemblages to the degree these streams do.
- *Wintering waterfowl* (as a group) should be considered in identifying conservation and management priorities due to their economic importance in the region and their value to maintaining wildlife habitat through management (e.g., hunted waterfowl and wildlife-friendly land management that benefits many species). This includes hunted waterfowl (geese, ducks) and other waterbirds (egrets, heron, ibis, stilts, avocets, curlews, godwits, etc).
- *Grasshopper sparrow* (*Ammodramus savannarum*) is an uncommon, locally distributed grassland bird in California and a good indicator of relatively pristine and unfragmented grasslands. It tends to inhabit native grasslands over non-native grasslands or ruderal fields, but may also utilize wet or dry pastures.

- *Heron rookeries* are uncommon and localized in Yolo County[3], and lead a tenuous existence due to direct (habitat loss) and indirect (recreation) anthropogenic impacts. The presence of rookeries in a watershed is at least suggestive of the aquatic integrity and health of fish populations and should be monitored as a management indicator within these anthropogenic landscapes.
- *Yellow-billed magpies* (*Pica nuttali*) appear to be suffering extremely high infection and mortality rates from West Nile virus, with elevated concern among biologists about the effects on species viability (Boyce 2005, in litt.). We recommend coordinating closely with biologists and pathologists involved in monitoring this phenomenon, and consider including magpie as a newly threatened species deserving of monitoring and perhaps special management actions under the plan.
- *American badger* (*Taxidea taxis*), is an uncommon and declining indicator of grassland integrity that is highly sensitive to habitat fragmentation and roadkill and therefore useful to reserve design and analysis.
- *Ringtail* (*Bassariscus astutus*) is an uncommon species and a potential indicator of healthy riparian habitats in the Central Valley.
- *Cougar* (*Puma concolor*), is an area-limited and dispersal limited species that contributes to ecosystem health via its role as a top carnivore (Soulé and Terborgh 1999). Consider adding cougar as a species to be considered in reserve design, to ensure adequate ecological connectivity among major habitat areas, and to plan for road-crossing improvements in appropriate locations as part of future road-improvement projects (e.g., fencing coupled with wildlife underpasses or overpasses).
- *Valley oak* (*Quercus lobata*) woodland is an uncommon and declining natural community of the valley floor that is beneficial to other species (e.g., Swainson's hawk) and an indicator of management success.
- *Blue oak* (*Quercus douglasii*) woodland and savanna in the foothills in the western end of the plan area, which are compromised by non-native species and disruption of the natural fire and grazing regimes.

Finally, the advisors agree with the conservative approach suggested by the EBR of including some high-priority species on the potentially covered list despite lack of recent observations in the plan area (e.g., red-legged frog and some vernal pool species). Survey coverage is too incomplete to remove species from the list due to lack of records in the plan area, and we specifically recommend retaining all potential vernal pool species and "red-light" (threatened, endangered, and proposed) species pending more comprehensive survey coverage. Note that species distributions are dynamic over time, and that a current snapshot of a species' known (or inferred) distribution may become inaccurate over a 50-year planning horizon, especially in light of ongoing climate change. We therefore urge reasonable caution in interpreting which species may occur within the study area over the next 50 or 100 years. Moreover, the plan should consider options for restoring or reintroducing populations of key species that have been

[3] Note, however, that black-crowned night heron and egret populations have increased dramatically near Davis in recent years, and that UC Davis is concerned that an egret and heron rookery has been damaging oaks in the Arboretum. Urban associated large waterbirds and barn owls seem to doing quite well in Davis.

extirpated from the county, so long as populations can reasonably be sustained in the region (e.g., red legged frogs, but not grizzly bears).

2.3 Covered Actions

The advisors were not provided detailed descriptions of development or management actions to be covered by permits issued under the plan, although we are aware of the following general categories of actions to be addressed. We therefore offer some preliminary recommendations on how these may be addressed in the plan.

2.3.1 Future Urban/Exurban Development

In coordination with other planning efforts, including the County's General Plan Update (http://yolocountygeneralplan.org) and the Integrated Regional Water Management Plan (www.yolowra.org), the NCCP/HCP should comprehensively analyze and account for the likely spatial patterns of future urban and exurban developments relative to existing development. This analysis should consider where new or upgraded road networks, flood-control projects, and utility corridors might be needed to support new development projects, and how placement of future developments and associated infrastructure might affect habitat fragmentation, wildlife movement, and conservation of biological resources. It should also review how these changes might constrain potential mitigation and restoration opportunities under the NCCP/HCP and especially where the NCCP/HCP can contribute to goals of other programs, such as those designed to reduce risks of flooding. For example, we hypothesize that many areas most at risk of flood losses are also good locations for maintaining agricultural reserves or for conserving or restoring natural habitats—thus revealing opportunities to achieve "win-win" solutions for the human and natural environments.

We recommend investigating results of recent development and transportation build-out models performed by Dr. Robert Johnston (UC Davis Professor of Environmental Studies) for the Central Valley. These can be used to help create alternatives for *scenario analyses* (discussed in Section 5.1). In addition, this analysis should examine the spatial distribution of sensitive habitats with respect to future development and protection in order to assess vulnerability. For example, occurrences of rare plants associated with alkali sink and vernal pool habitats, according to the maps provided, are very near the cities of Woodland and Davis, two communities in the county with very high growth pressure. This plan should specifically assess the vulnerability, and hence prioritization for protection, of these sites.

2.3.2 Flood Control and Water Supply Projects

Although we recognize that many flood-control actions are outside the jurisdiction of the NCCP/HCP participants, we strongly recommend reviewing recent and emerging plans and analyses from CALFED, Department of Water Resources, the county's Integrated Regional Water Management Plan, and other pertinent entities, to identify possible conflicts or synergies between the NCCP/HCP and these other planning efforts. See, for example, geographically pertinent Ecosystem Restoration Program (ERP) Plans from CALFED and the CALFED Independent Science Board's Levee Integrity Subcommittee's Draft Recommendations.

Effects of flood-control and water-supply projects, including upgrades, replacement, removal, or creation of levees, bypasses, and other flood-control or water-supply features, should be comprehensively analyzed and addressed in the plan. The plan should acknowledge and accommodate the need for comprehensive (as opposed to piecemeal) planning for these improvements, and of seeking opportunities for restoring and enhancing natural riparian and riverine communities and hydrological and ecological processes as a part of any upgrades recommended by other planning processes. For example, the advisors strongly recommend investigating opportunities for restoration of natural floodplain functions, river meanders, and riparian vegetation inside of newer, set-back levees in the event that older levees that constrain river channels are recommended for breaching or removal. The Sacramento Area Flood Control Agency (SAFCA) has begun this type of investigation for the Yolo Bypass. The plan should review this and other relevant efforts and recommend mechanisms to coordinate with SAFCA and other relevant entities to integrate aquatic, wetland, and riparian enhancement with flood control efforts.

We also recommend further research on whether or how to restore aquatic connectivity for Cache Creek (which could have adverse downstream effects due to mercury contamination). The plan should review the study entitled, "Enhancing Natural Values in Cache Creek within a Water Supply Augmentation Program" (Natural Heritage Institute 2003), which was commissioned by the Yolo County Flood Control and Water Conservation District.

2.3.3 Irrigation Improvements

Open-water conveyances, such as canals and ditches, can be inefficient in delivering water due to leakage, evaporation, and transpiration, and they may require frequent maintenance. This creates incentives for converting to piped water deliveries in some situations. However, conversion of naturally vegetated waterways to closed pipe systems removes habitat for a wide variety species, and could have adverse effects on, for example, giant garters snakes, which require vegetated channels to move between rice fields and other wetlands. We recommend that the plan investigate whether, and to what degree, such conversion to piped conveyances might occur in the plan area, and research the relative tradeoffs and alternatives in the plan. At the very least, consider appropriate mitigation actions where such conversion threatens to remove important movement corridors for giant garter snakes or to significantly reduce habitat availability for any target species.

An alternative to converting to piped conveyances may be to promote alternative forms of canal maintenance, such as revegetating with native plants. In addition to adding biological value, this can reduce maintenance costs and soil erosion into canals. See Section 6.1.3 for further details on alternative management actions for irrigation canals.

2.3.4 Road Improvements

The plan should analyze possible effects of planned or potential road improvements on wildlife movements and incorporate restoration and enhancement actions as mitigation. These can include, for example, (1) removal of fish-passage barriers with upgrades to roads crossing tributary streams, and (2) inclusion of wildlife underpasses (or overpasses) in strategic locations to accommodate movements by large mammals, reptiles, and amphibians with new or upgraded highways. Given the extensive agricultural development in the plan area, focus attention on potential wildlife movement corridors along riparian zones and bypasses. This can increase efficiencies, because road improvements that accommodate increased fish passage may also be used to increase terrestrial wildlife movement. Where new roads or road improvements are in areas of likely wildlife movement corridors, we recommend incorporating Before-After/Control-Impact studies of wildlife movement and roadkill to identify whether and where wildlife crossing structures will be beneficial to restoring ecological connectivity and to monitor success of the improvements (Forman et al. 2003).

3 Existing Information

The advisors recognize the considerable effort that has gone into compiling and summarizing existing data sources in the EBR. We offer the following recommendations to strengthen this already useful information for future phases.

3.1 Report Format

Although the EBR is relatively well researched and written, the advisors found it somewhat tedious to review due to its length and extensive redundancies between sections and species accounts. The 28 species accounts in Appendix A cover 258 pages, which could be greatly reduced by reorganizing the material. For example, moving all cited literature to a single section at the end (as opposed to separate literature cited sections for each species) would eliminate scores of pages, because numerous citations are common to many species.

Likewise, the model parameter descriptions and range maps are highly redundant between species having similar habitat requirements (at least as discriminated by available GIS layers). For example, it appears that the model parameters and predicted range maps are identical for all fairy shrimp species (and perhaps other vernal pool species): The maps basically show vernal pool distributions (same for all species) along with some species observation points. Why not produce one map for fairy shrimp species, and use different codes or colors to show where the different species have been detected? Similar combinations for other groups of species are also possible.

Finally, much of the descriptive text is redundant between species. Again using fairy shrimp as an example, paragraphs concerning life history, ecological roles, threats, management issues, etc., are identical or nearly so among the species. We suggest organizing the accounts such that general information that pertains to a suite of species is presented in a common introductory section, with species-specific accounts focusing on important species-specific considerations.

We realize that the EBR was formatted to allow each species account to stand alone. However, we recommend considering whether future plan documents can be organized to minimize redundancies, shorten overall length, and focus on key or discriminating information. NCCP and HCP documents (and accompanying environmental documents) are naturally very long due to plan complexity, and any means of shortening and focusing documents by removing unnecessary redundancy should be strongly considered. Over-long documents discourage careful review by the public and scientists.

3.2 Land-cover Mapping

The advisors recognize the difficulties faced by the consultants in compiling comprehensive land-cover (vegetation) maps from diverse and incomplete sources, and generally agree with the approach and the classification scheme they adopted. We offer a general caution on use and interpretation of these maps for predicting species occurrences and analyzing plan effects, along with some specific recommendations for mapping refinements to be considered (budgets permitting) during Phase II.

3.2.1 Caution about Use and Interpretation of Static Maps

Although we recognize that it is difficult to "map" the dynamics of changing land covers, especially in a largely agricultural region (with crop rotations, fallowing, and changes in crop distributions due to changing markets, water availability, etc.) we urge recognition by the JPA that static land-cover maps can be misleading, especially when making long-term (e.g., 50-year) predictions about wildlife distributions. For example, the distinction between "grain and hay" crops and "irrigated row and field crops" is blurred by crop rotations, and has implications for predicting suitable foraging areas for Swainson's hawks and other species. In the longer term, changing water availability, agricultural practices, and agricultural markets can cause marked shifts in crop types over large areas, with implications for support of target species. Therefore, consider whether alternative land-cover labels, map disclaimers, or other means can emphasize that maps used as figures or analytical tools in planning documents represent "snapshots" in time, and should be used with caution for analyzing dynamic systems.

Also, consider whether there are reasonable ways to incorporate effects of shifting agricultural land covers in models of species distributions and for forecasting future environmental conditions. For example, the history of crop planting and rotations and the average mix of crops over time could be developed using farm records and other information at the County Agriculture Commissioner's office. This history could be applied to lands in or near known Swainson's hawk nesting territories to better understand how farm history correlates with presence/absence of nesting Swainson's hawks, or the persistence of successful nest territories. Similar analyses may also be useful for other species within the agricultural landscape. We comment further below (Section 5.1) on how to use *scenario analyses* to better address landscape dynamics and how they may affect biological resources over the life of the plan.

3.2.2 Cartography

We recommend that all maps show, to the degree possible, continuous map coverage outside of planning area boundaries to show the plan's geographic context. Map coverages that are "clipped" to planning area boundaries remove one's ability to judge, for example, how habitats, species distributions, or other pertinent features connect across boundaries into adjoining areas. We also recommend that all maps include some additional geographic names commonly referred to in text, such as Willow Slough, Yolo Bypass, Capay Hills, Dunnigan Hills, and Blue Ridge.

3.2.3 Vernal Pool Complexes

The advisors have uncertainties about the resolution and completeness of existing vernal pool mapping. We recommend considering whether existing vernal pool complex mapping can be supplemented with finer resolution (ideally <0.25-ac, or at most 1-ac, minimum-mapping unit [MMU]) mapping of individual pools and their watersheds.

If not already done, we recommend reviewing the vernal pool density maps prepared by Robert Holland to ensure comprehensive coverage of vernal pool distributions, recognizing that his mapping was at relatively coarse resolution (40-ac MMU). We understand that another vernal pool mapping effort is currently underway at Chico State University, and encourage the JPA to investigate the utility of that data for this plan. In addition, consider using recent models for predicting the occurrence of vernal pool habitats that couple aerial photographic signals with hydrologic models (slope and drainage area; e.g., TOPMODEL). Careful use of this sort of model would enable a finer resolution mapping of likely vernal pool habitats (J. Viers, UC Davis Information Center for the Environment [ICE], personal communication to MS).

We further recommend considering whether vernal pools should be mapped in a GIS data layer separate from the land-cover data layer, so that vernal pools or vernal pool complexes can be mapped as an overlay on other land cover types, rather than treated as a separate vegetation community. We believe that vernal pools are best viewed as unique habitat features (i.e., "special elements" as defined by Noss et al. 1999) within a matrix of other land cover types, such as annual grasslands.

3.2.4 Valley Oak (and perhaps Coast Live Oak) Woodlands

The advisors recommend considering finer-resolution mapping (e.g., 0.25- to 1.0-ac MMU) for valley oak woodlands, to identify stands of this rare and declining community that can be conserved and enhanced through management. Mapping of small oak stands in the agricultural landscape (including coast live oaks as well as valley oaks) may also be important to addressing the distribution of Swainson's hawks and perhaps other species that use individual oaks or smaller stands of oaks as nest sites. For example, many Swainson's hawk observation points in the plan area (including nest observations) fall outside of predicted hawk nesting habitat based on current mapping (see Species Distribution Models, below). During the workshop, we zoomed in on at least one such observation point, finding that it coincided with a single large oak tree that is clear on aerial photographs, but too small to be mapped as "woodland." One way or another, this mapping/modeling limitation should be acknowledged and addressed.

3.2.5 Riparian Vegetation

We recommend finer-resolution (<1.0-ac MMU) mapping of riparian vegetation that differentiates vegetation subassociations or alliances (based on Sawyer and Keeler- Wolf 1995) that are important to determining habitat quality for covered species. To the degree feasible, we recommend mapping concentrations of exotic species within riparian zones to assist with identifying restoration and management opportunities. It should be possible to map concentrations of tamarisk, Arundo, and other key exotics using remotely sensed imagery. A variety of tools are currently available, such as SPOT satellite imagery, at moderate cost. Low elevation aerial photography is often available along California rivers and may be available for this region (see http://ice.ucdavis.edu/).

3.2.6 Grassland versus Fallow Grain Fields

We believe it is more appropriate to lump fallow grain fields in with grasslands, rather than with other agricultural types, depending on the length of time the fallow fields have been out of production. These fields may function more as annual grassland habitat than grain fields, particularly if they have been out of production for a decade or more. Some of these fields may be enrolled in the NRCS Conservation Reserve Program (CRP). Maps of land in this program can be obtained from the NRCS.

3.3 Watershed Mapping and Characterization

We recommend mapping and characterizing watersheds using criteria that reflect their ecological integrity and functionality. This information can be used, for example, in developing species habitat suitability models (especially for aquatic species), identifying high-integrity and high-priority watersheds for conservation, evaluating restoration potential, or analyzing how well a reserve system captures the range of environmental variation across the County. CalWater has mapped watersheds defined by smaller stream systems (first to fourth order). The following landscape-scale indicators of environmental status and quality should be developed for each CalWater watershed.

- General metrics useful for classifying watersheds for planning and analysis:
  - Area
  - Elevational range
  - Average annual precipitation
  - Means and variances in precipitation and temperature over the last 50 years
- Aquatic habitat types should be classified according to the system developed by Moyle and Ellison (1991) using the following variables:
  - Miles of permanent and intermittent streams
  - Extent of lakes or other lentic waters
  - Number of dams and diversions
  - Fish passage barriers
  - Miles of free-flowing versus impounded streams
  - Ditches, canals, reservoirs, and other artificial modifications to the natural flow regime
  - Location of gravel mining and other instream uses
  - Extent of Aquatic Diversity Areas
  - Extent of Pacific River Council Critical Aquatic Refuges
  - Isolated springs, wet meadows, fens, bogs, seeps
- Riparian extent and distribution are key indicators of habitat quality within a watershed. In most cases, accurate information will have to come from aerial photographs combined with field measurements of local habitat conditions.
- Buffering around riparian areas is important for sustaining river health, so it would be helpful to understand the extent to which riparian areas in the County are currently buffered, both physically (e.g., by native upland vegetation versus agricultural fields or impervious development) and legally (e.g., existing conservation easements along streams).

3.4 Characterizing Flow Regimes and Barriers for Aquatic Species

The distribution and abundance of many native stream species are determined largely by stream flow characteristics and how these affect physical habitat conditions and fish movements. An environmental flow regime encompasses the timing, magnitude, duration, and frequency of flows necessary to support target species and facilitate specific ecological processes. Where the timing of different life stages of target species is known, it is relatively easy to identify the approximate timing and duration of flows necessary to support them.[4] Most short lived target species require adequate flows each year to reproduce, while longer-lived species can sustain their populations with a lower frequency of flow conditions conducive to reproduction. Physical barriers, including dams, diversions, logjams, and poorly designed culverts, also limit fish movements and fragment populations. If the plan addresses aquatic species, we recommend attempting to characterize both the flow regimes and the nature and location of stream passage barriers to better understand fish distributions and the potential for the plan to improve conditions for fish.

3.4.1 Flow Regimes

Estimating the magnitude of flows necessary to support or optimize conditions for target species and processes can be difficult. Environmental engineers and biologists have developed relatively elaborate methods for determining ideal flow regimes, such as physical habitat simulation (PHABSIM) and Instream Incremental Flow Methodology (IFIM). These identify optimum flow magnitudes based on known habitat preferences of target species, measured habitat conditions (velocity and depth) at various flows, and numerical models that predict habitat conditions at a range of flows. Where empirical data relating flows to habitat conditions do not exist for a particular stream, approximating the flows necessary to support target species must rely on expert opinion or flow regimes measured on similar streams that support the species.

On regulated rivers, an analysis of existing (regulated) and historical (unimpaired) hydrology can be used to understand the natural flow regime and how it may relate to the restoration or enhancement of target species. An analysis of the existing regulated flow patterns, historic patterns, and the flow requirements of target species provides can provide information on what may be required to balance species needs with economic or other demands on water flows (Natural Heritage Institute 2003). However, specifying an idealized environmental flow pattern can be complicated by trade-offs. For instance, depending on the key limiting factor, it may be best to reduce spawning flows in order to increase spring flows for adequate instream water temperatures. Reducing spawning flows by 100 cfs for approximately 60 – 90 days can save 12,000 to 18,000 acre feet. In critically dry years, this can make a big difference in the ability to control instream water temperatures that affect fish survivorship.

If the NCCP/HCP is to address effects on native fish species, the advisors recommend the following general approach to understanding their flow requirements on area streams:

- Compare existing vs. historical hydrology to understand natural hydrologic patterns and how they have been altered.
- Define the timing of the different life stages of target species.
- Approximate the timing, magnitude, frequency, and duration of flows necessary to restore native fish species.
- Identify obvious gaps between objective flow requirements and existing flows.

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[4] Conceptual life-history models for salmon, splittail, and a composite of shorebirds in Yolo Bypass were covered in Habitat Improvement for Native Fish in the Yolo Bypass (Natural Heritage Institute et al. 2002).

3.4.2 Fish Passage Barriers

The advisors recommend a detailed analysis and mapping of passage barriers in the Yolo Bypass and other creeks and rivers in Yolo County to support plans to improve passage for anadromous fishes (whether by the NCCP/HCP or by other applicable plans). We recommend evaluating existing culverts (perhaps with assistance from CalTrans) using models that address fish passage under a wide range of stream flows (e.g., FishXing (http://stream.fs.us/fishxing/).

A number of resource agencies and non-governmental organizations have been evaluating fish restoration opportunities in the Yolo Bypass. For example, a plan that improved the riparian and channel habitat along the toe drain in the bypass and in some selected ditches through the bypass could significantly improve conditions for salmon passage. Such a plan would need to evaluate opportunities for passage through or around the Cache Creek settling basin. Additional passage problems exist in smaller tributaries to the Yolo Bypass. For example, Putah Creek has a seasonal check dam in its lower reaches that typically blocks upstream salmon migration until it is removed in late autumn.

3.5 Species Distribution Mapping

Good information on target species distributions and abundances is a fundamental data gap for nearly all conservation plans. Modeling species distributions beyond known occurrence (presence) records is therefore a powerful tool for conservation planning, especially in cases where occurrence records are sparse and constrained by factors such as restricted access to private land. Such models can be used to direct future surveys for species of interest as well as to evaluate a range of potential future scenarios for the region of interest. Although the consultants have recognized the value of species distribution modeling, we urge caution in interpreting the simple matrix (GIS overlay) models produced so far, and suggest that more rigorous statistical models or expert-opinion models be developed for many species.

3.5.1 Critique of Matrix Model and Alternative Approaches

We agree with the consultants that the GIS overlay model of species habitats presented in the EBR is a useful but limited tool. It is useful for exploring species-habitat associations, but is *not* a reliable method for mapping habitat values or predicting actual species distributions. The benefit of the method is the ability to quickly and interactively explore what factors, *of those available in the GIS*, seem to be associated with species occurrences (e.g., they are most useful as *exploratory* rather than *forecasting* models; O'Connor 2002). This exploratory function can be used to inform other, more accurate, predictive models using any of a wide variety of multivariate empirical models and expert opinion models.

Species-habitat models are accurate only to the extent that habitat relationships of particular species are well documented empirically. The simplest habitat models, such as those used in the nationwide Gap Analysis program, are low in resolution and predict species occurrence in vegetation types, soil conditions, or sometimes climatic envelopes within which the species is likely to occur (Scott et al. 1993). The resulting maps inevitably contain significant errors of commission (false positives) in that species do not occur in every site within the broad predicted distribution. They may also contain errors of omission, for example, if the species actually occurs in cover types not contained in the model. While such maps are more accurate than the general range maps found, for example, in field guides, and even crude models are useful in serving as hypotheses of potential distribution within a planning area, we believe that better methods are available for predicting distributions at a scale useful to NCCP planning, where tough decisions about including or excluding sites from reserve systems are necessary.

The matrix models presented in the EBR suffer similar omission and commission errors, as is evident from reviewing the predictive maps in Appendix A (where many species occurrence points fall outside predicted suitable habitat, or large areas of predicted suitable habitat are devoid of species observations). These errors are due in part to limitations of the environmental variables available in GIS coverages, but also in how these variables are treated in the model logic. Specifically, the matrix model approach used in the EBR is overly constraining in that it allows only for Boolean (logical) "and" statements (i.e., as the intersection of all suitable variable categories) when combining variables to predict habitat suitability (e.g., habitat for species x occurs if a pixel has vegetation type v *and* soil type s *and* at elevations less than y). However, many species distributions may be more accurately modeled using more flexible logic. For example, what if species x uses vegetation type v only on soil type s, but uses vegetation type b regardless of soil type? Or what if a species uses a broad array of vegetation communities when close to water, but is restricted to specific vegetation types farther from water? Compounding this inflexibility is the reduction of all environmental gradients to discrete categorical variables (e.g., using distance from water to define "near" vs. "far" from water; more on this in Section 3.5.2). More sophisticated models, such as decision-tree, neural network, fuzzy logic, or multiple logistic regression models, to name just a few of many available approaches (Scott et al. 2002, Guisan and Thuiller 2005), can sidestep many of these problems by allowing use of continuous variables and less constraining logic.

Most useful for conservation planning are relatively high-resolution models produced by relating occurrence records to potential predictor variables at site and/or landscape scales through statistical techniques such as multiple logistic regression. Occurrences represent the dependent variable in these models, whereas site or landscape features represent independent variables (Carroll et al. 1999, 2001).

Ideally, statistical models are based on presence-absence data. However, occurrence records (e.g., in the CNDDB) are typically presence data only, so points or polygons representing presence must be compared statistically to points that are randomly generated (or for more refined models, to "pseudo-absence data") to assess the statistical significance of the model. Because the association of species occurrences with particular environmental features is assumed to represent habitat selection, statistical models have been called "resource selection functions" (Boyce and McDonald 1999). Depending on the species, the resources or predictor variables that have been found significant in these models include particular vegetation or cover types, patch sizes, geological or topographic features, soil types, climatic envelopes, primary productivity (or some surrogate thereof), road density, distance from human settlement, density of prey, etc. (Carroll et al. 2001). The GIS map output of such models shows a gradient of probabilities of occurrence, which is assumed to parallel a gradient of habitat quality or potential population density for the species in question. Such probability gradients can be more revealing for conservation planning than discrete suitable/unsuitable categorizations.

In some cases, the life history or habitat relationships of a species may be relatively well known, even though actual occurrence data are scarce. In these cases statistical models can be built through reference to the technical literature on the species, informed by expert knowledge. (Note that the EBR matrix model is a type of expert knowledge model, albeit with the logical constraints described above.) It is important to recognize that the vast majority of statistical distribution models have been developed for vertebrate species, as the habitat variables affecting plant and invertebrate distribution often occur at a finer scale than available GIS databases. Nevertheless, habitat models with high predictive power have been developed for some plant species. For example, models based on a multivariate statistic, Mahalanobis distance, proved very useful in directing field surveys for several rare plants in Shenendoah National Park, Virginia. In this case the odds of finding new locations predicted from the models were up to 12 times greater than with random searches (Van Manen et al. 2005).

We recommend that the consultants thoroughly review the available literature and databases on species of interest in the planning region, then develop statistical distribution models for those species for which adequate knowledge and data (dependent and independent variables) are available. There is a large and growing body of literature and available statistical models to draw on (see e.g., Scott et al. 2002, Guisan and Thuiller 2005, and Beissinger et al. 2006). One promising method that makes good use of available GIS data is species-likelihood mapping using Ecological Niche Factor Analysis (ENFA) implemented using the freeware program BioMapper (downloadable from http://www.unil.ch/biomapper). ENFA is a multivariate statistical method that uses species presence-only data and GIS layers of environmental variables to map probabilities of species occurrence across a landscape (Hirzel et al. 2002).

3.5.2 Uses and Limitations of Available GIS Data

Note that while available GIS coverages for environmental variables (e.g., soils, vegetation, elevation) are finite, usually categorical (not continuous), and often limiting for predicting species occurrences, GIS can be used to create meaningful new variables from these discrete coverages either using multivariate statistical techniques or expert knowledge. For example, (1) the spatial arrangement of land covers (size, juxtaposition, contiguity, etc.) may be more important than the discrete presence/absence of particular land-cover types for predicting species occurrences; (2) distance from water sources, roads, trees, or other features may create gradients of habitat quality, even within discrete land covers; and (3) the density of roads or other features measured at various landscape scales may be highly predictive of species presence/absence. We recommend incorporating such GIS-based "landscape" variables in future models, where appropriate, especially for wildlife species.[5]

In general, we recommend the use of continuous (gradient) variables, wherever possible, rather than categorical variables. Examples of such data include elevation, distance from water or other features, density of landscape features (scaled as necessary for each species) and climatic variables. There is usually no reason to simplify these continuous variables to categorical

[5] Plant distributions may not be predicted as well as mobile wildlife species by such constructed landscape variables, because extant plant distributions may represent remnant populations that do not appear to "select" habitats via dispersal as readily as animals.

variables (e.g., near/far from water using a single distance for all species), which may unnecessarily reduce a model's predictive power.

Refer to Section 3.3 for recommendations concerning watershed variables that may be useful in species distribution modeling. We further recommend that the consultants investigate the availability and use of climate data, such as seasonal rainfall or temperature iso-lines, to define ecological gradients that may affect species distributions. Such data may be particularly useful for forecasting potential effects of climate change on species distributions over the life of the plan.

We recognize that the number of species observation points within Yolo County may be too limited to build robust statistical models for some species (e.g., BioMapper appears to require at least about 50, and ideally more than 100 location points, depending to some degree on spatial precision of the input variables and how selective a species is). To overcome this problem, we recommend including occurrences from outside the study area (Yolo County) to increase sample sizes for model building. Choosing occurrences from throughout the Central Valley, for example, would increase the number of known occurrences and increase the power to discern physical attributes that predict occurrences. Models developed using a larger study area window can then used to predict species occurrences within the smaller study area (Yolo County). For species having inadequate observation points even with an expanded study window, expert-opinion models are perfectly acceptable, so long as the model structure and logic are appropriate to reasonably predict species distributions.

We recommend using a combination of presence only methods (e.g., ENFA) as well as presence-absence models (e.g., CART, GLM, GAM, GARP, ANN, ME) if feasible. Choosing non-occurrence locations for presence-absence models presents a challenge in model development. We recommend using random points with a buffer to prevent re-sampling non-occurrences within the vicinity of other non-occurrences. Further, we recommend using 2-4 times the number of non-occurrences as occurrences.

Another issue to consider is the resolution of the dependent species location points, especially for those species that select habitats on a fine scale relative to available GIS environmental data layers. For example, species restricted to riparian habitats might be poorly predicted by a GIS model if the precision at which species occurrences were mapped is coarse relative to the mapped distribution of riparian habitats. To some degree this problem is alleviated if sample sizes are large. More importantly, note that the use of constructed landscape variables and multivariate statistical models (like BioMapper) can counter these problems, because they create continuous landscape variables around the *vicinity* of a point, rather then discrete yes/no variables at the point itself. For example, consider an observation point for a riparian species that falls near but not within a mapped riparian corridor, due to map-resolution problems. Using a discrete variable such as "the point falls inside/outside riparian" may inappropriately decrease the model's predictive power. In contrast a continuous landscape variable, such as "proportion of a 10-ha circle around the point that is riparian," would detect the nearby presence of riparian habitat and thus retain more of the model's predictive capacity.

3.5.3 Select Species-specific Recommendations

Here we recommend some approaches for filling distributional information gaps for select species or species groups, by modeling, additional surveys, or other techniques. This is not a comprehensive review covering all species of concern, and we urge the consultants to extrapolate these recommendations as appropriate to other species or communities.

Vernal Pool and Alkali Sink Associated Species. We do NOT recommend employing habitat suitability models to attempt predicting the distribution of vernal pool and alkali sink associated species, which respond to micro-scale habitat variables (and perhaps stochastic events) not generally available in GIS coverages[6]. These systems often have a high degree of local endemism, presumably as a result of long periods of genetic isolation. Most detailed studies of vernal pool and alkali sink systems describe new and sometimes surprising distributions of novel species or populations of at-risk species of plants or invertebrates. Very little genetic work has been completed to verify the uniqueness of most vernal pool and alkali sink systems. Further, there are very few occurrences of these habitats and they tend to be small. Thus, surveying them at the appropriate time for these relatively easy to detect vulnerable species is the most appropriate approach. Vernal pool and alkali sink habitats within this planning region should therefore be assumed to house some unique biological resources until definitive field surveys prove otherwise.

Serpentine-dependent Plants. We do NOT recommend employing habitat suitability models to attempt predicting the distribution of plant species on ultramafic soils. The location of ultramafic soils within the county is well described by existing coverages, and many of these sites have been surveyed by Dr. Susan Harrison of UC Davis. Like vernal pools, ultramafic soils often have a high degree of local endemism, presumably as a result of long periods of genetic isolation. Serpentine habitats within this planning region should be assumed to support unique biological resources until definitive field surveys prove otherwise. Existing field surveys should be adequate to map potential occurrences of rare serpentine plants. This plan could defer to this existing research and incorporate data from Susan Harrison's work on beta-diversity of serpentine plants conducted on the McLaughlin reserve in Yolo, Napa, and Lake Counties.

California Tiger Salamander. Modeling potential distribution of this species may be difficult, and we recommend additional field surveys, if possible. In Yolo County, tiger salamanders are known from the vicinity of a single vernal pool west of Dunnigan. Local tiger salamander expert Dr. Brad Shaffer (personal communication to MS) feels that it is quite likely that additional ponds in the Dunnigan Hills contain tiger salamanders, but there are few other observations near Yolo County. Known occurrences are found south of Dixon and again in the foothills of the coast range in Solano County. Although valley floor ponds in Yolo County may be suitable habitat for tiger salamanders, there are no known current or historical records from the majority of Yolo County. Because invasive fishes (including mosquito fish) and bullfrogs have detrimental effects on salamander populations, identifying aquatic habitats free of these threats, while difficult, would be fruitful. We also recommend researching other approaches that have

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[6] This should not be confused with our earlier (Section 3.2.3) recommendation to consider improving predictive models of where vernal pools or pool complexes may be located. Rather, we do not recommend trying to predict which mapped vernal pools are likely to support target species or not in the absence of pool-specific survey data.

been used for predicting tiger salamander distribution and especially for prioritizing conservation areas based on sustainability of tiger salamander metapopulations. For example, movements among breeding pools and between breeding pools and other habitats are considered important to tiger salamander metapopulation viability, and have been explicitly modeled using fuzzy logic to prioritize ponds and inter-pond linkages for conservation in Santa Barbara County (Pyke 2005a). Shaffer (in press) has also developed a model of tiger salamander movement away from aquatic habitats at the Jepson Preserve, which may be useful.

Spadefoot toad. The spadefoot toad has a known distribution in the Dunnigan Hills region of the county. This species is patchily distributed in the Central Valley. With much of the Dunnigan Hills in private ownership, it is difficult to assess the degree to which farm ponds or other small water bodies may provide habitat for this sensitive species (Dr. B. Shaffer, personal communication to MS). We do not believe that habitat suitability models will be very useful for this species using existing GIS data layers.

Red-legged Frog. The advisors recommend that the consultants seek expert opinion from Shawn Barry (slbarry@ucdavis.edu) regarding potential red-legged frog occurrences in Yolo County. We do not believe that habitat modeling will be very accurate for this species with existing GIS data layers.

Giant Garter Snake. Giant garter snake habitat could be modeled as rice growing areas with attending water supply and drainage canals located in the northern part of Yolo County, north of Interstate 5, and the eastern part of the County east of Highway 13. The USGS has documented giant garter snake populations along the Colusa Basin Drainage Canal into Ridgecut Slough in this northern part of Yolo County (Wylie and Martin 2004a). Giant garter snakes were reported historically from Conaway Ranch along Willow Creek in the eastern part of Yolo County (CNDDB). The USGS did not find any giant garter snakes in the western part of Yolo County in surveys during 2003 and 2004 (Wylie and Martin 2004b). Barriers to movement from highways and the lack of connectivity from water sources likely preclude giant garter snakes from inhabiting the western part of Yolo County. Additional field surveys may be warranted in the Yolo Bypass and Vic Fazio Refuge. Although giant garter snakes were historically sighted in the Conaway Ranch, their distribution and abundance in the Yolo Bypass is unknown, and the Bypass may be important for connecting species populations.

Fish. As discussed in Sections 3.3 and 3.4, the distribution and abundance of many native stream species are determined largely by stream flow characteristics and in-stream barriers and how these affect physical habitat conditions and fish movements (i.e., many fish are *process limited* and/or *dispersal-limited* as defined above). It may therefore be difficult to accurately predict fish distributions based on habitat mapping using existing GIS data layers, which probably do not capture the habitat features of interest. The mapping and characterization of watersheds discussed in Section 3.3 and characterization of flow regimes and barriers discussed in Section 3.4 may help with predicting potential distributions for certain species (with and without restoration actions). If fish species are to be addressed by the NCCP/HCP, we recommend consulting with species experts (e.g., P. Moyle) for additional information on the known distribution of fish species in local streams and associating these to the degree possible with information on flow regimes, known or suspected barriers, and other habitat quality variables (e.g., presence or absence of nonnative aquatic species; width and quality of riparian vegetation). This will be most useful in identifying potential actions to recover fish populations in certain streams or stream reaches by, for example, removing physical passage barriers, removing water contaminants, altering the timing, duration, or magnitude of stream flows, or restoring riparian vegetation and/or adjacent upland buffering.

Swainson's Hawks. That Swainson's hawks have a strong preference for agricultural habitats and for the prey that inhabit alfalfa is well known (Woodbridge 1991, Babcock 1995) with some individuals in the Sacramento Valley hunting as much as 22.5 km from the nest site (Babcock 1995, Bloom personal observations). While some birds may travel long distances in search of available prey, breeding territories can be small particularly in rodent-rich alfalfa crops. In theory, pairs of hawks that are forced to travel greater distances in search of food probably have poorer nesting success than those that travel short distances. Because this hawk requires 30-year old trees in which to build nests, the plan should address nest-tree availability within suitable foraging habitats. Existing GIS layers do not have sufficient resolution to predict nest-tree availability, and using riparian forests or oak woodlands to represent nest-tree availability suffers from errors of omission.

The distribution and density of nesting Swainson's hawks remain poorly documented in some parts of Yolo County and the Central Valley outside of a well-surveyed core area near the larger cities and rivers (Schlorff and Bloom 1984). Yolo County Swainson's hawks tend to nest in trees closest to the major rivers and active agricultural areas, and as a result most surveys are focused there. This is at least in part due to volunteer efforts attempting to maximize their success at finding the greatest number of nests, and environmental surveys for development projects, which tend to be near cities and towns. Numbers of *known* nesting pairs decrease from this well-surveyed core area toward the east and west, which could reflect lesser survey effort there and/or reduced carrying capacity for the species. Ultimately, the availability of nesting trees, such as large oaks, within suitable foraging areas may limit Swainson's hawk nesting distribution.

In order to fine tune the known distribution of Swainson's hawk nests in Yolo County, we recommend surveying from the foothills to the interior valley riverine systems. Further, the existing data set should be refined to show the distribution of distinct nesting territories by examining each existing occurrence record. This may mean excluding duplicate nest records of the same territory from different years and eliminating single bird observations from the data set to more accurately reflect the real number of nesting pairs. Ideally, nest locations should also be differentiated from foraging or other observations to better refine modeling approaches and understand the species habitat needs.

Other Birds. The following species are all uncommon and/or nest very locally. Requesting the volunteer involvement in avian surveys by local Audubon Society birders through their newsletters could be used to gather additional information on these species.

- Tri-colored blackbird - The tri-colored blackbird is a colonial, largely endemic icterid that has received considerable state-wide monitoring attention. The advisors recommend contacting Edward Beedy and William Hamilton (Beedy and Hamilton 1997) for the most current knowledge on the local distribution and habitat needs of Yolo County populations.

Because breeding populations tend to shift about between years, historic locations should be surveyed first, followed by perceived potential wetlands.

- Burrowing owl – The advisors suggest that the consultants contact Dave DeSante of the Institute for Bird Populations (IBP) to obtain the latest known extant nesting and wintering population distributions. Because so few pairs remain in the county we suggest surveying optimal habitat (relatively flat, short grasslands and pastures, including overgrazed areas; California ground squirrel colonies).
- Short-eared owl and northern harrier – These two species are poorly studied and uncommon breeding species in California, with most known Central Valley breeding areas located on State and Federal Wildlife Refuges. Except as foraging habitat in certain areas, most private land does not support these species. The most likely explanation is that both species nest on the ground and are vulnerable to agricultural practices, such as flooding and harvesting. While this also occurs on State and Federal Refuges, some areas are usually left undisturbed and some successful nesting does occur. The advisors suggest contacting the managers of nearby State, Federal and private refuges for the latest information on current breeding localities and potential habitat acquisition/management goals for short-eared owls and northern harrier. Private lands with natural wetlands in close association with grasslands should also be surveyed.
- Bank swallow – We suggest that the consultants contact Ron Schlorff of the California Department of Fish and Game and the U.S. Army Corps of Engineers (USACE) for the latest information on the nesting distribution of this colonial species, particularly along the Sacramento River. Mapping the distribution as being along all riparian corridors would be highly inaccurate, due to the species' dependence on tall banks and bluffs for nesting and the limited areas in which appropriate bluffs and soils occur.
- Black tern -- The advisors suggest contacting Dave Shuford of Point Reyes Bird Observatory (PRBO) to learn the latest on potential breeding locations and associated wetland habitats (rice fields, etc.) in Yolo County.
- Yellow-billed cuckoos require large (greater than 100 m across) patches of riparian forest, and may use orchards that are adjacent to such patches (T. Beedy personal communication). Modeling cuckoo habitat as all riparian forests or all orchards would be highly inaccurate, although incorporating patch size, contiguity, and distance variables may allow the development of useful GIS habitat suitability models. A habitat suitability model for yellow-billed cuckoo was developed, tested, and published by Greco et al. (2002) for a stretch of the Sacramento River upstream of Yolo County. We recommend reviewing this model to see if it is appropriate for the study area or can be refined.

Mammals. Distribution data for many mammal species are sparse, and small, inconspicuous, or nocturnal mammals can be very costly to survey effectively. Some use of models, perhaps coupled with some sample surveys to verify models, is advised for mammal species included in the plan. Some species-specific considerations:

- San Joaquin pocket mouse (*Perognathus inornatus*), if included as a target species, probably occurs in grasslands and some shrublands in foothills (e.g., Dunnigan Hills) or larger remaining natural areas on the valley floor. As a burrowing rodent, this species probably prefers relatively friable soils (e.g., loams and sandy loams) and avoids wetland or very heavy (clay) soils. Be aware that the taxonomy of *P. inornatus* is confusing, that some subspecies in the Central Valley are probably distinct species, and that existing location data for pocket mice in California include classification errors (e.g., *P. inornatus* incorrectly identified as *P. longimembris*; Williams 1993, Hafner 1998).

- American badger could be modeled as likely present in larger grassland areas with low road densities. We recommend reviewing the literature to determine minimum viable habitat areas and effects of road density on persistence of this species. A graduate student at UC Davis, Jessie Quinn, is studying American badgers in the region and should be contacted for further information.
- Bats tend to be underrepresented in NCCP/HCP plans due to lack of reliable distribution data. We recommend compiling and reviewing available roost-site data for the six bat species of special concern that may occur in the county. Bats are known to roost in trestles, bridges, and overpasses in the study area. The I-80 overpass in the Vic Fazio Yolo Wildlife Area is a prime example.

3.6 Other Data Gaps and Mapping Needs

We recommend collecting and using additional data to better understand and analyze species distributions, existing and potential ecological conditions, and especially plan effects on ecosystem integrity and populations of focal species.

3.6.1 *Groundwater*

Groundwater depletion can lead to de-watering of streams and downcutting within stream banks, and can make restoration of riparian vegetation difficult. For example, although mature cottonwood and willow trees can tap groundwater several meters deep (Stromberg et al. 1996), seedling establishment requires a shallow water table that remains available during the first summer of growth (Mahoney and Rood 1992). Unfortunately, reliable data are often lacking for depth to water table or rates of groundwater depletion. We recommend assessing to what degree these are issues for streams in the County and considering whether augmenting existing data on groundwater conditions in the county should be within the scope of the NCCP/HCP or is being adequately addressed by other planning efforts.

The California Department of Water Resources maintains a database of groundwater levels in wells. However, water levels in wells are almost always lower than the true water table, because wells are deep and their pumping creates water-level gradients. Indirect indicators of groundwater depth can often be useful for assessing conditions for riparian restoration near streams. Such indirect indicators include surface-water elevation in the stream and volunteer growth of woody vegetation along waterways. Nevertheless, we recommend a reconnaissance-level survey of water table depth and soil texture to confirm conclusions based on indirect indicators prior to riparian restoration efforts. The survey could consist of hand-auguring to the water table in late summer or fall at several points.

3.6.2 *Water Quality*

Mapping major sources of point and non-point source pollutants can help identify priority conservation areas and locations where countering threats to water quality (e.g., by restoration of wetlands) would benefit biological goals. We recommend investigating to what degree these pollutant sources have been mapped and where they may affect NCCP/HCP decisions about conservation and restoration options.

Wetland restoration in areas with mercury contamination is problematic. We understand that wetland restoration projects may actually increase mercury-contamination problems, by converting mercury to organic, bioavailable forms (methyl mercury) via microbial methylation. From this form the contaminant bioaccumulates in aquatic food chains and is a neurotoxin (http://ca.water.usgs.gov/mercury/). The issue of how to manage stream reaches with mercury contamination is being studied in conjunction with CALFED management of the Bay Delta (http://loer.tamug.tamu.edu/calfed/) as well as other watersheds. The NCCP/HCP should consider incorporating best management practices based on these studies.[7]

3.6.3 *Reserve Status*

At the workshop the consultants presented preliminary maps of existing reserves in the plan area, acknowledging that there were inaccuracies and omissions in the available data. We agree with the consultants that updating and refining the protected-area database for Yolo County (and adjacent counties) is a priority early in the planning process. All existing "green space" (including for example, agricultural easements, mitigation banks, and public parks) should be mapped. We further recommend creating refined definitions of reserve status that reveal the degree to which designations provide protection and management for biological resources (perhaps based on a local refinement of the GAP categories of reserve status; Scott et al. 1993). We also recommend that existing and proposed ecological restoration and enhancement sites be added to the protected-area database to help guide planning, and that areas highly suitable for restoration and enhancement be mapped. This information is necessary to perform a useful GAP analysis and to identify lands where changing management practices or restoring habitat on existing conservation areas will help sustain and restore target resources.

[7] More information is available in a CALFED report for Cache Creek at the following website: http://loer.tamug.tamu.edu/calfed/Report/Final/CacheCreekSynthesis.pdf. The Nature Conservancy is experiencing similar problems with methyl mercury in the Cosumnes watershed and has not yet devised a plan to deal with it.

4 Conservation Design Approach

This section recommends approaches for designing an ecological reserve network in the County to meet NCCP and HCP goals. The approach should be refined once the biological goals for the plan are more fully developed (see Section 2.1).

4.1 Subdivide the Planning Area, but Recognize Geographic Interdependencies

Given the extensive conversion of natural habitats to agriculture on the Valley floor, and the existing constraints to natural stream corridors, the advisors do not believe that traditional landscape-level "reserve design" or "reserve selection" approaches should be broadly applied across the entire study area, as was proposed in the ERB. We recognize the value of objective representation and reserve-design modeling approaches--such as the use of the simulated annealing selection algorithm, SITES, advocated in the ERB--but we believe they apply best only within the remaining native upland vegetation communities in the western portion of the plan area. We therefore suggest that the plan area be broadly segmented into subdivisions that reflect different ecological and planning contexts, and therefore within which different conservation design goals, approaches, principles, and implementation tools may apply. Consider for example, the following four subdivisions:

- *Native Uplands*. Use SITES or other appropriate reserve selection/reserve design approaches to ensure adequate representation of remaining natural habitats within core ecological reserves, and that core reserves are adequately buffered and linked to accommodate ecological processes. Consider using the hierarchical goals and objectives structure discussed earlier (Section 2.1) to help establish representation goals for communities based on their irreplaceability and vulnerability (Margules and Pressey 2000).
- *Managed Agricultural Landscape.* Use zoning, incentive programs, easements, best management practices, restoration, and other means to maximize wildlife-friendly agricultural mosaics and practices and to cluster development in areas with least impacts to biological integrity. Consider design of a network of restoration sites for very rare habitats (e.g., vernal pools, alkali sinks, and valley oak woodlands) that strategically utilizes land with suitable characteristics (e.g., appropriate soil characteristics) to support restoration. Explicitly recognize the potential for win-win management strategies using native pollinators (Kremen et al. 2004) and irrigation canal vegetation corridors and tailwater ponds to reduce soil loss and farm management costs.
- *Riparian/Riverine Corridors*. Emphasize restoration and maintenance of riparian/riverine corridors, with particular attention to restoring wide "nodes" of riparian habitat at strategic location, as well as continuous, naturally vegetated buffers adjacent to riparian corridors to protect aquatic and riparian habitat quality. Consider maintaining and enhancing aquatic and wetland connectivity, including fish passage, addressing known problems, such as chemical contamination and exotic invasions, and restoring natural habitat conditions.

- *Yolo Bypass*. Continue successful management measures in the Yolo Bypass, and evaluate improvements to management and monitoring for target species, such as recommended habitat improvements for native fishes (Natural Heritage Institute et al. 2002).

The following sections provide additional guidance for conservation planning within these broad subdivisions. First, however, we want to emphasize that these subdivisions are somewhat artificial and their components may be highly interdigitated and interdependent. For example, the agricultural landscape of the valley floor is embedded with numerous riparian corridors, emergent wetlands, and valley oak woodlands. Moreover, some species of concern need habitats or resources found in two or more of the subdivisions. Thus, although it may be convenient to subdivide Yolo County this way for conservation planning, we urge recognition of these interdependencies and the need to integrate approaches across the subdivisions. Thus, before presenting specific recommendations for each major subdivision, we emphasize the following broad, guiding principles that apply regardless of location:

- The reserve system should contain representative samples of all kinds of natural communities in the County, across their natural range of variation. Strive to conserve large open-space systems that comprise a full range of environmental gradients and community types within contiguous areas, as opposed to scattered reserves each supporting a small sample of the available variation.
- Maximize conservation of the rarest (and most irreplaceable) natural habitats in the plan area—with a goal of no further loss (or no net loss) of vernal pools, natural wetlands, rare soils or geological substrates supporting endemic species, native fish habitat, and oak woodlands. Make mitigation for removal of vegetation types proportional to their biological irreplaceability, with "in-kind" mitigation to achieve no net loss of the rarest types, and possibly "out-of-kind" mitigation for less-rare types.
- Connect reserves to one another and to reserves outside the county to allow for wildlife movement and shifting environmental conditions (e.g., with climate change). Build a conservation network that is adaptable and resilient to environmental as well as economic changes.
- Emphasize wildlife-friendly management of "working landscapes," with incentive-based programs for local landowners, to ensure long-term maintenance and enhancement of native wildlife that depend on agricultural ecosystems.
- Contribute to restoration and maintenance of healthy riverine/riparian corridors, with particular attention to restoring wide "nodes" of riparian habitat at strategic locations, maintaining and enhancing aquatic, hydrologic, and wetland connectivity, restoring natural habitat and flow conditions, and control of exotic species and chemical contamination.
- Concentrate future urban or exurban development close to existing urban areas and along existing roads, particularly in those areas with the lowest biodiversity values, the least likelihood of flooding, and the lowest need for investment in additional infrastructure (e.g., roads and flood-control systems).
- Managed conserved lands for viable populations of native species in natural patterns of abundance and distribution, and to sustain ecological and evolutionary processes within their natural or historic range of variability.

The goal of maintaining viable populations is properly applied to covered species as well as other focal species (see Section 2.2). The complication is that most of these taxa have much wider distributions than Yolo County, which means that the Yolo NCCP/HCP cannot address their viability in a comprehensive manner. This said, it is nevertheless imperative that planners take into consideration the entire distribution of each of these species, consider their habitat and population trends beyond Yolo County, and design the Yolo NCCP/HCP to contribute positively to their global conservation.

Similarly for ecological processes and adaptability to change, the Yolo NCCP/HCP should consider the broader ecological context (spatial and temporal) within which the plan will operate and strive to ensure that habitat protection and management actions taken within the plan area are intelligently coordinated with actions taken outside the plan area boundaries. Note that the plan should be adaptable in the face of both environmental (e.g., climatic) changes and economic changes (e.g., shifts in land-use and water-use patterns in response to changing socio-economic conditions).

The following sections provide additional guidance for implementing these general principles within the four major subdivisions of the planning area suggested above.

4.2 Native Uplands

The native upland region includes the largely undeveloped slopes of Blue Ridge, Little Blue Ridge, and the Capay and Dunnigan Hills. The advisors suggest that this region of mostly natural vegetation is relatively well suited to conservation planning using traditional reserve design and reserve selection approaches, with an emphasis on representation of all major vegetation communities within a reserve system that includes large biological core areas that are adequately linked and buffered to maintain the range of normal ecological processes. We further assume that this region is currently subject to lower land prices and development pressures than agricultural lands on the flatter valley floor, and that setting aside additional reserve areas is a feasible conservation goal.

4.2.1 Biological Goals

Use approaches similar to those established by Noss and Cooperrider (1994) and Margules and Pressey (2000) to establish representation goals for reserve selection within the upland subdivision. Use these representation goals, along with the basic principles of reserve design (Noss et al. 1997:73-110), to design a network of well-connected and buffered ecological reserves that captures the range of environmental variation within the subdivision, retains viable populations of resident species, and connects functionally (if not physically) with reserves in other subdivisions as well as outside the planning area.

The representation strategy (applied to species, ecosystems, or other natural features) is one of the oldest in conservation and is applied today largely through site-selection algorithms (e.g., SITES, as discussed above). Complementary to the strategy of protecting or properly managing known or likely occurrences of sensitive species is the "coarse filter" strategy of representing all ecosystems in a region across their natural range of variation along environmental gradients

(Noss 1987, Hunter 1991). A strong argument for the coarse filter is that, because species distributions correspond in large part to contemporary environmental conditions, protecting a full range of habitats is likely to capture species, genetic variation, communities, and other elements of biodiversity that are poorly known or surveyed. Bacteria, fungi, bryophytes, and many invertebrate groups, for instance, would rarely be considered as individual species in conservation planning because data on their distributions are not available. Given that species distributions are determined largely by environmental factors, such as climate and substrate, and that vegetation and other species assemblages respond to gradients of these factors across the landscape, protecting examples of all types of vegetation or physical habitat classes ought to capture the vast majority of species without having to consider those taxa individually. However, in regions with high endemism, such as much of California, the coarse filter is predicted to perform more poorly than in regions inhabited by mostly widespread species, because populations of endemic species often are found in very few locations of a given habitat class (Noss and Cooperrider 1994).

4.2.2 Conservation Design Principles

Use the basic principles of reserve design (e.g., Noss et al. 1997:73-110) to guide reserve design. We emphasize the following guidelines for conserving the native upland subdivision:

- Minimize development incursions into large blocks of intact upland habitats. Concentrate development near existing development and roads. Maximize infill, densification, and community aggregation strategies to reduce habitat fragmentation by exurban and low density housing.
- Avoid fragmenting large upland areas by roads or other developments, which can have severe effects on area-dependent species, like American badger, mountain lion, and golden eagle. Internal fragmentation also constrains use of important management measures, such as prescribed fire and managed grazing.
- Maximally avoid impacts to rare communities that support narrow endemic species, such as serpentine soils.
- Avoid impacts to grasslands on or near the interface with oak woodlands and savannahs, which are valuable to a variety of declining bird species and other wildlife.
- Concentrate reserve selection adjacent to existing reserves to increase the size, connectivity, and buffering of existing conservation investments. Along the western boundary, ensure connectivity with Berryessa/Blue Ridge conservation areas established by the Napa County Land Trust.
- Buffer natural open hillsides from intensive land uses with lower intensity agricultural uses.

4.2.3 Reserve Selection Approaches

Reserve selection algorithms, including simulated annealing programs such as SITES, are computerized mathematical algorithms linked to GIS that can be used to objectively select sites for inclusion a conservation network to meet specifically defined goals. One common goal is that the selected sites *represent* (i.e., contain significant samples of) all features of interest (e.g., species or habitats) in a highly efficient manner (i.e., in the smallest area or without unnecessary redundancy). Such algorithms are useful because they are more objective than approaches based purely on expert opinion, where subjective biases and preferences are known to influence results. They are also more useful than site-scoring approaches because they are based on principles of efficiency and complementarity and therefore can ensure that all features are represented in a selected network. In contrast, sites ranked highest in a scoring approach might contain many of the same features while missing many others.

In a nutshell, modern algorithm-based approaches to site selection are more systematic than earlier approaches. Some characteristics of systematic conservation planning (Margules and Pressey 2000) are the following:

- Explicit, quantitative goals
- Assessment of how well goals are met in existing reserves (i.e., gap analysis)
- Efficiency – offer the most bang for the buck (most biodiversity for least cost)
- Complementarity – sites are chosen to complement, rather than duplicate, existing protected areas and other selected sites
- Flexibility – present various options for achieving goals
- Irreplaceability – evaluate the extent to which a site is needed to achieve goals (or contributes to goals)
- Persistence – considers viability over the long term

Unfortunately, the last characteristic, persistence, is not commonly evaluated in site-selection algorithms because such algorithms poorly consider site configuration. Rather, persistence of features (in particular, populations of species) is best considered by combining population viability analysis with site-selection algorithms (e.g., Noss et al. 2002, Carroll et al. 2003).

For NCCPs, the utility of site selection algorithms is primarily that they are highly efficient in achieving stated goals for each conservation target (i.e., species or other feature of interest) and they are transparent, i.e., they can be applied interactively in a workshop format to examine the consequences of altering goals (e.g., the percentage of each feature to be included in reserves) on the overall reserve network. Nevertheless, as noted earlier, they do not apply well in highly human-modified landscapes because they assume a dichotomy of reserve vs. non-reserve. On agricultural and suburban lands, and even some resource-management lands (e.g., "working forests"), conservation goals might be better achieved through incentives that encourage retention of habitat structural elements (e.g., vegetated ditches and fence lines, retained trees in fields to provide bird nesting sites, etc.).

Finally, we emphasize that no reserve selection algorithm can completely "design" an adequate reserve network. Rather, they represent one set of tools to inform selection of sites to be incorporated into a reserve system. The basic principles of reserve design (Noss et al. 1997), considering the specific needs of all target species and ecosystem processes of concern, must also be applied to ensure that the selected reserves are large enough and sufficiently connected and buffered against adverse edge effects to meet NCCP and HCP goals.

4.2.4 Implementation Tools

Although it is not appropriate for science advisors to directly advocate for particular plan policies, it is appropriate to recommend implementation tools or approaches that might best achieve biological goals. With this in mind, we recommend that the plan consider basing mitigation approaches on the irreplaceability of each vegetation community type to create incentives to avoid removal of the rarest communities. As noted above, the irreplaceability of a feature or site is defined by the extent to which it contributes to the conservation planning goals (Margules and Pressey 2000). A site is completely irreplaceable if it contains features found nowhere else (i.e., in the planning area or globally). Irreplaceability has been measured in several ways. When site-selection algorithms are used, relative irreplaceability can be measured by the number of times that a given site (planning unit) is selected in various runs of the algorithm (Noss et al. 2002). More generally, the rarest or most critically imperiled species or communities (e.g., ranked G1 by NatureServe) would be considered most irreplaceable, as would the sites holding such features. By definition, these features and sites should be favored over more replaceable features or sites in all phases of conservation planning.

4.3 Agricultural Landscape

A large portion of the biological diversity and ecological value in Yolo County is found within the extensive agricultural mosaic on the Valley floor, both because of intrinsic habitat value of various crop types (e.g., flooded rice fields as habitat for waterfowl and giant garter snakes, alfalfa and row crops as foraging habitat for Swainson's hawks), as well as the interdispersion of other habitats or habitat features within this agricultural matrix (e.g., valley oaks for nesting Swainson's' hawks, emergent wetlands used by numerous species, irrigation ditches that provide nesting substrates for burrowing owls and dispersal corridors for giant garter snakes).

This vast agricultural landscape is also subject to growing development pressures (urban expansion as well as exurban sprawl development), which reduces agricultural productivity as well as biological diversity. Moreover, current land uses that promote biodiversity can change with changing markets, water availability, flood-control improvements, and agricultural technology (e.g., converting open irrigation ditches to closed pipe conveyances), among other factors. We recognize that these complex dynamics, as well as the economic and social issues of imposing restrictions on agricultural communities, make conservation planning in this landscape especially challenging. Here we provide a menu of ideas and options for addressing these challenges, with a focus on zoning and incentive-based approaches to maximize continued value of these agricultural lands to biodiversity conservation.

4.3.1 Biological Goals

The science advisors urge recognition by the JPA of the importance of maintaining and enhancing wildlife-friendly agricultural mosaics and practices in the important agricultural areas of Yolo County. Some specific goals that should be addressed by various implementation tools include:

- Maintain contiguous and extensive agricultural mosaics that provide value to diverse native wildlife. Cluster urban/exurban development in limited areas, close to existing urbanized cities, out of flood-prone areas, and preferably in agricultural types having limited biodiversity value. For example, orchards support a much lower diversity of native species than do rice fields, so all else being equal, removing orchards for urban growth may be less detrimental than removing rice fields.

- Maintain and enhance aquatic and riparian connectivity through agricultural areas for giant garter snakes and numerous other species, and buffer major drainages with broad agricultural "greenbelts" to maximize their biodiversity value.
- Maintain and enhance all rare natural habitat types remaining within the agricultural landscape, such as alkali and saline playas, riparian habitats, ponds and emergent wetlands, vernal pools, and valley oak woodlands.
- Maintain and enhance wildlife-friendly habitat features, such as native-shrub hedgerows, berms, flooded agriculture (rice fields), vegetated ditches, tailwater ponds, and nest trees.
- Increase nesting habitat for Swainson's hawks by increasing nest-tree availability (especially valley oaks and coast live oaks) in suitable foraging areas where tree availability may be a limiting factor.
- Retain or increase high-quality Swainson's hawk foraging habitat (alfalfa and certain row crops) within 1 mile of existing or potential nest trees.
- Increase abundance of elderberry shrubs along drainages as habitat for valley elderberry longhorn beetle.
- Increase populations of native pollinators and seed dispersers that can benefit agricultural economics as well as biodiversity (Kremen et al. 2004) by maintaining or restoring some native vegetation communities within the agricultural matrix.
- Increase use of wildlife-friendly best management practices to minimize unintentional killing of wildlife by mowing during nesting of ground-nesting birds or draining of wetlands before fledging of wetland species.
- Increase use of organic farming methods to minimize use of pesticides, fuels, fertilizers, etc., which adversely affect biodiversity.

4.3.2 Conservation Design Principles

Future development in agricultural areas should be clustered near existing development and roads, and should avoid areas near streams, within floodplains, or in potentially restorable habitat areas. All remaining vernal pools, alkali or saline soils supporting endemic plants, natural emergent wetlands, valley oak woodlands, and riparian forests should be included in ecological reserves or otherwise conserved and managed to benefit target species. Broad, unbroken agricultural mosaics should be maintained, especially along all rivers, streams, and bypasses, and around other features of high biological value, such as alkali or saline sinks. Natural upland slopes (e.g., Dunnigan Hills and the foothills of the Capay Hills and Blue Ridge) should be broadly buffered from development by agricultural zones.

Along with the obvious use of riparian corridors as "backbones" for conservation design within the agricultural landscape, consider whether other features, such as railroad ROWs, may also be useful. We recommend investigating the potential values (and problems) of maintaining railroad rights-of-way (ROW) as wildlife habitat and to benefit ecological connectivity across the landscape. For example, existing railroad trestles are used as bat roosts, ROWs may support remnant grasslands, vernal pools, or other rare habitats, and elevated railroad beds may serve as travel corridors for terrestrial species across seasonally flooded landscapes.

Vernal pool systems generally exist within a much larger matrix of annual grassland habitat and can have complex hydrologic characteristics that depend not only on annual precipitation patterns but also on various watershed characteristics, including soil substrate, soil structure, and topography (Hanes and Stromberg 1998). Rains et al. (in press) found that some vernal pools are supported by perched aquifers wherein seasonal surface water and perched groundwater hydrologic ally and biogeochemically connect uplands, vernal pools, and streams at the catchment scale. However, it is still unknown how much connectivity exists between the various stores in this system; therefore it is difficult to use hydrology as a reasonable measure for determining necessary and sufficient buffers for vernal pool ecosystems.

Marty (2005) found that vernal pool hydrology as well as native species diversity could be negatively impacted by changes in range management at a vernal pool site in Sacramento County, CA. These results suggest that the ability to provide optimal management of a site may be an important factor in determining appropriate buffers for vernal pool systems.

4.3.3 Implementation Tools

Yolo County has an opportunity with this NCCP/HCP to create a true partnership between agriculture and conservation by building into the plan incentives for retaining land in agriculture while improving habitat quality with various incentives. This would be a groundbreaking endeavor within the NCCP process and could serve as a model for other counties dominated by agricultural land.

We recommend designating Agricultural Reserves or Agricultural Greenbelts that retain the farm economy while enhancing ecological integrity. Candidates for such agricultural greenbelts include broad areas along riparian corridors, between rivers and their setback levees, and other biologically valuable areas or areas otherwise unsuited to development. For example, we specifically recommend a wide agricultural greenbelt centered on Willow Slough between the cities of Davis and Woodland, due to extensive use by Swainson's hawks and other species. We recommend reviewing the local Resource Conservation District's plan to conserve features in the Willow Slough area.

For purposes of designating future urbanizing areas and developing a mitigation program for the agricultural landscape, we recommend rating land cover types in agricultural areas by their irreplaceability and vulnerability. For example the following rare habitats embedded within the agricultural matrix are irreplaceable in their ability to support narrow endemic species, and therefore should be subject to no-loss provisions via local resource protection ordinances:

- Alkali sinks
- Vernal pools
- Saline soils

The following native habitats or habitat features provide very high value for retaining numerous species and ecosystem values within the agricultural matrix, and should be conserved and enhanced wherever possible. Consider no-net-loss provisions using local ordinances or other means.

- Valley oak woodland
- Riparian forest
- Emergent wetlands

The following native habitats are less rare, but still valuable as wildlife habitat. Some losses may be acceptable, subject to reasonable guidelines to minimize fragmentation of larger blocks and to mitigate for losses:

- Blue oak woodland
- Grasslands

For croplands, we recommend basing mitigation on a matrix of biological values and costs for each crop type based in part on spatial context. The matrix should consider such factors as these:

- *Rice fields*. If properly managed, these provide great benefits to wintering waterfowl (including numerous wading birds as well as hunted waterfowl), black terns, giant garter snakes, and other species. Greatest value may accrue to extensive blocks of relatively contiguous rice fields (which may minimize disturbance by human activities), and especially those that are interconnected by naturally vegetated irrigation ditches (used by dispersing giant garter snakes).
- *Orchards*. Although orchards adjacent to extensive riparian areas may benefit yellow-billed cuckoos or other species (T. Beedy personal communication), in general orchards support lower numbers of native species than other crop types, and their conversion to development is expected to be less detrimental to biodiversity than loss of other types. Orchards may also require intensive use of pesticides that harm native species. Development on existing agricultural lands should preferentially be focused in orchards (as opposed to other crop types), at least where they are not adjacent to wide riparian forests.
- *Row Crops*. Different types of row crops vary greatly in the benefits and threats they pose to native wildlife, due to differences in tilling, timing, rotations, pesticide uses, and the types of food or cover they offer, among other factors. We recommend reviewing husbandry techniques for the major row-crop types in the study area to determine whether and how to apply different mitigation or management options to them.
- *Alfalfa*. Alfalfa fields are favored foraging areas for Swainson's hawks, due to their support of dense vole populations and their frequent mowing. However, alfalfa is a very intensive crop in terms of water and petrochemical use, and frequent mowing can adversely affect ground-nesting bird species. Consequently, we recommend creating incentives to retain or expand alfalfa crops within 1 mile of known or potential Swainson's hawk nesting trees, but not necessarily everywhere in the agricultural landscape.

In addition, we recommend researching and incorporating as appropriate various options for incentivising wildlife-friendly farming, such as farmland trusts, conservation easements, and safe harbor-type agreements. See Yolo County Resource Conservation District recommendations for wildlife friendly farming (www.yolorcd.org). See also existing programs of the Audubon Society, CALFED's Working Landscape Committee, the University of California, and others for ways that the NCCP/HCP can help implement sustainable, wildlife-friendly agricultural practices. Some specific management actions that could be addressed in such agreements:

- Increase nest-site availability for Swainson's hawks by planting oaks within appropriate agricultural mosaics (alfalfa and row crops) that are lacking trees. Consider creating incentives to retain high-quality Swainson's hawk foraging habitat (alfalfa and certain row crops) within 1 mile of existing or potential nest trees, but not necessarily throughout the region.
- Protect and enhance black tern nesting areas in rice fields, such as by creating elevated islands within flooded rice fields as predator-resistant nesting substrates. Black terns currently nest along irrigation ditch berms in the Valley, but these may be subject to high predation rates (T. Beedy, personal communication).
- Consider creating or maintaining small, naturally vegetated areas within the agricultural matrix as sources of native pollinators. Native habitats in proximity to agricultural fields have been demonstrated to contribute significantly to pollination rates in some crop types (Kremen et al. 2004).
- Consider alternatives to converting open ditches to underground pipes, which increases water and irrigation efficiency but would adversely affect giant garter snakes and other species that rely on the open waters. One mitigation alternative could be to utilize conserved water to augment in-stream flows.
- Plant elderberry bushes or other native species to benefit native wildlife along irrigation ditches.
- Use irrigation canal vegetation corridors and tailwater ponds to create pockets of habitat as well as reduce soil loss and herbicide use.
- Use native perennial grass habitat restoration and fire management in grazing lands to reduce invasive species cover and enhance rangeland forage. Existing examples include the Stone and Bobcat ranches north of Winters (http://www.audubon-ca.org/LSP/projects.htm).

4.4 Riparian / Riverine Corridors

Riparian/riverine corridors, including major rivers and streams as well as smaller tributaries, contribute greatly to the biodiversity value of Yolo County, despite being highly altered and constrained by human changes to the landscape. In addition to their intrinsic value for supporting a diversity of aquatic and wetland-dependent species, riparian corridors provide valuable resources for species living primarily in native uplands or agricultural areas (e.g., nest trees for Swainson's hawks). They also can serve as "backbones" for design of reserve networks, facilitating movement of species through less hospitable environments, and playing a key role in linking reserves together.

However, the major riparian systems in the planning area are highly impacted by human activities. They are constrained by levees, dams, road crossings, and other constructed features, and degraded by mining and other in-stream activities. Much of their water is diverted for agricultural and other uses, and what remains is degraded in quality by a number of contaminants, including heavy metals, pesticides, and eroded soils. The natural water-flow regimes that native organisms evolved under have been greatly altered relative to natural conditions, and fish can no longer reach former portions of their habitat due to barriers and lowered flows during key portions of life cycles. Water temperatures are often higher than natural, adding greater stress to the system, especially for cool-water species. And both the aquatic and riparian habitats have been invaded by numerous alien species that further degrade conditions for native species and ecosystem functions.

In addition to biological degradation in and along the area's streams, risks to human populations and economies are also increasing. Despite the extensive levee system, flood risk is high and getting worse as older levees degrade, soils subside, new human communities are built in floodplains, and the regional climate changes towards warmer and wetter conditions (Department of Water Resources 2005, Mount and Twiss 2005, Hayhoe et al. 2004).

Maintaining and improving biological conditions along these important riparian corridors, reducing flood risks to human populations, and providing continued water for agricultural uses, are major challenges that cannot be tackled alone by this NCCP/HCP. Nevertheless, we recommend that the NCCP/HCP coordinate closely with other ongoing efforts to improve environmental conditions and reduce flood risks in the Central Valley, such as the CALFED program and various efforts of the California Department of Water Resources (DWR). The plan should strive to contribute to the goals of these other programs while meeting NCCP/HCP goals.

4.4.1 Biological Goals

Primary biological goals for riparian and riverine systems in the planning area are listed below. Some of these are best accomplished by reserve design (Section 4.4.2) and others by management actions (Section 6.1).

- Improve habitat connectivity, including aquatic continuity for fish passage.
- Increase the amount of naturally inundated floodplain in the planning area.

- Create self-sustaining riparian corridors with appropriate composition of native vegetation and shading of aquatic habitats.
- Restore natural or semi-natural flow regimes required by native aquatic species.
- Reduce exotic vegetation and enhance native riparian vegetation, especially by increasing native riparian trees and woodlands.
- Reduce and control invasive exotic animal species in aquatic habitats (e.g., New Zealand mud snail) and prevent future invasions.
- Protect and enhance upper watersheds.
- Provide scientifically justifiable buffers of upland vegetation adjacent to wetlands.
- Improve water quality by controlling runoff and other means.

4.4.2 Conservation Design Principles

The reserve network designed by the NCCP/HCP should include all major riparian corridors within biological reserves and use them as "backbones" to connect other reserve areas, to the degree feasible. In general, the conservation design should strive to ensure protection, restoration, and management of broad greenbelts along important tributaries, including Willow Slough, Cache Creek, and Putah Creek, and should use restoration of native vegetation and hydrological functions to broaden existing riparian vegetation and floodplains where feasible.

The following types of locations deserve special attention in conservation and restoration planning in riparian areas:

- Confluences of riparian/riverine systems (i.e., junctions of tributaries with larger streams or rivers, because riparian junctions often serve as biodiversity hotspots)
- Mature riparian forest, or areas with potential to become mature forests over time
- Wide (>100 m) riparian areas
- Functional or potentially restorable floodplain riparian areas (e.g., land laying between old or degraded levees near the stream and newer set-back levees, where breaching or removal of the older levee can restore some natural flooding processes, river meanders, and wide riparian vegetation)

Below we discuss some reserve-design recommendations and considerations for the planning area. Note that many goals concerning improving habitat quality and ecological functionality in riparian and riverine systems depend on potentially complex management solutions, which are addressed in Section 6.1.

Create continuous riparian corridors with wide nodes in key locations. The advisors strongly recommend that conservation, restoration, and enhancement of riverine corridors strive to create continuous riparian vegetation corridors along major streams and tributaries through the plan area, with major "nodes" of wider riparian vegetation at strategic locations, including at riverine junctions and other locations scattered along river corridors. All else being equal, if the amount

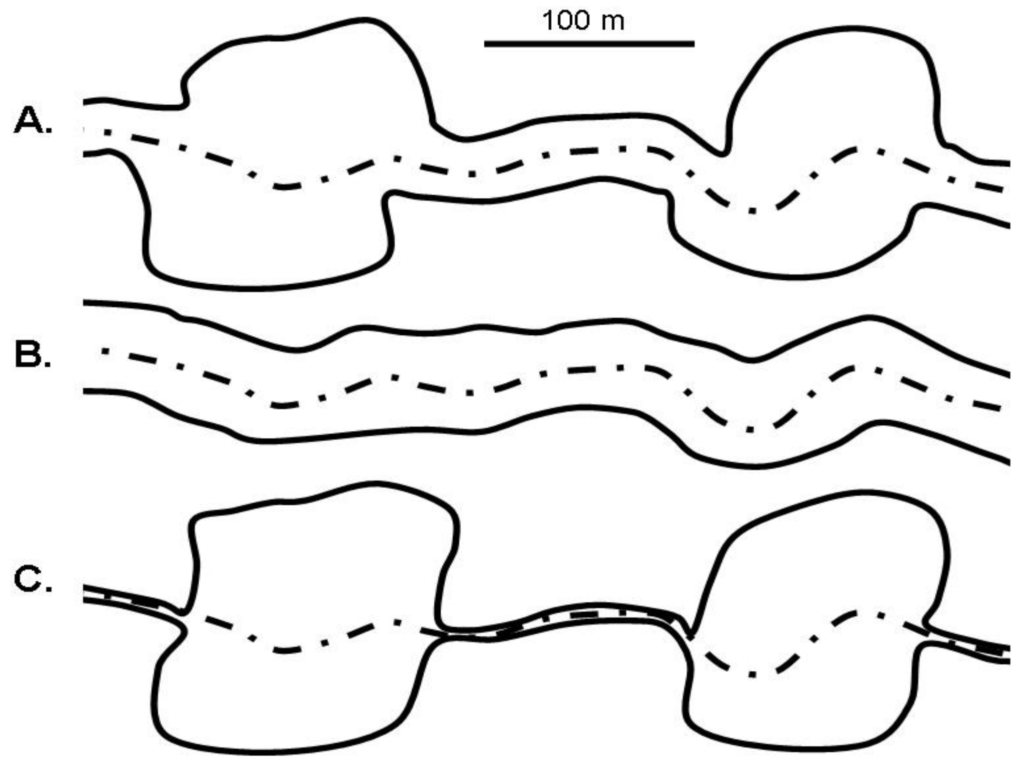

Figure 1. Comparison of 3 conceptual reserve design alternatives along a riparian corridor. The 3 reserves enclose roughly the same acreage, but in differing arrangements. **A**. Superior design combining wide biodiversity "nodes" (large enough to support nesting yellow-billed cuckoos) as well as continuous lateral corridors sufficiently wide to shade the stream and provide habitat and movement cover for multiple species. **B**. Less suitable design that provides wider shading and movement cover, but no biodiversity nodes (won't support cuckoos). **C**. Less suitable design with biodiversity nodes but insufficient lateral corridors (reduced shading, multi-species habitat, and movement).

of riparian vegetation that can be maintained and restored is limited, it should be distributed according to the conceptual design in Figure 1A.

Provide habitat continuity and connectivity, including for fish passage. Improving fish passage in streams and floodplains would benefit aquatic species in Yolo County, and should be incorporated into the plan if the NCCP/HCP is to cover native fish species. Even if the NCCP/HCP does not seek take authorizations for native fishes, improving fish passage may be mitigation measure to consider if projects approved under the NCCP/HCP are expected to have adverse effects on aquatic resources. Appendix E provides additional details and recommendations for improving fish passage, including some site-specific recommendations.

Increase amount of inundated floodplain habitat. Recent studies (NHI et al. 2002, NHI 2003, Sommer, personal communication) demonstrate that seasonally inundated floodplain habitat provides important habitat for salmon and splittail, and the CALFED ERP identifies restoration of fish habitat in the Yolo Bypass as a high priority. If the NCCP/HCP is to cover these species, or if mitigation options for indirect impacts to these species are to be included in the plan, consider options for increasing seasonal flooding in areas that would increase spawning and rearing habitat for these species. Appendix E presents additional information, including site-specific recommendations.

Create self-sustaining riparian corridors. Creating self-sustaining riparian corridors for habitat and for water temperature would benefit a variety of terrestrial, riparian, and aquatic species. For example, a carefully restored riparian corridor along Cache Creek between Capay and Yolo could not only increase habitat for numerous species, but would also reduce the magnitude of peak flows and sediment moving downstream to Woodland and the Yolo Bypass. See Appendix E for additional details.

Protect and enhance upper watersheds. The upper watershed of Cache Creek encompasses many unique open space natural areas that provide important habitat for native plant and animal species. These areas should be surveyed and protected to provide dependable long-term refugia for native species. The Bear Creek watershed also supports several unique assemblages of native flora and numerous native resident fish species. However, grazing has severely reduced riparian vegetation along portions of Bear Creek. Conservation of the Bear Creek watershed and restoration of riparian vegetation there should be a high priority.

Provide upland buffers adjacent to wetlands to sustain their ecological viability. Regulations by the state of California establish minimum requirements for riparian buffers along perennial streams. Federal forest lands require even more protective buffer dimensions and activities within riparian areas (Gregory 1996). Such protection is not required for urban, residential, or agricultural lands. Much of the future land use change in Yolo County will occur in these non-regulated land types. A recent review of riparian management by the National Research Council concluded that more consistent frameworks for riparian management were needed across all land use types (NRC 2002). The NCCP/HCP should develop consistent and scientifically sound buffer requirements that include best management practices for use of forested buffers, grass buffers, flow detention basins, interception swales, and other forms of riparian management and protection.

4.4.3 Implementation Tools

We recognize that it is not fully within the jurisdiction of this plan to influence aquatic connectivity along rivers and streams (e.g., changing water releases from reservoirs or recommending dam removals). Nevertheless, we recommend that the plan review other pertinent plans and recommendations (e.g., the CALFED Ecological Restoration Plans that are geographically relevant) to identify possible opportunities to improve natural hydrological connectivity through mitigation for future projects, including flood-control or transportation upgrades or repairs. For example, ERP reports identify as a significant mortality factor the stranding of juvenile Chinook salmon and other fish in borrow pits, toe drains, and other depressions along the base of existing levees. In coordination with CALFED, DWR, or other agencies, the NCCP/HCP could incorporate specific remediation or mitigation actions to rectify such problems. See Appendix E for detailed recommendations concerning potential improvements to stream flows, fish passage, and other relevant actions if the NCCP/HCP is determined to affect aquatic systems and species.

4.5 Yolo Bypass

The Yolo Bypass is a leveed floodplain managed for multiple benefits, including maintaining a diversity of habitats for waterfowl and wetland-associated species, for agriculture, and for flood conveyance. The Bypass provides habitat for at least 42 resident and seasonal fish species, 15 of which are native. It supports state and federally listed species (delta smelt, steelhead trout, spring-run and winter-run Chinook salmon) as well as game fish (white sturgeon and striped bass). The Yolo Bypass also provides important staging and wintering habitat for shorebirds migrating along the Pacific Flyway. The Yolo Bypass appears to be especially important to the Swainson's hawk, which uses the floodplain as foraging habitat.

4.5.1 Biological Goals

The Bypass is currently managed to provide diverse benefits to both people and wildlife, and this should continue and be improved upon through the plan. Given the unique land-use situation for the Yolo Bypass, biological goals for this subdivision should combine relevant goals from both the riparian/riverine subdivision and the agricultural subdivision. In addition, we emphasize the following specific goals for the Yolo Bypass (See NHI et al. 2002 for additional specific recommendations):

- Increase the amount of riparian forest habitats within the Yolo Bypass.
- Reduce water temperatures via restoration (e.g., increase shading vegetation) and management (control of water flows) to favor cool-water native fishes and disfavor warm-water nonnatives.
- Create habitat continuity and connectivity, including fish passage between the Bypass and the Sacramento River, Cache Creek, and Putah Creek, and links in riparian habitat between the Bypass and its tributaries.
- Increase frequency of inundated floodplain habitat, including during low-flow conditions.

4.5.2 Conservation Design Principles

See previous sections on conservation design principles for the riparian and riverine subdivision and the agricultural subdivision for pertinent principles to also apply within the Yolo Bypass subdivision. In addition, we offer the following, more specific, guidelines for the Yolo Bypass:

- Increase the contiguity of naturally vegetated areas relative to existing conditions, and increase the amount of riparian scrub and forest, via restoration in areas with appropriate soils and ground water depths. Some specific locations where such actions would be most beneficial:
    - Create a nearly continuous corridor of riparian vegetation along the Tule Canal/Toe Drain, linking the existing riparian area near Fremont Weir with the Delta.

- Create a riparian corridor along the existing channel at the west edge of the Yolo Bypass between Knights Landing Ridge Cut and Putah Creek, providing a habitat link between those waterways.
- Create a riparian corridor along Putah and Cache Creeks, providing better interconnection between the east and west habitat corridors of the Bypass.
- Allow natural development of a swath of tules in the southern end of the Bypass at the upper end of the intertidal range (sea level to +4 feet, National Geodetic Vertical Datum [NGVD] 1929) and intertidal mudflat habitat at the lower end (sea level to -4 feet NGVD 1929).

- Increase the width of riparian scrub and forest habitat wherever feasible to create high-quality habitat for riparian birds and other species.
- Create localized floodplain areas adjacent to the Tule Canal/Toe Drain and along Putah Creek to provide seasonal floodplain habitat that would persist long enough to benefit native fish in normal to dry years, when substantial inundation would not otherwise occur. Minimize obstructions to fish movement between channels and the floodplains.
- Provide unrestricted year-round fish passage along the Tule Canal/Toe Drain to the Sacramento River across the Fremont Weir, and between the Toe Drain and Putah and Cache Creeks.

Appendix E provides more detailed and site-specific recommendations for conservation and restoration actions to be considered for the Yolo Bypass area.

4.5.3 Implementation Tools

Significant improvements can be made to the management of the Bypass to increase habitat for native fish and other species in coordination with other ongoing planning efforts, including those of CALFED, DWR, Yolo Bypass Working Group, and others. SAFCA is developing the Lower Sacramento River Regional Project, which offers an opportunity to enhance aquatic, wetland, and riparian habitats while also providing for increased flood conveyance capacity. Landowner concerns should be considered and have been documented in "A Framework for the Future: The Yolo Bypass Management Strategy" (Yolo Bypass Working Group, 2001). The NCCP/HCP should consider implementing various landowner assurances, conservation easements, and other incentives to encourage wildlife-friendly agriculture and address water rights issues consistent with biological goals.

One of the major programs for improving habitat conditions in the Central Valley is the Central Valley Habitat Joint Venture (CVHJV). The CVHJV's mission is to "protect, maintain and restore habitat to increase waterfowl populations to desired levels in the Central Valley of California consistent with other objectives of the *North American Waterfowl Management Plan* (http://www.nawmp.ab.ca/index.html). The CVHJV has the following goals (for more information, see http://www.mp.usbr.gov/cvhjv/):

- Enhancing 291,555 acres of wetland habitat,
- Enhancing waterfowl habitat on 443,000 acres of agricultural land,

- Protecting 80,000 acres of existing wetlands through acquisition or perpetual conservation easements,
- Restoring and protecting 120,000 acres of historic wetlands through acquisition or perpetual conservation easements.

Another regional program targeting improvements in fish habitat is the CVPIA Anadromous Fish Recovery Program (AFRP). The purpose of the CVPIA is to mitigate for the adverse impacts of the Central Valley Project on anadromous fish. Habitat enhancement in the Yolo Bypass addresses two specific goals of the AFRP:

- To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California.
- To contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (http://watershare.mp.usbr.gov/documents/3402.cfm).

5 Conservation Analyses

Analyzing the likely effects of a conservation plan on target resources is one of the most critical, difficult, and underdeveloped tasks in most NCCP/HCPs. This section offers some recommendations for improving the analyses included in the plan, to improve its scientific as well as legal defensibility. At a minimum, the plan must fully and objectively analyze its likely effects on populations of covered species, which often requires assessing plan effects on physical or ecological processes. It also requires careful consideration of such uncertainties as effects of global climate change or how land uses are likely to change within the plan area over the next 50 years, with or without plan implementation.

5.1 Conservation and Take of Covered Species

Analyzing effects on target species populations is required for any HCP or NCCP, yet "conservation and take" analyses remain weak and scientifically indefensible for many regional conservation plans. HCP and NCCP guidelines essentially require a plan to assess its *net effects* on *populations* of covered species. In other words, the plan should predict, as best possible with available knowledge and models, whether plan implementation will increase, decrease, or have no measurable effect on a species' population size, sustainability, or recovery.

This is not easy; and due to insufficient time, money, expertise, data, or precedence, many conservation plans have done little to analyze plan effects beyond tallying species location points or habitat acreages falling inside or outside of preserve boundaries. Recognize that these are poor metrics for representing population sizes and distributions, due only partly to geographic biases in survey coverage and poor predictive accuracy of habitat models. Sometimes, vegetation community types are used as proxies to represent a species "habitat," which is a poor way to model habitat value for nearly any species. Clearly, the best possible habitat and distribution models that have been devised for a species should always be used in the quantitative analysis of conservation and take (refer to model discussion in Section 3.5). This quantification must be supplemented with a systematic assessment of plan effects on the physical and ecological processes affecting the species' habitat quality and population dynamics.

Ideally, an NCCP/HCP should perform quantitative Population Viability Analyses (PVA) on each covered species to determine the likely impacts of the plan on species populations. However, formal PVAs are not possible for nearly any species due to insufficient data on species life histories, genetics, and other factors and we do NOT recommend performing PVAs for this plan (except, perhaps, for such well-studied species as Swainson's hawk).

Instead, we recommend using a systematic approach to analyzing likely effects of the plan (and alternatives) on target species populations that uses available information to best effect. Although not fully quantitative, this approach forces thorough consideration of each known limiting factor for a species and how the plan is likely to affect that limiting factor (increase, decrease, or no measurable effect on its influence on the species' population). Moreover, the relative strength of each of these factors should be weighed relative to one another in determining the overall, cumulative effects of the plan on species' populations. For example, a plan scenario or alternative may result in a slight decrease in the acreage of potential habitat for a species, but with improved quality of that habitat to support that species (due to improved management or habitat connectivity, for example). The assessment should carefully weigh whether the combined effect of these positive and negative changes is most likely to increase, decrease, or not measurably affect the species population size and sustainability. The evidence used to make these decisions should be carefully documented in the plan analysis, including disclosure of key uncertainties bearing on them. These uncertainties should often become the targets of monitoring in the adaptive management paradigm to reduce uncertainty over time, and to test whether the hypothesized net effect was correct.

The following example demonstrates how the proposed analytical approach might work for Swainson's hawk and a hypothetical plan scenario that closely reflects the conservation design recommendations in Section 4 (i.e., a biologically preferred scenario). This example is purely hypothetical, and presented only to illustrate an approach for systematically addressing likely net effects on species populations in the planning area. Modify this structure as needed to best reflect those threats, limiting processes, or other factors influencing a particular species (e.g., migration barriers, invasive exotics, limiting resources). Also, to the degree feasible with available data and knowledge, replace qualitative with quantitative assessments, and relativistic weighting of the various factors with explicit weighting factors that reflect the relative influence of each factor on species population size or sustainability.

Hypothetical Example Conservation Analysis for Swainson's Hawk

Limiting Factors	**Net Effect**[8]	**Explanation**
Habitat Area	**0/-**	Minor proportional removal of current habitat (xx acres or xx%) expected to be at least partially offset by improved management and spatial configuration of habitat.
Dispersal	0	Plan will have no measurable effect on dispersal.
Resources	**+/0**	Plan expected to increase nest-tree availability over 50-year planning horizon.
Other Processes	0	None identified.
Misc. Threats	0/+	Use of BMPs on enrolled conservation lands expected to yield minor reductions in mortality rates.
Uncertainties	0	Uncertain relationship between nest-tree availability and population size. Effectiveness of mitigation measures (e.g., planting trees) uncertain. Changes in agricultural crop distributions unknown, but plan incentives expected to maintain a favorable mix of foraging habitats.
Net Population Effect	+/0	Over the long term, potential increases in nest-tree availability and improved hawk-friendly agricultural management should offset minor losses in occupied habitat, and may have a small net positive effect on population size and carrying capacity.

[8] For net effect, +, -, or 0 = positive, negative, or no measurable effect, respectively. **Bolded** effects represent those thought to have the greatest influence on population size or persistence. To the degree feasible, qualitative comparisons and weightings should be replaced with quantitative estimates and weighting factors.

5.2 Effects on Ecological Processes

As discussed in Section 5.1, analyzing plan effects on target species requires assessing the plan's effect on ecological processes that influence species' habitat and populations. However, analyzing the effects of a conservation plan on ecological processes is challenging, and not often adequately performed, because myriad physical, chemical, climatic, hydrological, geomorphological, edaphic, ecological, and evolutionary processes affect the distribution, abundance, and viability of populations and communities. Abiotic processes such as flooding, drought, temperature changes, and fire regimes are limiting to some species or at some times, whereas biotic processes including herbivory (e.g., grazing), competition, or predation from native or non-native species may be more limiting to other species or to the same species at other times or sites. A special form of biotic processes—direct human impacts such as habitat conversion, alteration, fragmentation, roadkill, and pollution—is the predominant limiting factor for many species in human-dominated landscapes and comprise the leading threat to biodiversity worldwide (Noss and Cooperrider 1994).

Given the complexity of considering ecological processes in conservation planning, we do not recommend a comprehensive assessment of all natural and anthropogenic processes operating within the planning region, and how they might be affected by plan actions. Rather, we recommend a two-pronged strategy that is consistent with the fine filter/coarse filter approach to conservation planning (Noss 1987) discussed earlier and with additional recommendations made by Hunter (2005) regarding a mesofilter:

- Identify the dominant ecological processes that shape the natural communities of the planning area, and estimate their natural or historic range of variability (Landres et al. 1999).
- In keeping with our recommendations regarding conservation and take of covered species (section 5.1, above), identify the processes that act as limiting factors for covered species and focal species at particular times and places. Clear examples of major importance to target species in this planning region include seasonal water-flow regimes; flooding, scouring, erosion/deposition, and other hydrological processes; fire; fish and wildlife movement or migration; pollination; and grazing.

We note that the characterization of natural or historic range of variability (NRV or HRV, respectively) in a thorough and scientifically defensible manner can be very difficult, time-consuming, and controversial. However, an approximation of NRV or HRV that relies on existing knowledge (e.g., from the scientific literature and historical documents) of particular natural communities can be developed feasibly for a conservation plan. In all cases, characterization of NRV or HRV requires knowledge of reference conditions, which may be contemporary (e.g., relatively large and unaltered examples of natural communities where natural processes still operate much as they have for centuries or longer) or historical (e.g., from dendrochronology, pollen/charcoal analysis, notes of early land surveyors or naturalists, historical photographs and vegetation maps). Some mix of contemporary and historical reference information is desirable. As discussed in section 6.1.4, fire history records and contemporary blue oak stand structure suggest that a relatively high fire frequency favors blue oak recruitment (McClaren and Bartolome 1989); hence, moving blue oak communities back into that range of variability in fire frequency is a reasonable management goal. Importantly, because the objective is to determine an acceptable range of variability that meets conservation goals, reference conditions should not be limited to a single reference natural area or a snapshot in time, but should span multiple sites across the region and period of time measured in at least decades. The NRV or HRV concept is most relevant to the native uplands in the western portion of the Yolo County planning area, where opportunities to restore communities to conditions within NRV or HRV are tangible. In addition, characterization of NRV or HRV for water-flow regimes is critical for assessing effects on aquatic and riparian species (Section 3.4). NRV/HRV analysis for agricultural and other non-natural systems may be more challenging.

The complementary fine-filter approach of analyzing plan effects on ecological processes considers the autecology of particular species, which is especially urgent for covered species. As noted earlier, because of anthropogenic habitat alteration, most of the planning area is currently far outside natural conditions. The NRV/HRV concept is still relevant for providing a baseline for comparison and, in some sites, for setting targets for restoration. Nevertheless, the more immediate need is to identify the processes that affect the distribution and viability of species in the near term. For example, as discussed in section 6.1.2, under contemporary conditions a lack of livestock grazing is a primary limiting factor for native vernal pool species, because grazed pools tend to have longer periods of inundation, closer to the NRV/HRV for vernal pool hydrodynamics (Marty 2005). Species of interest usually must be treated individually in such analyses because the autecology of no two species is identical; different species have different sets of, and responses to, limiting factors. Nevertheless, a primary limiting factor, such as unnatural hydrology or road impacts, may be held in common by many species. Hence, consistent with the umbrella assumption of the focal species approach (Lambeck 1997), moderating the limiting factors and otherwise meeting the needs of the most sensitive species in a given vulnerability group will likely improve the prospects for persistence of less sensitive co-occurring species with similar habitat requirements and vulnerabilities.

5.3 Scenario Modeling *(contributed by S. Gregory)*

It is difficult to assess the future consequences of a conservation plan on target resources given the total collective impacts of land-use and management changes that will occur over time with or without the NCCP/HCP and especially considering uncertain changes in climate, water availability, crop prices, environmental or land-use regulations, and so on. Land use planners facing similar uncertainties have used the development and analysis of alternative future scenarios to evaluate the potential outcomes of human actions and management options (Hulse and Gregory 2001, Schoonenboom 1995). Scenario analyses are now an important tool in conservation planning based on quantitative modeling as well as narrative projections of future change. For an NCCP/HCP, scenario building can be used to generate the alternatives to be analyzed in the environmental documents prepared pursuant to NEPA and CEQA.

Projections of future change are never exact, but likely scenarios can be developed and used as a basis for community discussion and planning. The advisors believe this plan would benefit from a scenario modeling exercise designed to (1) project likely and alternative future changes and land use patterns, (2) assess the consequences of those changes on target resources, and (3) explore effects of various conservation and mitigation policies relative to NCCP/HCP goals. We recommend that Yolo County develop a range of plausible future scenarios and use resource professionals or natural resource models to assess their likely effects on target resources. These scenarios should consider major foreseeable changes, such as predicted climate change, changes in water availability or costs, community growth patterns, or changes in agricultural practices.

5.3.1 Defining Scenarios

Future changes in the landscape and human population of Yolo County could be explicitly defined as a basis for assessment of alternative outcomes and their desirability. Alternative scenarios can be developed through stakeholder processes, professional or expert judgment, or simulation models (Hulse and Gregory 2001, Hulse et al. 2002, Schoonenboom 1995). Stakeholder processes employ citizen stakeholder groups to define assumptions about how future land and water use will unfold. These scenarios can then be used with planning processes and models to produce maps of future land and water use, translating the citizen group's assumptions into mapped form. This citizen-driven approach has the advantages of citizen involvement, greater political plausibility and increased likelihood of institutional acceptance. But these stakeholder–driven processes have the disadvantage that they do not statistically quantify the likelihood of various alternatives, and the number of alternatives produced is typically quite limited (3 to 10).

A second common approach for creating mapped alternative futures is expert-judgment, with experts in the biophysical and social sciences defining processes and rates of transition that determine future land and water use conditions. Some such scenarios already exist for the study area through the work of Robert Johnston (UC Davis, Dept. Environmental Science & Policy) and the Sacramento Area Council of Governments (SACOG). Alternative futures produced from expert judgment have the advantages of quantifiable statistical likelihood (based on the larger number of alternatives produced), but they suffer from unclear political plausibility and lack of citizen involvement (and thus credibility in the community).

Simulation modeling has been used to define alternative futures by representing the rules by which people make decisions and then projecting those policies across the landscape. This approach has the advantage of being able to quickly produce and analyze large numbers of alternative scenarios, and thus can be used to represent the statistical likelihood of various alternative futures.

Development of alternative future scenarios is more likely to gain broader public support if local communities and regional decision makers are involved (Lee 1993, Gunderson et al. 1995). Community cooperation is also essential for successful implementation of these solutions (Kirch 1997, Daily 1999). The types of scenarios that should be considered for Yolo County include population growth and where those people live and work, resource demands, water availability, and climate change. Thus, a mix of expert models and simulations can be used as a baseline to create a series of scenarios that are updated, modified, and assessed by citizen groups. This may be an effective way to utilize existing expertise and incorporate public participation.

5.4 Assessment of Aquatic Communities and Species *(contributed by S. Gregory)*

Most NCCP/HCP impacts on aquatic species are indirect effects due to changes in ecological processes rather than direct take of species. Such indirect effects can be difficult to estimate. We recommend assessing current conditions of stream ecosystems using one or more of several commonly used assessment indices and models, and then predicting likely future conditions based on expected changes in these indices and models (perhaps as part of the scenario modeling approach described in Section 5.3). Although forecasting future changes entails some uncertainty, the predictions can and should be tested as part of the adaptive monitoring program (Section 6). Thus, the aquatic assessment methods described in this section should also be considered for inclusion in the monitoring program, particularly if the plan addresses native fish and aquatic habitats.

Two useful approaches are biological assessments and physical habitat assessments, both of which provide important information for planning and monitoring (Hawkins et al. 2000). The NCCP/HCP should evaluate the existing knowledge of stream condition in the area (see Sections 3.3 through 3.6) and address how monitoring using one or more of the following types of assessment can address plan effects and management decisions into the future. The state of California and the USGS National Water-Quality Assessment (NAWQA) program (http://water.usgs.gov/nawqa/) are employing the following types of assessments in the area covered by the NCCP/HCP.

5.4.1 Biological Assessments

Biological assessments include several well-established measures of biological health for stream ecosystems. Resource scientists around the world have used such biological measures as the EPT (Ephemeroptera-Plecoptera-Trichoptera) Index, Index of Biological Integrity (IBI), and ecological community models, such as RIVPAK. These biological assessments all use the abundance or presence of aquatic biota as measures for interpreting the ecological condition or health of the system. They differ in the organisms used as indicators and their complexity, assumptions, and use of reference sites.

*EPT Index***.** This indicator of aquatic ecosystem condition measures the proportion of the aquatic insect community comprised of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These orders of insects require cool, unpolluted streams with clean gravels, which also reflect the habitat requirements of key NCCP/HCP species like steelhead. The EPT Index is a simple index of overall water quality and invertebrate communities. It does not directly evaluate fish communities, but it does assess their food resources and water quality. The method has been widely used throughout the world and is potential tool for monitoring NCCP/HCP effects on aquatic resources.

*Index of Biotic Integrity (IBI)***.** Recognizing the limits of simple ecological indices, ecologists have attempted to develop indices based on important relationships between aquatic biota and physical and environmental factors. The Index of Biotic Integrity (IBI) integrates known relationships between native aquatic species and the physical habitat or water quality, and generates a single composite index (Karr 1991). IBI can be modified for local species and targeted at particular types of biota, such as invertebrates or fish (Karr 1981, Plafkin et al. 1989). The basic goal should be to maintain an IBI in the very good to excellent range for all aquatic habitats included in the NCCP/HCP plan area.

5.4.2 Physical Assessments

The second general approach for aquatic assessment addresses the physical habitat of the aquatic ecosystem. Because the amount of water diverted from local streams—or remaining in streams to support NCCP/HCP species—is a concern, assessing the effects of discharge on aquatic habitat is directly applicable to assessing current habitat conditions and NCCP/HCP effects, and for designing future alternatives. Several physical assessment methods are available.

Standard-setting methods identify minimum flow standards that are required to protect certain instream flow values of interest (Petts and Maddock 1994). These may be based on either historical streamflow records or on hydraulic field data to examine relationships between stream discharge and indices of fish habitat quality (Tennant 1976, Espegren 1998).

Incremental methods estimate changes in habitat relative to incremental changes in instream flows (Bovee et al.1998; Espegren 1998). These methods combine extensive hydraulic data with biological information about the depths and velocities at which various life stages of target aquatic species are observed (Bovee et al.1998; Espegren 1998). The method most widely used in the United States is the Instream Flow Incremental Methodology (IFIM). Output from IFIM models can be used to evaluate the relative consequences of changes in instream flow on downstream habitats. Relationships between discharge and the distribution of aquatic organisms also have been assessed using a method known as Physical Habitat Simulation (PHABSIM). Changes in depth and velocity with discharge are related to an organism's habitat preference. PHABSIM requires detailed field survey data and is often used as part of IFIM to generate habitat-discharge relationships.

5.5 Representation Analyses

Representation analysis involves evaluating how well a reserve system *represents*, or samples, the range of variation within an area of interest, such as whether it includes significant examples of all vegetation types, species habitats, or geological substrates in the area. We recommend a representation analysis of physical (abiotic) habitats and natural vegetation within the plan area, assessing to what degree each type is represented in existing or potential reserves or special management areas. Physical attributes that should be considered in the representation analysis include watershed attributes (see Section 3.3), climate variables, and geological substrates.

For certain types of resources, it may be useful to perform a resource-focused representation analysis. For example, we recommend analyzing vernal pool distributions by geographic substrate, to ensure that reserves provide adequate representation of different types of pools (and associated species communities) that may vary with substrate.

Other factors to be subject to representation analysis should be assessed during refinement of the plan's biological goals and plan development.

5.6 Effects of Global Warming

Regional climate change models predict a range of outcomes for temperature and precipitation changes in California's Central Valley (Hayhoe et al. 2004). One plausible outcome is that both winter precipitation and temperatures will increase. Using this scenario, Pyke (2005b) predicted how regional climate change would interact with vernal pool conservation in the Central Valley. He concluded that current vernal pool protection in the Central Valley favors vernal pool habitat in drier parts of the Central Valley (Southern Sacramento and San Joaquin Valleys) and suggested that protection of vernal pool habitats needed to include vernal pools in the northern Sacramento Valley to ensure the long-term viability of the threatened and endangered vernal pool invertebrates.

Recent and emerging climate-change models suggest that precipitation in California, generally, will shift toward rainfall, reducing winter snow pack (Hayhoe et al 2004). Yolo County lies in an interesting location because much of the county obtains its water from the southern portion of the coast range through Cache Creek, Willow Slough, and Putah Creek. These creeks are entirely rainfall driven. The eastern edge of the county, however, lies along the Sacramento River, obtaining its water from the Sierra Nevada. Thus, the eastern portion of the agricultural lands are likely more vulnerable to perturbation by global climate change effects on snow pack. Chris Field (Stanford University) is currently attempting to predict shifts in agricultural practices as a consequence of these changes. Different watersheds within the county may have distinctly different futures. At the present time, however, we do not know enough to accurately predict the likely effects on all target resources. We recommend reviewing these studies and predictions, and incorporating them while developing alternative scenarios, analyzing plan effects, and especially developing an adaptive management and monitoring plan that can effectively measure and respond to changing futures.

6 Adaptive Management and Monitoring

Adaptive management is "a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form – 'active' adaptive management – employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed" (B.C. Ministry of Forests 2000). This plan's adaptive management strategy should be based on plan goals and objectives (as recommended in Section 2.1), yet be flexible and contain direct feedback loops to inform land managers and those overseeing NCCP/HCP implementation. If possible, specific *a priori* management thresholds should be developed under each plan objective. Management thresholds would tell the land manager when a change or action needs to take place (Noss and Cooperrider 1994). Therefore, plan objectives and action plans should evolve as more is learned about the system being monitored.

6.1 Preliminary Management Recommendations for Select Issues

Although it is too early in the planning process to identify all necessary and sufficient management and monitoring guidelines, we offer the following preliminary recommendations for select topics or resources to be considered in the required Adaptive Management Plan.

6.1.1 Levee Maintenance

It appears that current levee management actions in the county vary from place to place, depending in part on the local management authority. For example, in some locations, vegetation on levees is kept clear by prescribed fire, whereas herbicides, hand-clearing, or other techniques may be used elsewhere. Also, poisoning of burrowing rodents may be used to maintain levee integrity. We recommend a comprehensive review of levee maintenance plans or actions used by various management entities and an attempt to synthesize a set of best management practices for levee maintenance that are cost effective but compatible with NCCP/HCP goals. There is an active research group on levees at UC Davis, led by Professor Jeffrey Mount (Geology). We recommend consultation with Dr. Mount regarding habitat management methods, levee setbacks, and levee integrity within the county. Some considerations to be addressed in the management plan:

- Vegetation burning or non-selective herbicide use kills elderberry shrubs required by the valley elderberry longhorn beetle. More selective methods should be considered. For example, managed goat grazing may be an effective and biologically preferred vegetation management method along levees (with goat herds used to limit grazing on desirable species).
- Rodent control may kill non-target species, reduces burrow availability for burrowing owls, amphibians, and reptiles, and removes a food source for raptors, garter snakes, and other target species.

- Levees, if maintained in natural or semi-natural vegetation and with some direct human uses regulated, may serve valuable roles as breeding habitat or movement corridors for native species.
- The improvement of one levee system generally increases the chance of levee failure in another place, whether inside or outside of the county. Thus, management of the Yolo County levee system for the maintenance of open space and habitat, or for housing, requires consideration of effects on adjoining jurisdictions.

6.1.2 Vernal Pool and Grassland Management

Management of vernal pool and annual grassland areas (e.g., Grasslands Regional Park) should be informed by the latest land-management research for these systems. This research reveals that managed grazing and fire are essential tools for countering the adverse effects of annual grasses and thatch buildup on natural ecological processes and native species.

California's annual grasslands are typically dominated by non-native species of grasses and forbs. However, native species persist and remain dominant in areas where extreme edaphic or hydrologic conditions exclude the non-native competitors. The hydrologic conditions in vernal pools help maintain the dominance of native species in this system, but recent research suggests that land management practices such as fire and grazing are necessary to maintain the native diversity of the plants and animals that inhabit the vernal pools. Marty (2005) found that grazing in particular plays a critical role in maintaining vernal pool hydrology. When cattle were removed from a vernal pool site in Sacramento County, the ungrazed pools remained inundated 50 days less than pools grazed at historic levels. Increased evapotranspiration in the ungrazed pools due to a much higher abundance of grasses was the likely reason for this altered inundation period. The study also found that native species plant and aquatic invertebrate richness in the vernal pools declined with grazing removal. Shortened inundation periods in vernal pools may eliminate suitable habitat for several of the vernal pool species considered in this HCP/NCCP including California Tiger Salamander (*Ambystoma californiense*), vernal pool tadpole shrimp (*Lepidurus packardi*) and western spadefoot toad (*Spea [Scaphiopus] hammondii*). In areas that have not been grazed or burned in the recent past, a robust monitoring program should be implemented in conjunction with any management changes in order to determine whether sensitive species are responding positively to the management changes. In particular, grazing regimes should be chosen that do not harm rare vernal pool grasses in areas such as Grasslands Regional Park.

Fire in conjunction with grazing also helps to maintain native species diversity in these vernal pool and grassland habitats. At four vernal pool sites in the Sacramento Valley (Vina Plains Preserve, Jepson Prairie Preserve, Cosumnes River Preserve, Howard Ranch), Marty (unpublished data) found that late spring burning significantly reduced the cover of non-native annual grasses throughout the vernal pool grasslands but increased the cover of non-native forbs across all sites in the Valley. Native diversity was not consistently higher in burned pastures at all sites studied, but certain sites (Jepson Prairie, Cosumnes River Preserve) showed marked increases in native plant diversity and cover with the addition of burning in a grazed system. These studies show that burning and grazing are important management tools in vernal pool grasslands but are likely to have the most significant effects when used in combination rather than separately.

6.1.3 Emergent Wetlands, Ponds, and Irrigation Canals

Management of permanent drains, ponds, or other wetland features may vary based on geographic context and the species they are being managed for. In some areas, it may be best to maintain permanent waters to provide habitat for giant garter snakes, western pond turtles, and a variety of wetland birds. However, permanent ponds also provide habitat for exotic species that are detrimental to native species, such as rare amphibians. Periodically draining ponds during late summer to control bullfrogs and other exotic species can therefore be a useful management tool to benefit rare amphibians, such as California tiger salamander. Site-specific management directives should be developed for the management of emergent wetlands and ponds to address such issues, based on site-specific monitoring surveys and management goals, during plan implementation.

Many canals in the county are currently maintained with little or no vegetation allowed. This entails herbicide treatments several times each year. An alternative approach is exemplified by John Anderson, a native seed farmer located between Winters and Davis. Mr. Anderson converted irrigation canals on his property to vegetated stretches dominated by common native wetland plants (*Carex* and *Scirpus*, not *Typha*). This vegetation requires little maintenance, discourages weed growth, reduces surface erosion into canals, and provides wildlife habitat. In addition, a small sediment trapping pond catches sediment that runs off with irrigation water. Each year the pond is dredged and the soil is placed back on fields. The Audubon California Landowner Stewardship Program (http://ca.audubon.org/LSP/Willow_Slough.htm) is assisting landowners in obtaining funding from the Natural Resources Conservation Service (NRCS) to help fund these projects. Promoting this sort of management could increase wildlife habitat area within the county while potentially reducing annual costs to landowners.

6.1.4 Oak Woodlands and Savannahs

Oak woodlands and savannahs play an important ecological role in California's Central Valley and surrounding foothills. Acorns provide an important food source for a suite of vertebrate and invertebrate species. Oaks within an annual grassland matrix add structural diversity and create a patchwork of shade, vertical and horizontal structure, and temperature and moisture variability that enhance biodiversity.

A primary management concern in blue oak woodland and savannah habitat involves the lack of blue oak sapling recruitment (Muick and Bartolome 1987). Researchers have found that successful establishment of this species depends upon a combination of factors, including abundant acorn production, lack of acorn predation, sufficient rainfall, protection from desiccation during germination, limited competition for light and water, and escape from browsers and burrowing gophers (McClaren 1987). McCreary and George (2005) found that cattle can have negative effects on blue oak seedlings depending on timing of grazing and stocking densities. They provided the following recommendations for grazing management in oak woodlands and savannas: (1) Do not graze pastures in the summer months; (2) limit grazing to remove approximately half of the annual forage produced; (3) plant oaks more than ½ mile from stock water sources; (4) protect planted and natural seedlings using protection cages until the trees are over 6 feet tall.

Muick and Bartolome (1987) found blue oak sapling recruitment varied by region and was not negatively or positively impacted by cattle grazing in a survey of blue oaks at 52 sites in California. Anecdotal evidence suggests that Native Americans managed blue oak woodlands to for a number of reasons and likely burned some of these sites on an annual basis. McClaren and Bartolome (1989) showed that high fire frequency might have favored oak regeneration in the past. They compared oak stand age structure in the Central Sierra with fire history, and showed that oak recruitment was highest during periods of high fire frequency in the 1880's to 1940's. Feral pigs may also be adversely affecting oak recruitment. Further research on the magnitude and interaction between these various factors on oak woodland should be a priority for the adaptive management program, with a goal to increase oak recruitment in areas where it is thought to be limiting biological diversity.

6.1.5 Riparian and Riverine Systems

Riparian and riverine corridors provide some of the richest wildlife habitat in the study area, but management is needed to counter a variety of threats to their ecological integrity.

Maintain riparian buffer zones and control contaminant inputs. Riparian buffer zones (or setbacks) should be established to prevent vegetation disturbance and ground compaction, minimize bank erosion, and promote native floodplain vegetation and its associated ecological benefits. The minimum width of the riparian management zone should be from 50 to 300 feet depending on the stream size and local topography (Kondolf et al 1996). In addition, management of non-point source sources of sediments, nutrients and other pollutants is critical to restoring and maintaining riparian areas. There are many guides for best management practices (BMPs) to reduce erosion and sediment yield and improve stormwater quality (www.dot.ca.gov/hq/oppd/stormwtr).

Rivers near urban and suburban areas are often adversely affected by urban storm water runoff including: (1) altering hydraulic characteristics of receiving streams by increasing peak discharge, increasing flooding and the duration and frequency of elevated discharge, and reducing base flow; (2) changing stream morphology by increasing bank erosion, streambed scouring, and channel widening; (3) altering fish and macroinvertebrate communities, and decreasing populations of sensitive species. The goal of urban/suburban BMPs is to minimize these impacts. In existing developed areas, BMPs should address a range of water quantity and quality issues. In new developments, BMPs should be designed so that post-development peak discharge rates, volume, and pollutant loads are no greater than pre-development conditions. The following BMPs should be tailored by the plan to best achieve biological and physical goals:

- Infiltration systems to capture runoff and allow it to infiltrate into the ground. These systems include porous pavement, trenches, and wells.
- Detention and retention systems, such as agricultural tailwater ponds, to temporarily capture runoff and retain it for a short period of time before it is slowly released.

- Constructed wetland systems to allow biological uptake of pollutants while also detaining and retaining flows.
- Filtration systems to remove suspended material from runoff.
- Conveyance and delivery systems that direct storm water away from impervious surfaces to areas where it may be detained or infiltrated.

Restore natural or semi-natural flow regimes. Maintaining ecological conditions favored by native fish would also help reduce the potential for non-native fish to displace native fish. Currently, the high winter flows combined with the relative high turbidity of Cache Creek appears to give native fish a competitive advantage over non-natives. Maintaining cooler water temperatures in the main-stem Cache Creek and the Bear Creek watershed, particularly during May and June when exotic fish generally reproduce, may also reduce the potential for exotic species. Many exotic species, particularly bass, have difficulty reproducing in cold water conditions. Restoration and maintenance of riparian vegetation along Bear Creek would probably reduce local stream temperatures in Bear Creek. It may be possible to modify the operations of the Clear Lake and Indian Valley releases to strategically reduce water temperatures. Presumably, hypolimnetic (bottom of the reservoir) releases from Indian Valley are considerably cooler than the epilimnetic (top of the lake) releases from Clear Lake. By stepping up releases from Indian Valley in May and simultaneously reducing the flows from Clear Lake, it may be possible to significantly reduced water temperatures in the mainstem of Cache Creek.

Reduce exotic vegetation and enhance native riparian vegetation. Exotic vegetation, primarily *Arundo donax*, black locust, and *Tamarisk spp*., must be controlled to preserve native riparian habitats and values. In addition to direct exotic vegetation removal programs, it may be possible to limit exotic vegetation by modifying reservoir releases. It is possible that existing releases, which are higher in the summer than the late spring, may impede cottonwood recruitment and encourage tamarisk recruitment. Managing release so that flows in late April and May are slightly higher than flows throughout the summer months should improve conditions for cottonwood establishment. Paul Robins (Yolo County RCD) has been involved in removal efforts within the county. Consultation on the success of on-going efforts and management strategies for minimizing spread should be incorporated into the adaptive management plan.

Reduce and control invasive exotic animal species in aquatic habitats. The New Zealand mud snail was first observed in Putah Creek in recent years. A brief fishing closure allowed management of the population from the Monticello dam downstream to Lake Solano. Continued monitoring for the mud snail is recommended. The plan should address what action would, or could, be taken if the mud snail population expands and whether there are any habitat management options to help limit the invasion potential of this species. There are numerous other exotic species in the region's aquatic habitats, many of which are fully naturalized and difficult to control or remove. We recommend reviewing the available literature on exotic aquatic species to determine best management practices that may be feasible to implement.

One key to preserving native resident fish species is minimizing the future potential for introduction and colonization by invasive exotic fish species. Intentional introduction of red eye bass or spotted bass by agencies along with unofficial introduction from live bait buckets is the greatest risk of exotic fish colonization in the upper Cache Creek watershed (P. Moyle, personal communication to ES). Although exotic fish are dominant downstream of 94B, there seems to be little risk that exotic fish from this reach will move upstream and displace the native fish assemblages. Most of the exotic fish in the upper watershed have probably colonized from Clear Lake where they were introduced in the early 20th Century. Red shiners present near Rumsey may have been a bait bucket introduction in the upper watershed rather than a migration of red shiners from downstream.

6.1.6 Rice Fields and Associated Water Conveyance Systems

Rice fields support large wintering populations of waterfowl, shorebirds, and giant garter snakes, but how they are managed has a large influence on wildlife use and mortality. Traditional rice farming methods are generally compatible with supporting populations of giant garter snakes, but some modifications of farming practices would further benefit giant garter snakes. Educating field workers about giant garter snakes and instructing them not to kill the snakes they encounter while farming would be helpful. Farming practice modifications, particularly as they relate to pesticide applications are specified in *Managing Ricelands for Giant Garter Snakes* (www.cdpr.ca.gov/docs/es/espdfs/ggsbroch.pdf).

In maintaining irrigation supply and drainage canals, benign neglect is the best policy from the point of view of garter snakes. Some recommendations to minimize adverse effects of necessary maintenance actions on giant garter snakes and other sensitive species:

- Any canal maintenance that is necessary should be done during the period of activity for giant garter snakes, May through September.
- Vegetation should be managed with native wetland plants and not removed from canals. If removal is required, then clear one side of a canal at a time in any given year to leave cover for amphibians, birds, and snakes.
- Mowing of ditch banks and field access roads should be done at blade heights greater than six inches.
- Burning of rice fields to remove straw is generally not encouraged (for biological as well as air-quality reasons). Any burning that is done should be conducted during winter when snakes are underground.
- Maintaining water in drainage canals maintains core habitat for giant garter snakes when rice fields do not have emergent vegetation.
- Duration of flooding in rice fields should be extended long enough to prevent the nests of the white-faced ibis from drying out too early in the season, which can cause significant mortality.
- Consider creating small, isolated islands of elevated soil within rice fields to increase secure nesting sites for black terns (*Chlidonias niger*). Black terns currently nest on elevated berms along irrigation canals and levees, but are subject to heavy predation. Isolated islands surrounded by flooded rice are expected to increase nest success (T. Beedy, personal communication).

6.1.7 Other Agricultural Types

We recommend a thorough review of literature on best management practices in Central Valley agricultural areas that can be incorporated into reserve management plans, safe-harbor agreements, conservation easements, or other means of promoting wildlife-friendly agricultural practices. Some issues to consider:

- Pesticide aerosols have negative impacts on native species, especially frogs (Davidson et al. 2002, Davidson 2004), and best management practices to avoid aerosol drift should be researched and incorporated.
- Agricultural incentives to retain alfalfa within about 1 mile of Swainson's hawk nest trees both should be considered.
- Encourage planting of oak trees within the agricultural matrix to provide future nesting sites for Swainson's hawks, both to replace old oak trees that die over time and to increase nesting opportunities where tree availability may currently be limiting.
- Plant native plants along roadsides and irrigation canals to reduce weedy invasions as well as maintenance costs.

6.2 Preliminary Monitoring Recommendations

We recommend using the approach presented in Atkinson et al. (2004) to guide development of the monitoring program. This dovetails well with the hierarchical approach to setting goals, objectives, and criteria recommended in Section 2.1. Development of management-oriented conceptual models, as presented in Atkinson et al. (2004) is especially useful for relating plan goals to management actions within an adaptive management program.

6.2.1 Monitoring Recommendations for Select Species

The type and intensity of monitoring for target resources should vary with species. In general, monitoring effort should be sufficient to understand relative population status, trends, threats, and responses to management at reasonable levels of precision for all covered species. However, it is not essential to obtain precise estimates of population size for all species, and limitations of time, money, expertise, and access make obtaining such estimates unreasonable. Moreover, intensive population monitoring can actually harm some species, and it is unnecessary to achieve plan goals for many of them.

For animals, relative indices of distribution and abundance may suffice for most species, such as derived from simple presence-absence surveys, periodically sampled throughout reserves, and corrected using detection probabilities (Azuma et al. 1990, MacKenzie et al. 2002). We recommend reviewing Vojta (2005) and associated papers recently published as a Special Section of the Journal of Wildlife Management: *The value and utility of presence-absence data to wildlife monitoring and research*.

For rare plants it is often relatively simple to obtain a crude estimate of plant population size without destructive sampling or disturbing populations. A census-based approach to estimating population viability is available through diffusion approximation methods (Morris and Doak

2003). To conduct such assessments one only needs an estimate of population size, and not complete demographic information regarding individual performance. Listed plant species and threatened vernal pool taxa, in particular, would benefit from yearly assessments of population performance. These censuses could be at a crude level, estimating extent and density of a population when populations are large, and could consist of counting individuals when populations are small.

Here we provide some preliminary recommendations for monitoring select species, communities, threats, or processes (not a comprehensive list):

- *Swainson's Hawk.* Swainson's hawk should receive relatively intensive monitoring, designed to estimate nesting populations, and perhaps nest success, annually. Swainson's hawk appears to be nest-limited, and it is worth testing this hypothesis over time by looking for a correlation between the distribution and density of large trees in association with foraging areas, and the number of nesting pairs of Swainson's hawks. Nest success may also vary with foraging territory quality, a hypothesis that should be tested and used to define management triggers. If, for example, the acreage of alfalfa or number of nest trees fell below specified thresholds, then specific management actions and more detailed monitoring may be triggered.
- *Invasive Species.* Distributions and relative abundance should be monitored for some invasive species. A few of the many species of concern include perennial pepperweed[9], Argentine ants, New Zealand mud snails, bull frogs, non-native fish, and feral pigs. Surveys of weed distributions along roads and canals should be considered for inclusion in the monitoring program.
- *Oak Recruitment.* Areas where oak recruitment is occurring or not should be identified to look for limiting factors. The plan should provide for additional study of interactions between fire, grazing, and oak recruitment.
- *Road kill surveys* in Capay Valley are recommended in those areas where road improvements are made or new traffic is generated, using a Before-After/Control-Impact (BACI) sampling design.
- *Aquatic habitat factors.* Some factors to consider for periodic monitoring along streams include spawning gravel habitat for fish, bank stability, geomorphology (down cutting), and mercury levels, including identification of the source, methylation process, and impact on aquatic food chains.
- *Fire regime* and the natural range of fire intervals in various habitat types.
- *West Nile virus* which may be at least partially responsible for population decline of yellow-billed magpie.

[9]The advisors observed this invasive within vernal pools in Grasslands Regional Park

7 List of Additional Information Sources

Here we list some additional information sources that should be consulted during plan development.

- *Suitability Analysis for Enhancing Wildlife Habitat in the Yolo Basin*. A habitat suitability analysis for the Yolo Bypass based on soil types, landforms, and historical vegetation patterns was completed in 1995 by Jones & Stokes Associates.
- *Yolo Bypass Management Strategy*. This is a blueprint for management of lands and resources in the Yolo Bypass developed by local landowners, agencies, and interested parties during a two-year planning process funded by CALFED (Yolo Bypass Working Group et al. 2001). The Strategy articulates principles to guide land-use and habitat-restoration activities, such as acquiring lands or easements on a willing-seller basis and providing safe-harbor protection for parcels adjoining restoration sites.
- *Habitat Improvement for Native Fish in the Yolo Bypass*. CALFED funded an evaluation of opportunities for fish habitat enhancement throughout the Yolo Bypass (Natural Heritage Institute et al., 2002). Primary factors used to define suitability included flow regime, site topography, site availability, and the opportunity to improve fish passage. The study examined the potential for near-term implementation of a demonstration-scale floodplain restoration project. The study identified small- and large-scale enhancement opportunities, including a demonstration project at Putah Creek.
- *North Delta National Wildlife Refuge*. Little Holland Tract, Liberty Island, and Prospect Island are leveed, low-elevation islands near the southern end of the Yolo Bypass that experienced multiple levee failures or other difficult farming conditions in the 1980s and 1990s. The landowners eventually opted to discontinue farming and sell the islands for use as habitat. The islands are presently owned by USACE, the Trust for Public Land, and U. S. Bureau of Reclamation, respectively. These holdings prompted the U. S. Fish and Wildlife Service to investigate the feasibility of incorporating the islands as the core of a new wildlife refuge.
- *South Delta Wildlife Refuge Draft Environmental Assessment*. USFWS completed a draft environmental assessment for the South Delta Wildlife Refuge in 2000. A wide range of potential refuge sizes was included in the analysis, reflecting tentative interest on the part of some local landowners in selling their land to the refuge. The document addressed agricultural and flood impact issues at a reconnaissance level. The refuge proposal generated local political controversy, and further study has been deferred indefinitely. Also, some of the more northerly lands considered for inclusion have since been added to California Department of Fish and Game's Yolo Basin Wildlife Area.
- *USACE Comprehensive Study*. The major reservoirs in the Sacramento and San Joaquin watersheds each have a percentage of their capacity allocated for flood storage. Historically, each reservoir has been operated during flood events according to its own "flood curve," without regard to concurrent storage or releases at other reservoirs in the system. The New Year's Day flood of 1997 demonstrated that uncoordinated reservoir operation can exacerbate flood stages along downstream reaches of the major rivers and flood bypasses. This

realization prompted Congress to direct the USACE to undertake a major, integrated evaluation of the entire Central Valley flood control system beginning in 1998. The study evaluated a broad range of strategies for minimizing flood damage, including setback levees and flood easements. Enhancement of riparian and aquatic habitat along major waterways in the flood control system was also a prominent goal of the study. The Comprehensive Study developed analysis tools and identified potential elements of integrated flood damage reduction and ecosystem restoration projects. The Comprehensive Study's December 2002 Interim Report and technical studies documentation are available at (http://www.compstudy.org/reports.html)

- *CALFED Science Program*. In 2001, the CALFED Science Program hosted a workshop to identify projects that would be suitable for adaptive management. Attendees included local scientists, resource agencies, environmental groups, and experts from other regions of the country. The group reviewed a range of possible projects including tidal Delta wetlands, floodplain habitat, and flow in upstream tributaries. As part of this workshop, Yolo Bypass was identified as one of the regions of the Delta with the greatest potential for adaptive management at an ecosystem scale; however, many constraints were noted, including flood conveyance and landowner issues (Natural Heritage Institute et al. 2002).
- *CALFED Ecosystem Restoration Program*. CALFED's Ecosystem Restoration Program is another major effort toward improving habitat conditions in the Sacramento-San Joaquin watershed and to advance the scientific basis for restoration. ERP goals are to:
  - Recover 19 at-risk native species and contribute to the recovery of 25 additional species
  - Rehabilitate natural processes related to hydrology, stream channels, sediment, floodplains, and ecosystem water quality
  - Maintain and enhance fish populations critical to commercial, sport, and recreational fisheries
  - Protect and restore functional habitats, including aquatic, upland, and riparian, to allow species to thrive
  - Reduce the negative impacts of invasive species and prevent additional introductions that compete with and destroy native species
  - Improve and maintain water and sediment quality to better support target species (http://calfed.ca.gov/Programs/EcosystemRestoration/Ecosystem.shtml).
- *Central Valley Habitat Joint Venture.* One of the major programs for improving habitat conditions in the Central Valley is the Central Valley Habitat Joint Venture (CVHJV). The CVHJV's mission is to "Protect, maintain and restore habitat to increase waterfowl populations to desired levels in the Central Valley of California consistent with other objectives of the North American Waterfowl Management Plan."
- *Central Valley Project Improvement Act Anadromous Fish Recovery Program*. Another regional program targeting improvements in fish habitat is the CVPIA Anadromous Fish Recovery Program (AFRP). The purpose of the CVPIA is to mitigate for the adverse impacts of the Central Valley Project on anadromous fish. Habitat enhancement in the Yolo Bypass addresses two specific goals of the AFRP:
  - To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California.

  - To contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. (http://watershare.mp.usbr.gov/documents/3402.cfm).

- *Yolo County Flood Control and Water Conservation District*.
- *California Wilderness Coalition* regarding their priorities and plans for the Cache Creek watershed.
- *Lower Putah Creek Coordination Committee*, the *Putah Creek Council,* and with the *UC Davis Putah-Cache Creek Bioregion Project*.
- Bunn et al. (2005) report on conservation challenges and conservation strategies for the Central Valley and Bay-Delta Region of California.
- *California Landowner Stewardship Program*. This local program has been instrumental in helping farmers restore native vegetation to grazing lands, build tailwater retention ponds for sediment runoff, and vegetate irrigation canals for enhanced wildlife value. They frequently partner with various state and federal programs to offset farmers' costs of implementation (http://www.audubon-ca.org/LSP/Willow_Slough.htm).
- *The John Muir Institute for the Environment (UC Davis)* is a consortium of UCD researchers working on environmental issues. This organization can provide expert advice on physical environmental features such as levee management, but might also be helpful in finding expert assistance in biological management as well.

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Attachment A
Biographies of Advisors

Peter H. Bloom, M.S. Research Associate, Western Foundation of Vertebrate Zoology. Mr. Bloom is a doctoral candidate at the University of Idaho, Moscow, College of Natural Resources, and is working on a long-term study of natal dispersal and philopatry in California raptors. Mr. Bloom is a conservation biologist and zoologist who focuses on birds of prey and has studied Swainson's hawk throughout California. He has also been a science advisor on the Central/Coastal NCCP in Orange County and several large ranches in southern California. His research focuses on long-term ecological studies that lead to the conservation of raptors and their habitats.

Jaymee T. Marty, Ph.D. Ecoregional Ecologist, The Nature Conservancy. Dr. Marty is a conservation biologist and restoration ecologist who has over 10 years of experience conducting research on how land management affects vegetation and invertebrates in riparian, grassland and vernal pool habitats. Dr. Marty's current research focuses on the multi-trophic effects of management and restoration techniques including grazing and fire on vegetation and aquatic invertebrates in vernal pool and grassland ecosystems. She conducted her dissertation research in Yuba County on Beale AFB, where she studied the effects of fire, grazing and herbicide treatments on California native grass species. Her work has received extensive national press and was recently published in *Conservation Biology*.

Reed Noss, Ph.D. Professor, Department of Biology, University of Central Florida, Orlando, Florida. Dr. Noss is an internationally known conservation biologist with special expertise in landscape ecology, land use planning, ecosystem management, and reserve design. He is leading a new conservation biology graduate program at the University of Central Florida. He has a particular interest in translating the principles of conservation biology to policy and management, and was first author of an influential book entitled *The Science of Conservation Planning*. Dr. Noss has served as a member and as lead scientist on numerous scientific advisory committees, including those for several other NCCP/HCPs. He has served both as President of the Society for Conservation Biology and as Editor-in-Chief of its journal, *Conservation Biology*.

Mark Schwartz, Ph.D. Professor, Department of Environmental Science and Policy, UC Davis. Chancellor's Fellow. Chair, Graduate Group in Ecology. Dr. Schwartz is a plant ecologist and conservation biologist with expertise in plant community ecology, plant demography and biogeography. His research focuses on assessing biogeographic and phylogenetic predictors of rarity; predicting responses of species distributions to global climate change (both native and invasive plant species), modeling mutualisms, and habitat assessment and viability modeling in rare plants.

Elizabeth Soderstrom, Ph.D. Natural Heritage Institute. Dr. Soderstrom is a river scientist with expertise in adaptive management, instream flow requirements, and transboundary river basin management. She is an active member of the Trinity River Adaptive Management Working Group, and the Guadalupe River Adaptive Management Team. For the Natural Heritage Institute, Dr. Soderstrom has managed a range of projects, including a feasibility study to improve habitat for native fish in the Yolo Bypass; a USAID-funded project on the management of the Okavango River Basin in southern Africa; and an EPA-funded project on wetland habitat in the Sierra Nevada of California. In addition, she has served as the lead facilitator for the CALFED Independent Science Board.

Wayne Spencer, Ph.D., Senior Conservation Biologist, Conservation Biology Institute, San Diego. Dr. Spencer is a conservation biologist and wildlife ecologist with expertise in conservation planning and endangered species recovery. He has worked on various regional NCCPs and HCPs in California as a consulting biologist, science advisor, and science facilitator. His research focuses primarily on rare and endangered mammal species, including the endangered Stephens' kangaroo rat and Pacific pocket mouse. He previously studied the ecology and evolution of mammalian space-use patterns, spatial cognition, and the brain. He is also a Research Associate with the San Diego Natural History Museum, and serves on the Science Advisory Committee and as President of the Board for South Coast Wildlands. Dr. Spencer serves as Lead Advisor and Science Facilitator for the Yolo County NCCP/HCP.

Glenn Wylie,, **Ph.D., Research Wildlife Biologist, USGS Western Ecological Research Center, Dixon, CA**. Dr. Wylie is a wildlife biologist specializing in wetland ecology as it concerns migratory birds and listed species in California. In the last 10 years he has been researching the distribution, abundance, and ecological requirements of giant garter snakes. Dr. Wylie was a science advisor for the Recovery Team for giant garter snakes and has advised habitat conservation planning for the city of Sacramento. He is currently advising Solano County in developing a habitat recovery plan as well as participating as an independent science advisor for the Yuba/Sutter and Yolo County NCCP/HCPs.

Attachment B
Field trip Summary

Prepared by Kateri Harrison

The Science Advisors participated in a field trip route through various habitat areas in Yolo County as described in the following highlights:

- Grasslands Regional Park is the only known location within the plan area with grassland sparrow breeding habitat. The Park also provides foraging habitat for the Swainson's hawk and the Northern harrier. On-site vernal pools provide habitat for four federally listed plant species. Plants may be pollinator limited since some pollinators, such as ground nesting solitary bees, only travel 20-30 meters from their home pool. Land management issues at the Park included mowing, thatch management, prescribed fire as a management tool, and restoration of surface topography to improve pool hydrology.
- Cache Creek Conservancy[10] is a 130-acre preserve. Water is supplied to a restored wetland pond from the Gordon Slough Irrigation Ditch via the Capay Dam, located in upstream Cache Creek. After circulating through the pond, water is discharged into Cache Creek. Cache Creek riparian habitat contains several invasive plants including star thistle, tamarisk, and Arundo and invasive fauna including bullfrogs and bass. The creek was/is subject to gravel mining activities. Salmon restoration in the Creek may be challenging because of the lack of deep pools. Mercury is a concern on the Cache Creek Conservancy preserve. Elemental mercury flows into the wetland pond which provides an anaerobic environment that supports the bacteria-mediated methylation process, producing bioavailable methyl-mercury. This water then flows into the creek, physically distributing methyl mercury to the Creek's aquatic food chain. The Central Valley Regional Water Quality Control Board is establishing parameters regarding discharge of methyl-mercury to Cache Creek. Other water quality data on Cache Creek is collected by the local Resource Conservation District.
- Capay Valley area is an example of blue oak habitat and oak recruitment. Dr. Jaymee Marty provided an overview of the oak recruitment problems and uncertainties including complex multiple variables such as fire, rodents, herbivory and canopy gaps. Seedlings put down taproot quickly and survive for 10 years; but then often enter stasis with stunted seedlings. It is difficult to suggest management guidelines for oak woodlands, at this time, given the high level of uncertainty. Oak woodlands within TNC's Consumnes Reserve have a nicely distributed age structure. Valley Oak and Canyon Live Oak have a patchy and limited distribution in the plan area. Valley Oaks tend to be found a specified distance from a creek.

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[10] See Cache Creek Conservancy website at: http://www.cachecreekconservancy.org/index.cfm?SECT=1

Appendix C
Workshop Attendance

Monday, August 15, 1005 from 8:00 a.m. to 5:00 p.m.

Science Advisors in Attendance

Reed Noss, Ph.D.	Mark Schwartz, Ph.D.	Glenn Wylie, Ph.D.
Jaymee Marty, Ph.D.	Peter Bloom	Wayne Spencer, Ph.D.
Elizabeth Soderstrom, Ph.D.		

Agency Staff in Attendance

Maria Wong (Yolo County)	Craig Aubrey (USFWS)	Brenda Johnson, Ph.D. (DFG)

HCP/NCCP Consultants in Attendance

Brian Boroski, Ph.D.	Scott Fleury, Ph.D.	John Sterling
John Gerlach, Ph.D.	Charmaine Delmatier	

Note-taker in Attendance
Kateri Harrison

Tuesday, August 16, 1005 from 9:00 a.m. to 4:30 p.m.

Closed session of the Science Advisors Workshop.

ATTENDANCE

Science Advisors in Attendance

Reed Noss, Ph.D.	Mark Schwartz, Ph.D.	Glenn Wylie, Ph.D.
Jaymee Marty, Ph.D.	Peter Bloom	Wayne Spencer, Ph.D.
Elizabeth Soderstrom, Ph.D.		

Note-taker in Attendance
Kateri Harrison

Attachment D

Initial Questions
Addressed by Science Advisors

Yolo County
Natural Community Conservation Plan
Habitat Conservation Plan

Prepared by Wayne Spencer
Lead Advisor and Facilitator

CONSERVATION BIOLOGY INSTITUTE

10 August 2005

The following questions provide a broad framework for scientific input to this NCCP/HCP plan. Additional and more detailed questions will certainly arise during discussion and will also be addressed. These initial questions are provided as a starting point only.

Species Addressed

Is the current list of species to be addressed by the plan comprehensive enough to achieve the plan's biological goals? Should any species be added to assist in reserve design (e.g., species with no special protection status but that may serve as useful reserve design or monitoring indicators)? Should any species be removed as highly unlikely to be found in the plan area or affected by the plan?

Are there any new or pending taxonomic revisions or other issues that would affect the list of species addressed?

Are there effective ways of grouping species to assist in designing, managing, or monitoring a reserve (e.g., by species guilds or communities, landscape-level versus site-specific management requirements, narrow endemics versus wide-spread species)? Are there any species that can serve as good indicators or umbrellas for other species, habitats, or communities?

Existing Data

Do the biological data reports and maps prepared to date appropriately compile and interpret existing information, and do they present a firm scientific foundation for conservation planning? Are there additional data sources or literature pertaining to the resources of the plan area that should be incorporated into the database and considered during planning and analysis?

What gaps in existing information create the greatest uncertainties for planning, analyzing, managing, and monitoring an ecosystem reserve in this setting? What are the most effective methods for addressing these data gaps?

Are habitat suitability models or other models recommended for predicting species ranges where distribution data are sparse? If so, what standards for formatting, parameterizing, or testing such models are recommended? Are the existing data for input variables sufficiently accurate and precise to model species' distributions?

Are there any ecological processes for which additional data or modeling may be essential for reserve design or analysis?

Given the dynamic nature of agricultural landscapes over the short term (e.g., crop rotation), and mid to long term (e.g., with changing markets, water availability) are static vegetation maps useful for predicting species distributions or habitat quality for those species that use agricultural areas (e.g., Swainson's hawk)? Are there useful alternatives, such as dynamic maps or future scenario modeling?

Conservation Guidelines and Reserve Design Process

What basic tenets of reserve design are most pertinent to planning a reserve system in this area, and how should these tenets be translated into measurable standards and guidelines for reserve design? What theoretical or empirical support is available for designing necessary and sufficient biological core areas, linkages, wildlife movement corridors, buffers, or other components of reserve design?

What objective methods are recommended for designing a necessary and sufficient reserve system to meet plan goals? Are explicit reserve-selection algorithms (such as the SITES or PATCH programs) recommended, and are existing data sufficient for their application? How can scientifically justifiable goals be set for such methods in this plan area?

Given the agricultural nature of this landscape, and the goal of preserving working landscapes, what reserve design approaches may be most effective (e.g., "hardline" vs. "softline" reserves, "safe harbor" agreements)?

What aspects of the planning area ecosystem (e.g., vegetation communities, geological substrates, hydrological subdivisions, climate regimes) should be used for setting reserve design goals? What ecosystem gradients are most important to consider?

Does existing information reveal specific geographic locations that are critical to reserve design (e.g., biodiversity "hotspots," crucial linkages, rare microhabitats, genetically unique population areas)?

What ecological processes are most critical to maintaining ecosystem and species viability, and how can they be effectively accommodated in designing an ecosystem reserve for this region?

How can long-term processes or cycles (e.g., population dynamics, disturbance cycles, ecological migration) be effectively addressed? What effects might local or global climate changes have on this ecosystem and the target species, and how can these effects be effectively addressed?

Conservation Analyses

What types of data can best be quantified (habitat acres, population sizes, species distributions, etc.) to analyze plan effects on target species and ecosystem processes? Are there ecosystem processes that should be quantified to assess and compare alternative reserve scenarios and effects on covered resources? What other issues must be addressed to confidently assess plan effects on species or ecosystem viability (e.g., effects on pollinators, competitors, mutualists, predators, population genetics, etc.)?

How should uncertainties about plan effects be addressed in the conservation analysis?

Management and Monitoring

What management actions are necessary and sufficient to meet the plan's biological goals? How are current or future land uses likely to directly or indirectly affect biological resources on adjacent reserve areas, and vice-versa? How might adverse effects be minimized via the adaptive management program?

What specific management principles or hypotheses are most important to test via the adaptive management program? How can the adaptive management program best deal with shifting land uses (e.g., changing agricultural landscapes and practices)?

Is existing information sufficient to suggest measurable ranges, endpoints, or indicators for monitoring species or ecosystem processes? What specific monitoring protocols are necessary and sufficient to detect changes in species populations or ecological processes? To what degree and for what species might complete population counts, indices of abundance, or simple presence-absence surveys be sufficient for monitoring plan effects?

What aspects of this environment might most effectively be used to monitor ecosystem integrity? Are there good indicator or umbrella species, physical measurements, or other factors that can be monitored as proxies for covered species or aspects of ecosystem health?

Attachment E
Detailed Recommendations Concerning Aquatic Resources

Aquatic resource issues are of great concern in Yolo County due both to declining health of aquatic systems and the species they support, and to increasing water demands and risks of flooding in human communities. Flood-control levees throughout the region are degrading and in need of a major overhaul. The Independent Science Advisors understand that the Yolo County NCCP/HCP JPA has not at this time decided to seek coverage for aquatic species, and that other state, federal, and regional planning efforts are underway to address aquatic and flood-control issues (e.g., via the CALFED program, various flood-control plans and initiatives, and the County's Integrated Regional Water Management Plan and General Plan update). Nevertheless, the Science Advisors felt compelled to offer recommendations concerning conservation and restoration of aquatic resources in the study area in hopes they may be useful.

We recognize that many of these recommendations may stray beyond the scope of the current NCCP/HCP planning effort and that many can only be implemented via other regulatory mechanisms and planning bodies. Nevertheless, the following detailed recommendations are offered in hope they may be useful to the NCCP/HCP or to other planning efforts that the County may be involved in. At the very least, we hope NCCP/HCP participants will consider these recommendations as they move forward, to avoid direct conflicts with efforts to improve aquatic resource condition by other programs, and to be aware of potential synergies between the NCCP/HCP and other planning efforts. Wherever possible, the NCCP/HCP should seek mutually beneficial actions with these other efforts. In some cases, NCCP/HCP mitigation, restoration, management, and monitoring actions may help further priority efforts of these other programs.

Conservation Recommendations for Area Streams

Improving Aquatic Connectivity for Fish Passage

Improving fish passage in streams and floodplains of Yolo County is a critical biological goal. For example, increasing fish passage in the Yolo Bypass both to Cache and Putah creeks, as well as the Sacramento River above Freemont weir, would increase both the numbers and diversity of salmon in the Sacramento Valley. The first hurdle to establishing salmon in the basin is the migration barriers posed by the Yolo Bypass and the Cache Creek settling basin. As formidable as these barriers seem, the recent observation of salmon in the Creek (Ayers and Moyle, personal communications to ES) indicates that they are not insurmountable. Salmon are apparently migrating up the bypass through the toe drain, then westward across the bypass just upstream of highway 80, and then north to a location near the outlet of the settling basin where they appear to use an old fish ladder to circumnavigate the settling basin (Sommer and Harrel, personal communications to ES). In addition to the settling basin, there may be several barriers to migration through the bypass, such as check dams and culverts in the bypass canals and ditches that normally prevent passage, which could be modified or eliminated to improve passage.

Upstream of the settling basin, the next barrier seems to be Moore Dam. Although not easily passable in its current configuration, fish migrated past it in the fall of 2000. Upstream of Moore

Dam the next passage problems are either low flow or Capay Dam. Capay Dam is an inflatable dam that should be feasible to ladder. Site-specific assessments of Capay Dam and Moore siphon are necessary to determine how much of a barrier they pose and to identify the magnitude of effort necessary to significantly improve passage.

Interviews with biologists familiar with the watershed (e.g., Ayers and Moyle personal communications to ES) indicates that upstream of Capay Dam there are no insurmountable barriers between Capay Dam and the upper watershed all the way to the Clear Lake and the Indian Valley dams, with possible exception of the "Jams," a cascade on the north fork just upstream of the confluence with the North Fork, which some thought was easily passable and others believed to be an insurmountable barrier.

Fish passage beyond the "Jams" all the way to Clear Lake may not be an important consideration at this time, because restoration of salmon and steelhead to the tributaries upstream of Clear Lake is probably not feasible. Fall-run salmon almost certainly would not migrate all the way to Clear Lake, and since spawning habitat conditions are so ideal downstream of Capay Dam, there is little reason for attempting salmon restoration upstream of Capay at this time. Steelhead may be able to migrate all the way to the Clear Lake tributaries, but the prospects for successful reproduction and out-migration are questionable. It probably makes more sense to focus steelhead restoration efforts in a few tributaries downstream of Clear Lake such as the North Fork, Bear Creek, Rocky Creek, and Long Valley. If those efforts are successful, then evaluation of restoration opportunities upstream of Clear Lake may be warranted.

Roads and culverts can create barriers to upstream movements of anadromous fish, at least under certain stream-flow conditions. We recommend further evaluation of existing culverts (perhaps with assistance from CalTrans) using models that address fish passage under a wide range of stream flows for example, FishXing (http://stream.fs.us/fishxing/. It may be possible to modify or retrofit culverts to improve fish passage over a wider range of stream flows. While state regulations may improve the design of future bridges and culverts, many existing stream crossings may be inadequate for fish passage.

Increasing Inundated Floodplain Habitat

Recent studies (NHI et al. 2002, NHI 2003, Sommer, personal communication) demonstrate that seasonally inundated floodplain habitat provides important habitat for salmon and splittail, and the CALFED ERP identifies restoration of fish habitat in the Yolo Bypass as a high priority. Currently, in the bypass floodplain habitat is only inundated in wet years when large floods are directed through the bypass. With small flows from the Sacramento River, Cache, or Putah Creek, it would be possible to replicate inundated floodplain conditions for native fish habitat by backing impounding water on low lying areas of the bypass adjacent to Tule Canal. This habitat would benefit adult splittail moving up the bypass to spawn, provide rearing habitat for young splittail, and rearing habitat for juvenile salmon from Cache and Putah Creeks as well as the Sacramento River.

Modifying Fremont weir at the head of the Yolo Bypass to pass water and allow fish passage at moderate flows in the Sacramento River may be the best way to increase the occurrence of inundated floodplain habitat in the Yolo Bypass. Modifying the weir would not increase the frequency or size of large floods in the bypass, but it would allow Sacramento water to flow through the bypass, creating inundated habitat along the margins of the Tule canal while still allowing agricultural uses throughout other parts of the bypass. Salmon that migrated up the toe drain would then be able to continue upstream into the Sacramento River or into Cache Creek if migration flows were available.

Creating Self-sustaining Riparian Corridors

Creating self-sustaining riparian corridors for habitat and for water temperature are critical restoration goals. For example, establishment of riparian vegetation (cottonwoods, willows, etc.) particularly in the currently denuded reach between Capay Dam and Moore Siphon on Cache Creek, could create hundreds of acres of new riparian habitat and improve opportunities for nature recreation. A riparian corridor in this reach would link wildlife habitats in the Yolo bypass and the delta with natural areas in the upper Cache Creek Watershed. A carefully designed and developed riparian corridor between Capay and Yolo could not only increase habitat but would also reduce the magnitude of peak flows and sediment moving downstream to Woodland and the Yolo Bypass. Riparian vegetation combined with a wider corridor would slow and spread peak flood waters and sediment loads in the reaches above Road 94b.

Conserving Upper Watersheds

The upper watershed of Cache Creek encompasses many unique open space natural areas that provide important habitat for native plant and animal species. These areas should be surveyed and protected to provide dependable long-term refugia for native species. Several biologists we interviewed emphasized the biological richness of the undammed Bear Creek watershed. The Bear Creek watershed supports several unique assemblages of native flora and numerous native resident fish species. Due to long-term grazing, the riparian corridor along Bear Creek has been severely reduced or eliminated. Conservation of the Bear Creek watershed and restoration of riparian vegetation along the channel should be a high priority of a comprehensive watershed management project.

Providing Upland Buffers Adjacent to Wetlands

Regulations by the state of California establish minimum requirements for riparian buffers along perennial streams. Federal forest lands require even more protective buffer dimensions and activities within riparian areas (Gregory 1996). Such protection is not required for urban, residential, or agricultural lands. Much of the future land use change in Yolo County will occur in these non-regulated land types. A recent review of riparian management by the National Research Council concluded that more consistent frameworks for riparian management were needed across all land use types (National Research Council 2002). The NCCP/HCP should develop consistent and scientifically sound buffer requirements that include best management practices for use of forested buffers, grass buffers, flow detention basins, interception swales, and other forms of riparian management and protection.

Restoring Natural or Semi-natural Flow Regimes

Conserving and restoring flow regimes will require a reach-specific strategy that will depend on watershed characteristics and context. Best management practices include water conservation translated into instream flows, groundwater replenishment via stormwater recharge, conjunctive use, changing in the timing and magnitude of dam releases to more closely mimic historical flows, and channel and bank restoration (Flosi et al 1998). Channel and bank restoration include: 1) protecting relatively undisturbed reaches that still have intact banks and channels; 2) managing and controlling upstream sediment sources; 3) removal or re-engineering roads and road-stream crossings to reduce fine sediment inputs; 4) modifying or replacing culverts to improve in-channel hydrological connectivity; 5) restoring the connection between the channel and the floodplain by "dechannelizing" the river; and 6) injecting root wads and other large woody debris in areas where sources have been removed or diminished.

Conservation Recommendations for Yolo Bypass

We recommend increasing the contiguity of naturally vegetated areas relative to existing conditions in the Yolo Bypass, and increasing the amount of riparian scrub and forest, via restoration in areas with appropriate soils and ground water depths. Some specific locations where such actions would be most beneficial:

- Create a nearly continuous corridor of riparian vegetation along the Tule Canal/Toe Drain, linking the existing riparian area near Fremont Weir with the Delta.
- Create a riparian corridor along the existing channel at the west edge of the Yolo Bypass between Knights Landing Ridge Cut and Putah Creek, providing a habitat link between those waterways.
- Create a riparian corridor along Putah and Cache Creeks, providing better interconnection between the east and west habitat corridors of the Bypass.
- Allow natural development of a swath of tules in the southern end of the Bypass at the upper end of the intertidal range (sea level to +4 feet, National Geodetic Vertical Datum [NGVD] 1929) and intertidal mudflat habitat at the lower end (sea level to -4 feet NGVD 1929).
- Create localized floodplain areas adjacent to the Tule Canal/Toe Drain and along Putah Creek to provide seasonal floodplain habitat that would persist long enough to benefit native fish in normal to dry years, when substantial inundation would not otherwise occur. Minimize obstructions to fish movement between channels and the floodplains.
- Provide unrestricted year-round fish passage along the Tule Canal/Toe Drain to the Sacramento River across the Fremont Weir, and between the Toe Drain and Putah and Cache Creeks.

Below, these ecosystem enhancement concepts are described in relation to various geographic areas in the Bypass, beginning with a description of elements recommended for bypass-wide implementation. These recommendations were first discussed by a restoration planning group advising The Sacramento Area Flood Control Agency (SAFCA), but were never previously formalized or published.

Bypass-Wide Elements

One major restoration element that also supports flood control is the setback of sections of the east levee of the Yolo Bypass. In these areas, portions of the old east levee could be removed to provide aquatic connectivity between the two floodplains. Other portions of the old east levee could also be retained to provide upland refugia for terrestrial species during flood events.

Along almost the entire length of the Yolo Bypass, establishment of a riparian corridor is proposed. Ideally, this corridor should average about 500 feet wide, adjacent to the Tule Canal and Toe Drain along the east side of the Bypass, from Fremont Weir down to Little Holland Tract. More research is needed to determine the elevation above groundwater required for native riparian vegetation to flourish in the relatively heavy clay-silt soils prevalent in the Bypass. Successful establishment in some areas may require several years of seasonal flood irrigation or slight lowering of the ground surface. Lowering of the ground surface could also make it easier to provide shallow-water habitat in designated floodplain areas with less risk of overflowing onto adjacent agricultural lands.

Fremont Weir Area

A major constructed feature in this area could be the extension of the Tule Canal northward to connect to the Sacramento River to enhance adult fish passage by providing a perennial flow into the Bypass, except in extremely dry years. Currently, a small and outdated fish ladder passes through the weir approximately 0.75 mile from the east levee. Fish are probably unable to find the ladder, much less use it. Therefore, fish are unable to pass Fremont Weir unless the stage is high enough for water to pass over the top of it. Even then, non-salmonids such as sturgeon will have problems swimming over the top of the weir. A new fish passage channel could be constructed between the old and new portions of Fremont Weir and include gates to shut off the flow when needed. To aid the passage of fish from the floodplain to the river, the existing Fremont Weir fish ladder should be widened to make fish attraction and passage easier.

In addition to the new Tule Canal connection to the Sacramento River, a berm could be constructed perpendicular to flow in the Yolo Bypass approximately 9,000 feet south of Fremont Weir to keep seasonal floodwater on the floodplain. Data suggests that the Yolo Bypass is important spawning habitat for species like Sacramento splittail, which spawn on flooded vegetation in relatively shallow areas. In years when the Bypass does not inundate, splittail production declines (Sommer et al. 1997). The area north of the berm could fill when Sacramento River stage exceeds the level of the floodplain. If the Tule Canal is permanently connected to the Sacramento River, shallow water floodplain inundation could be accomplished even if the Fremont Weir is not overtopped. At the east end of the perpendicular berm, a drain structure could be constructed to allow the floodwater to empty from the floodplain and establish a connection to the Tule Canal. The inundated floodplain could be allowed to drain slowly and completely back into the Tule Canal so that fish stranding is minimized. Additionally, 4,000 feet of the original east levee could be removed just south of the Fremont Weir to allow water to move from the new Tule Canal channel out onto the floodplain. The 5,000 feet of levee just south of this removed portion could be retained to keep floodplain water from emptying into the Tule Canal. South of the perpendicular berm, portions of the east levee could be removed for floodplain connectivity and some retained for wildlife refuge during flood events.

Currently, at the location of the perpendicular berm described in the previous paragraph a canal crosses the Yolo Bypass and is siphoned through the east levee. The assumption is that this canal would have to be siphoned under the new portion of the Tule Canal.

Furthermore, two seasonal roads cross the Tule Canal in the Fremont Weir area. The crossings were constructed by laying culverts in the channel parallel to flow and then pushing soil over the top of them. To aid fish passage, the road crossings would have to be converted to permanent bridges. Landowners may also use the road crossings to back up water for agricultural use. Therefore, concrete piers could be constructed to provide the means for installation of flashboards while still allowing for fish passage.

Knights Landing Ridge Cut Area

The Knights Landing Ridge Cut runs southeasterly across the Bypass north of Interstate 5. A major constructed feature in this area could be the rerouting of approximately 2,000 feet of the channel nearest to the Tule Canal. The channel could gently curve to the south and then join the Tule Canal. Most of the new channel would be earthen trapezoidal, but at the connection to the Tule Canal, a 200 foot section would be rectangular concrete lined and could include an adult fish exclusion structure. This structure would keep migrating adult fish in the Tule Canal so that they can connect up with the Sacramento River at the Fremont Weir. If allowed to continue up the Knights Landing Ridge Cut, the fish would not be able to make it back into the Sacramento River.

Cache Creek Area

At Cache Creek's entry into the Yolo Bypass, just north of Interstate 5, a fish ladder could be constructed to aid adult fish migration. Currently, these adult migrants have no way to consistently pass the Cache Creek Settling Basin low flow outlet structure. To further aid adult fish migration, Cache Creek could be rerouted down the existing west side channel and across Yolo Bypass to the Tule Canal. Sparse riparian vegetation could be planted along the creek, necessitating the alignment across a wider portion of the Bypass to the south of Interstate 5. Discussions with Reclamation District RD2035 will be needed to determine the feasibility of the creek rerouting, due to their complex array of distribution and drainage channels in this area. It is possible that some of the existing RD2035 channels could be used for rerouting the creek.

Putah Creek

A permanent check dam could replace the old check dam on Putah Creek. The new check dam would maintain the ability to have flashboards removed so the upstream reach can be dewatered. Also in this area, Putah Creek could be rerouted to flow southeasterly across the Yolo Bypass and connect with the Toe Drain. This element was discussed in Habitat Improvement for Native Fish in the Yolo Bypass (NHI et al. 2002:93–99). The rerouting of the creek would provide consistent fish passage for adult migrants and provide habitat for many aquatic and terrestrial species.

3/10/15 Strip

The 3/10/15 strip lies along the Tule Canal from approximately 1 to 4 miles south of Interstate 5. At the northern end, a barrier weir could be constructed in the Tule Canal to back up water onto the floodplain during winter and spring flow pulses, providing temporary shallow water habitat when the Yolo Bypass would not otherwise be flooded. The height and configuration of the barrier would need to be determined, but would need to include fish passage. Also, an estimated 3 miles of berm would need to be constructed parallel to flow along the west bank of the Tule Canal in the Yolo Bypass to keep the diverted floodwater on the floodplain. The floodplain water would flow in an existing low area and would reenter the Tule Canal downstream at the end of the berm. Floodplain water would then be allowed to drain slowly and completely back into the Tule Canal so that no fish stranding occurs. It is also possible to channelize some this floodplain water before it reenters the Tule Canal and redirect it to flood a low area where the Sacramento Weir enters the Bypass.

In addition, one seasonal road crosses the Tule Canal just south of the Sacramento Bypass. The crossing was constructed by laying culverts in the channel parallel to flow and then pushing soil over the top of them. To aid fish passage, the road crossings would need to be converted to permanent bridges. Landowners may also use the road crossing to back up water for agricultural use. Therefore, concrete piers would need to be constructed to provide the means for installation of flashboards while still allowing for fish passage.

Greens Lake Area

The Greens Lake area is just south of Interstate 80. In this area, a barrier weir could be constructed in the Toe Drain approximately 1 mile south of Interstate 80. The barrier weir could be similar to the one proposed at the 3/10/15 strip and would be used to back up water onto the floodplain during winter and spring flow pulses, providing temporary shallow water habitat when the Yolo Bypass would not otherwise be flooded. In contrast to the 3/10/15 area, a 1-mile-long berm would be constructed perpendicular, instead of parallel, to flow in the Yolo Bypass to keep seasonal floodwater on the floodplain. Floodplain water would be allowed to drain slowly and completely back into the Toe Drain so that no fish stranding occurs, or would be routed through Greens Lake and connected to the existing Wildlife Area ponds.

Lisbon Weir Area

The Lisbon Weir area is approximately 6 miles south of Interstate 80. At this location, the old Lisbon Weir and flap gate structure could be removed and new weirs constructed in their place in the Toe Drain. The new main weir would be similar to the one constructed at the 3/10/15 strip and would be used to back up water onto the floodplain in the area northwest of the new weir during winter and spring flow pulses, providing temporary shallow water habitat when the Yolo Bypass would not otherwise be flooded. This weir could also be used to back up water for upstream users. A second weir could be constructed on the west side of the island where the flap gate structure is currently located. Flap gates could be included in the design of the new weirs to allow flood tide water to pass upstream and keep it from passing back downstream. In addition, a 1-mile-long berm could be constructed perpendicular to flow in the Yolo Bypass to keep seasonal floodwater on the floodplain. Floodplain water would be allowed to drain slowly and completely back into the Toe Drain so that no fish stranding occurs.

Toe Drain "Kink" Site

At this location, 4 miles south of Lisbon Weir, a barrier weir could be constructed in the Toe Drain. The barrier weir would be similar to the one constructed at the 3/10/15 strip and would be used to back up water onto the floodplain during winter and spring flow pulses, providing temporary shallow water habitat when the Yolo Bypass would not otherwise be flooded. Like a new Lisbon Weir barrier, flap gates would be included in the design to allow flood tide water to pass upstream and keep it from passing back downstream. Additionally, a 1-mile-long berm would be constructed perpendicular to flow in the Yolo Bypass to keep seasonal floodwater on the floodplain. Floodplain water would be allowed to drain slowly and completely back into the Toe Drain so that no stranding of fish occurs.

Other Relevant Studies and Plans

Significant improvements can be made to the management of the Bypass to increase habitat for native fish and other species in coordination with other ongoing planning efforts, including those of CALFED, DWR, Yolo Bypass Working Group, and others. The Sacramento Area Flood Control Agency (SAFCA) is developing the Lower Sacramento River Regional Project, which offers an opportunity to enhance aquatic, wetland, and riparian habitats while also providing for increased flood conveyance capacity. Landowner concerns should be considered and have been documented in "A Framework for the Future: The Yolo Bypass Management Strategy" (Yolo Bypass Working Group, 2001). Landowner assurances, conservation easements, and other incentives to encourage wildlife-friendly agriculture and address water rights issues should be explored.

One of the major programs for improving habitat conditions in the Central Valley is the Central Valley Habitat Joint Venture (CVHJV). The CVHJV's mission is to "protect, maintain and restore habitat to increase waterfowl populations to desired levels in the Central Valley of California consistent with other objectives of the *North American Waterfowl Management Plan* (http://www.nawmp.ab.ca/index.html). The CVHJV has the following goals (for more information, see http://www.mp.usbr.gov/cvhjv/):

- Enhancing 291,555 acres of wetland habitat,
- Enhancing waterfowl habitat on 443,000 acres of agricultural land,
- Protecting 80,000 acres of existing wetlands through acquisition or perpetual conservation easements,
- Restoring and protecting 120,000 acres of historic wetlands through acquisition or perpetual conservation easements.

Another regional program targeting improvements in fish habitat is the CVPIA Anadromous Fish Recovery Program (AFRP). The purpose of the CVPIA is to mitigate for the adverse impacts of the Central Valley Project on anadromous fish. Habitat enhancement in the Yolo Bypass addresses two specific goals of the AFRP:

- To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California
- To contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. (http://watershare.mp.usbr.gov/documents/3402.cfm)

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