Report of Independent Science Advisors for the Yuba and Sutter County Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP)

Prepared For
County of Sutter

Prepared By
The Independent Science Advisors:

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February 2006

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Attachments

1 Introduction

This report summarizes recommendations from a group of independent science advisors for the Yuba and Sutter 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 two counties, their consultants, the wildlife agencies, or any other entities involved in the NCCP/HCP.

Contents of this report reflect (1) the advisors' review of technical documents prepared by the NCCP/HCP consultants--particularly the *Phase I Inventory of Physical and Biological Resources* (Jones and Stokes 2005a) and the *Draft Land Use Report* (Jones and Stokes 2005b)—(2) results of a two-day science advisors' workshop, and (3) subsequent research and discussions amongst the advisors. Advisors were also encouraged to seek expert input from other scientists. Such outside input is cited as personal communications to advisors throughout this report.

The science advisors met August 11-12 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. 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, a representative of the U.S. Fish and Wildlife Service (Eric Tattersall), and a county representative (Rich Hall). 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 the advisors' report.

General questions that were addressed by advisors during their deliberations are included in Attachment B. 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 summary or the advisors' 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 will be answered as time allows in separate correspondence after this report is circulated.

The Science Advisors recognize that our recommendations are advisory only and are not binding on NCCP/HCP participants. As stated by CDFG in its August 2002 Guidance for the NCCP Independent Science Advisory Process, science advisors "do not comprise a 'blue ribbon panel' established to approve the planning process or alternatives, but instead are individual scientists providing expert advice and information to the planning process." Nevertheless, we suggest that a constructive way for NCCP/HCP participants 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 plan participants 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

In contrast to previous NCCP/HCP advisory processes individual advisors have participated in, this one is in a very early stage of development. As a result, advisors have ample opportunity to advise on the scope of the plan, including its geographic extent and species of concern, and to provide early advice on general planning approaches and principles.

2.1 Plan Area

The advisors feel that the Phase I Planning Area (PIPA), which was originally delineated for an HCP to encompass the cumulative impacts of various highway improvements, does not represent a sound basis for meeting NCCP or HCP planning goals. A larger planning area that makes sense both ecologically and economically will make this plan more scientifically defensible, more flexible, and easier to analyze and implement. We therefore strongly recommend considering the following potential boundary changes:

1. Extend the current southwest-south-southeast boundaries to the boundaries of Yolo and Placer Counties and to the Natomas HCP area, thus making the plan area contiguous with these other NCCP and HCP planning jurisdictions. This extension would not add any new types of natural or agricultural communities to those already included in the PIPA, nor do we expect it to add new species. However, this expansion would increase the plan's ability to internally balance land uses (e.g., future development versus conservation) and thus gain coverage for species, and it would increase the plan's ability to ensure functional connectivity for species and ecological process in key locations and corridors (such as along Coon Creek, the Feather River, and Sutter Bypass).

2. Extend the western boundary, where it currently follows the Feather River, at least to include the west bank and the current 500-year floodplain, or to some other natural or otherwise logical boundary west of the river, such as the outer extent of contiguous orchard lands, Highway 99, or the base of the Sutter Buttes (e.g., the 30-m elevation line). It does not make sense to include one bank of a river without the other. Including both banks, along with any contiguous lands likely to contribute to flood control, conservation, or ecological restoration actions, is essential to covering riparian and aquatic species, as well as to comprehensively accommodate any needed levee improvements.

3. Include most or all of the Sutter Bypass, at least south of Sutter Buttes, and consider including all of it as it wraps around the western side of the Sutter Buttes from the extensive wetlands of Butte Sink. This would increase inclusion of important habitat for numerous species and would help accommodate the need for habitat connectivity along the Bypass through and beyond the planning area.

4. Continue *excluding* the Sutter Buttes due to the unique and ecologically isolated nature of this area, but recognize and plan for functional connectivity from the Buttes to other areas (e.g., via Sutter Bypass). This NCCP/HCP may present the only

opportunity in the near term to take this step. The advisors believe that constraining the plan to cover primarily valley-bottom habitats (e.g., agricultural lands) makes biological and practical sense, and that including the Sutter Buttes in the plan would add unnecessary complexity to the planning efforts that might be best handled separately. However, the plan should recognize the uniqueness of the Buttes as a biological island within a flat agricultural landscape, and should consider and analyze possible plan effects on maintenance of biological values in the Buttes, and on movement of species and ecological processes between the Buttes and other habitats in or beyond the plan boundaries. We underscore that the Buttes are ecologically significant and should be considered in future conservation planning, even though excluding them from this plan at this time seems logical.

5. Consider *excluding* incorporated cities or other contiguously developed (but not agricultural) areas as necessary to improve planning efficiency or economy. Do not necessarily exclude spheres of influence (SOI) of existing cities, as they may include biologically important habitat areas subject to development, and should therefore be considered in NCCP/HCP planning.

6. Consider extending the central-eastern boundary (south of Beale Air Force Base) to include the extensive grasslands there (in and near the Spenceville area).

7. For the eastern-northeastern boundary, consider either (a) removing the northeastern region of blue oak woodland on sloping upland soils (and make this a primarily valley-bottom NCCP/HCP), or (b) include most or all of the oak woodland up to a natural or logical planning boundary, such as the interface between oaks and conifers (or a coincident elevational contour), or to the boundary of Forest Service lands. The current boundary in this northeastern blue oak/upland "wedge" (representing a fraction of this community type in Yuba County) does not make ecological or practical sense for planning and analysis (although we recognize it made sense for the original roadway HCP as a planning buffer around proposed project impact areas). Omitting oak woodlands and focusing on valley bottom lands (but possibly including grasslands in lower foothills) would simplify planning and analysis (e.g., by removing some species and natural communities from the list to be addressed).

   On the other hand, the advisors are concerned about the potential for exurban development to fragment the oak woodlands with additional roads and poorly planned "sprawl" development. Excluding this oak woodland would leave a wedge of land with no conservation planning apparatus between this NCCP and the extensive public lands in the Sierra Nevada. Including all of the oak woodlands in eastern Yuba County would, however, greatly increase the size of the planning area, which we recognize could increase the complexity, cost, and timeline for the plan. Thus, removing most of the oak woodland and focusing the plan area on valley bottom and adjacent grassland habitats makes biological and economic sense. Nevertheless, we also urge that the plan recognize the importance of the grassland-oak interface to wildlife, especially a variety of declining bird species.

   If the planning area excludes the bulk of upland oak woodlands, this interface issue should at least be addressed in planning principles and analyses. One way to deal with these competing rationales for including or excluding extensive upland habitats may be a phased planning approach, with the current NCCP/HCP focused on valley bottom and adjacent grasslands, and a future phase (or plan amendment) to extend through the blue-oak woodlands and other Sierra Nevada foothill habitats (and perhaps another phase to cover the Sutter Buttes).

2.2 Species Addressed

The advisors are concerned that the list of species proposed for coverage in the plan is too focused on listed species and species likely to be listed in the future to meet NCCP requirements. Note that NCCPs are not strictly endangered-species permitting plans, but are required by law 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.

We recommend considering the following species for inclusion in the plan, whether for coverage under state or federal take authorizations or in recognition of their economic or ecological contributions to achieving plan goals. Note that this list is preliminary, and should be comprehensively reviewed by the consultants and agencies depending on final determination of planning area boundaries (e.g., including or excluding higher-elevation habitats).

- Cougar (*Puma concolor*), is an area-limited and dispersal-limited species for which continued movement along riparian corridors and Sutter Bypass may be an issue. 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 (e.g., fencing coupled with wildlife underpasses or overpasses) in appropriate locations as part of future road-improvement projects.
- Consider including mule deer (*Odocoileus hemionus*) in the plan for similar reasons as cougar.
- 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. This species probably persists at low densities in larger grassland areas in the eastern portion of the study area.
- Ringtail (*Bassariscus astutus*) is an uncommon species and a potential indicator of healthy riparian habitats in the Central Valley.
- 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) as well as unhunted waterbirds (egrets, herons, ibises, stilts, avocets, curlews, godwits, etc).

- Grasshopper sparrow (*Ammodramus savannarum*) is an uncommon, locally distributed grassland bird in California and a good indicator of relatively unfragmented grasslands. It tends to inhabit native grasslands over non-native grasslands or ruderal fields, but may also utilize wet or dry pastures. For more information we recommend contacting David Shuford of Point Reyes Bird Observatory. He recently completed an account of grasshopper sparrow for the California Bird Species of Special Concern report to CDFG.
- Heron rookeries are uncommon and localized in the study area, 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 integrity of aquatic habitats and the health of fish populations, and could be monitored as a management indicator within these anthropogenic landscapes.
- Yellow-billed magpies (*Pica nuttali*) may be suffering high infection and mortality rates from West Nile virus (WNV), with elevated concern among biologists about the effects on species' viability (Boyce 2005, in litt.). Dan Airola (personal communications to WS and RH) summarized results of several recent surveys in the Sacramento Valley, all of which either detected declines in magpie populations (on the order of 60-66% in areas with high WNV incidence) or were inconclusive (but did not contradict that declines had occurred). Apparently, no corvids (e.g., magpies, crows, ravens) have been found carrying WNV antibodies, suggesting that any individuals that are infected die from the disease. Few recommendations for managing this threat, other than mosquito control, are apparently yet available. We recommend contacting Dan Airola and other biologists and pathologists involved in monitoring WNV and local bird populations. If best available science suggests WNV poses a real threat to magpies (or other species), consider including them as newly threatened species deserving of monitoring and perhaps special management actions under the plan. However, we recognize that it may be difficult to address the threat of WNV to these species via an NCCP/HCP.
- Tundra swan *(Cygnus columbianus*) is relatively common within its North American range, but loss of wetlands in wintering areas, such as California, have caused them to switch to use of extensive agricultural areas for wintering habitat, especially rice fields. The study area is of great importance to the species' wintering population (approximately 40,000-50,000 birds winter in this part of the Pacific Flyway), especially Irrigation District 10 in the north portion of the study area where nearly 100% of the western population of tundra swans reside during much of their November–February stay (David Yee, personal communication to RH). Maintaining the value of these wintering areas should be a goal of the NCCP/HCP, as it would benefit many additional species as well.

- Fall-run Chinook salmon is a listed species in the study area. Note that the information summarized in the *Resources Inventory* pertains mostly to spring-run Chinook.
- Other sensitive native fishes, including green sturgeon (*Acipenser medirgstris*), white sturgeon (*Acipenser transmontanus*), Sacramento splittail (*Pogonichthys macrolepidotus*), and Pacific lamprey (*Lampetra tridentata*) occur in the study area and should be considered by the plan. We address fish species and other aquatic resources in more detail in Section 4, below.
- Western spadefoot toad (*Spea [Scaphiopus] hammondii*) is both a state and federal species of concern and occurs in larger vernal pools in the Central Valley.
- California fairy shrimp (*Linderiella occidentalis)* has some overlap with the other listed vernal pool crustaceans, but occurs in a broader range of pool types and therefore will provide wider protection of the habitat.
- Other 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. 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. We recommend consulting with species experts (e.g., A. Shapiro, P. Ward, and R Thorp) as to whether these or other rare invertebrates may occur in the expanded study area, and how best to address them during planning and implementation:
    - Little is known about butterflies of local concern in the planning area. In nearby Yolo County, butterflies of 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), and *Phyciodes campestris* (field crescent, a marsh/riparian specialist). An additional butterfly population of interest may be Nelson's Hairstreak (*Mitoura gryneus nelsoni*). A population on gabbro in Yuba county, unlike the rest of the species, feeds on MacNab cypress (*Cupressus macnabiana*) (A. Shapiro, personal communication). These populations may reside outside the planning area.
    - 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) and *Andrena (Diandrena) blennospermatis* (R. Thorpe, UCD, personal communication, Thorp and Leong 1998).
    - Yuba and Sutter counties are not well collected for ants. Valley Oak Ant (*Proceratium californicum*) has been collected from Sutter County (Yuba City).

This endemic California species is known from only a handful of localities (about 10 altogether) (P. Ward personal communication).

- Blue oak (*Quercus douglasii*) woodlands and savannas are compromised by non-native species, habitat fragmentation, poor sapling recruitment, and disruption of natural fire and grazing regimes. The plan should address how these habitats will be managed to ensure continued ecological health and support of native wildlife.
- 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. The plan should address how valley oak habitats will be managed to ensure continued ecological health and support of native wildlife.

2.2.1 Treatment of Species not Confirmed in Study Area

During the workshop there was some discussion between advisors and consultants about whether certain species currently on the list should be excluded due to lack of recorded observations in the study area (e.g., midvalley fairy shrimp, [1]*Branchinecta mesovallensis*). The advisors feel that survey coverage is too incomplete to remove potential species due to lack of records in the plan area. We recommend retaining at least all potential vernal pool species pending more comprehensive survey coverage. Note also that the final delineation of planning area boundaries may affect which species have been recorded in the study area.

Finally, the advisors point out that species distributions are dynamic over time, and that a current snapshot of a species' known distribution may become inaccurate over a 50-year planning horizon, especially in light of ongoing climate change. Note that the emerging consensus from climate change models suggests longer and deeper inundations of local vernal pools, along with general warming in the area. It is unknown to what degree these changes could influence species distributions. We therefore urge reasonable caution in interpreting which species may occur within the study area over the next 50 or 100 years.

2.3 Covered Actions

Due to the early stages of this NCCP/HCP planning effort, information provided to the advisors does not include detailed descriptions of potential actions to be covered by the plan (e.g., development plans, road improvements, and levee or water conveyance improvements). However, we are aware of the following issues that should be addressed in the plan:

2.3.1 Flood-control projects

The plan should consider how flood-control projects, including upgrades, replacement, removal, or creation of levees, bypasses, and other flood-control features, represent opportunities and constraints to habitat conservation and restoration. The plan should

[1] Note that Branchinecta is misspelled in the species account, Appendix C, of the *Resources Inventory Report*.

acknowledge and accommodate the need for comprehensive (as opposed to piece-meal) 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. For example, the advisors strongly recommend investigating where and how older levees that constrain river channels can be breached or removed to restore some natural floodplain functions, river meanders, and riparian restoration zones inside of newer set-back levees.

Although we recognize that most flood-control actions are outside the jurisdiction of the NCCP/HCP participants, we strongly recommend reviewing recent and emerging plans and analyses from CALFED and Department of Water Resources 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). In particular, look for restoration opportunities and funding opportunities to improve ecological function along river corridors via future flood-control upgrades. Widening levee setbacks in key areas can both help provide and promote natural habitats as well as work toward better flood control.

2.3.2 Road improvements

The plan should analyze possible impacts 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 with new or upgraded highways to accommodate movements by large mammals, reptiles, and amphibians. Given the extensive agricultural development in the plan area, focus attention on potential wildlife movement corridors along riparian zones. This can increase efficiencies, because road improvements that accommodate increased fish passage may also be designed to increase terrestrial wildlife movement.

2.3.3 Irrigation Improvements

Open-water conveyances, such as canals and ditches, are 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 of species, and could have adverse effects on, for example, giant garter 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. In addition, mechanisms to convert water conserved from irrigation or conveyance improvements to "environmental" or "trust" water to meet instream flow needs should be considered.

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 7 for further recommendations on alternative management actions for irrigation canals.

2.3.4 Future urban/exurban development

The plan should comprehensively analyze and account for the likely spatial patterns of future developments relative to existing development and existing or upgraded road networks, flood-control projects, and water conveyances, and how placement of these developments may affect habitat fragmentation and conservation of biological resources, including by constraining mitigation and restoration opportunities or impeding wildlife movements. 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.

3 Review of Existing Information

The Inventory Reports we reviewed provide a useful starting point for planning, but given this early stage of plan development, we recognize that this information was intended to be preliminary and will be expanded and supplemented in later phases. We therefore offer the following advice for upgrading the information and maps during Phase II of the planning process. We strongly recommend that all reports and maps be comprehensively updated once the plan scope is finalized (including the geographic extent and the species and activities to be addressed by the plan), with the following considerations.

3.1 Land Cover and Other Maps

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 recognize that comparable GIS data may not be available for all data layers beyond study area boundaries. However, other, potentially lower-resolution coverages may be used to at least illustrate contiguity of various environmental or planning features beyond study area boundaries. For example, land coverages from the publicly available California Fire and Resource Assessment program (FRAP) could be used to illustrate contiguity of vegetation communities beyond the planning boundaries. Also, an attempt could be made to obtain and incorporate, as appropriate, GIS coverages from adjacent planning jurisdictions, such as land cover maps and species distribution maps prepared for the Placer and Yolo County NCCP/HCPs and the Natomas Basin HCP.

We also recommend that all maps include more common geographic names (especially names of streams and major water conveyances) and that water features (streams, lakes, bypasses, and other water conveyances) be shown on all maps, due to their importance to understanding resource distributions and processes throughout the study area.

3.1.1 Vernal Pool Mapping

The advisors are concerned about the resolution, accuracy, and completeness of vernal pool mapping presented in the Inventory Report. Dr. Jaymee Marty (JM) believes that significant vernal pools (and possibly associated species) were missed by the mapping procedures used by the consultants. During the workshop, JM pointed out some pools, visible on high-resolution aerial imagery, that were not mapped as vernal pools. She compared the vernal pool maps provided by the consultant with the maps created by Dr. Bob Holland and found that they were the same. Dr. Holland used a 40-acre minimum mapping unit (MMU) (Holland 1998). We recommend that the aerial mapping of vernal pool complexes be supplemented with finer resolution (e.g., 0.25-ac MMU) mapping of individual pools and their watersheds. We understand that another vernal pool mapping effort is underway (at Chico State University) and encourage the Working Group to investigate the utility of that data for this plan. We further recommend that vernal pools 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. 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.

3.1.2 Oak Woodland Mapping

The advisors have similar concerns for mapping of oak woodlands, especially valley oak woodlands, as for vernal pools. We urge finer-resolution mapping (e.g., 0.25 to 1.0 MMU) at least of valley oak woodlands, to identify stands of this rare and declining community that can be conserved and enhanced through management. This mapping of small oaks stands 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.

3.1.3 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 UC Davis Information Center for the Environment [ICE], http://ice.ucdavis.edu/).

3.1.4 Agricultural Types

Although we recognize that it is difficult to map the dynamics of changing agricultural systems (e.g., crop rotations and changes in crop distributions due to changing markets) we urge recognition by the plan that static maps of different crop types can be misleading when making long-term (e.g., 50-year) predictions about wildlife distributions. Consider whether alternative category labels, disclaimers, or other means can emphasize that static maps used as figures or analytical tools in planning documents should be used with caution for analyzing such dynamic systems. We comment further below on how to use *scenario analyses* to better address these dynamics and how they may affect biological resources over the life of the plan.

Also, consider whether there are reasonable ways to incorporate effects of shifting agricultural land cover into 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.

3.2 Open Space Mapping

To the degree feasible, all existing "green space" (including for example, agricultural easements, mitigation banks, and public parks) should be mapped to determine where additional conservation actions can best expand, connect, buffer, or otherwise supplement existing protected areas. We recommend refining and updating existing open space and reserve areas to include Spenceville, Grey Lodge, and Sutter National Wildlife Refuges, Sutter Buttes State Park, and any other applicable areas in or near the plan area (as expanded or otherwise revised). 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.

3.3 Watershed Mapping and Characterization

We recommend mapping and characterizing watersheds or portions of watersheds in the study area, 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 study area. 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 study area 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).

4 Addressing Information Gaps

This section makes further recommendations concerning how to fill important information gaps to create a firm foundation for planning and analysis. Key information gaps concern the distribution and abundance of target species, the ecological health of aquatic systems, the likely influence of changing land uses and changing climate on biological resources, and current and future operation of important ecological processes in the study area.

4.1 Species Distribution Models

As is usually true for NCCP/HCPs, the lack of good species distribution maps is a primary data gap for this plan. We recognize that complete survey coverage on private properties is not possible. We therefore recommend cautious use of various modeling approaches to help fill information gaps on species distributions.

Modeling species distributions beyond known occurrence (presence) records can be extremely useful 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 in evaluation of a range of potential future scenarios for the region of interest.

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 in which they are likely to occur (Scott et al. 1993). The resulting maps inevitably contain significant errors of commission (false positives) in that species invariably 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. Nevertheless, such maps are more accurate than the general range maps found, for example, in field guides. Even crude models are useful in serving as hypotheses of potential distribution within a planning area.

More 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 (i.e., they tell you where a species was observed, but not where attempts to observe the species failed), 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 animal 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.

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. Surprisingly, sometimes these "expert models" perform as well (i.e., when tested or validated against new field data) as models based on occurrence records as the dependent variable (Carroll et al. 2001). 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 resolution than available GIS environmental variables.

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). A recent monograph (Beissinger et al. 2006), although focusing on birds as example taxa, provides a comprehensive and readable review of modeling approaches in conservation biology; we urge the consultants to refer to this manuscript. 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).

4.1.1 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 appropriate GIS-based "landscape" variables in species distribution models, where appropriate, especially for wildlife species.[2]

In general, we recommend using 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 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 the study area 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 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. 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; see Scott et al. 2002, Guisan and Thuiller 2005) 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. There is not yet a consensus in the literature on the best methods for all species or circumstances, so species distribution models should be used selectively and strategically.

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[2] 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.

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.

4.1.2 Species-Specific Recommendations for Filling Data Gaps

Here we make some specific recommendations for a select species on approaches to filling data gaps with modeling or other methods.

Swainson's hawk. Consider using a species-specific model (e.g., that being developed by J. Estep) to better predict species distribution now and in the future. Consider high-resolution mapping of potential nest trees to identify current and future nesting areas and to identify areas of suitable foraging habitat that lack sufficient nest trees as areas where planting oaks could serve as an enhancement/mitigation tool. Existing GIS layers do not have sufficient resolution to predict nest-tree availability, and using vegetation maps (e.g., riparian forests or oak woodlands) to represent nest-tree availability will likely miss important nesting areas.

Note that several Swainson's hawks were observed during the August 11, 2005, Science Advisors' field trip, some in areas not containing location points in the maps provided to the advisors by Jones and Stokes Associates. At this time of year these would likely be breeding adults or young-of-the year within nesting territories, although they could also be birds of any age that had begun to disperse away from breeding territories. R. Hansen summarizes these observations as follows:

- 0920 hours – One Swainson's hawk seen in the air just east of Marysville (an area with few previous observation points).
- 0950 hours – One Swainson's hawk (a light morph adult) seen in flight heading north-northeast towards Beale AFB from the east end of Erie Road.
- 1015 hours – One Swainson's hawk circling over Ostrom Road, west of Virginia Road, between Olivehurst and Beale AFB.
- 1040 hours – One Swainson's hawk in flight over a valley oak stringer northeast of Main and Olive in Wheatland.

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 this species is has become locally quite rare, we suggest surveying optimal habitat (relatively flat, short-grass grasslands and pastures, including heavily grazed areas; especially where California ground squirrel colonies are present).

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 the study area (near Chico, California). We recommend reviewing this model to see if it is appropriate for the study area or can be refined.

Tricolored blackbird is known to occur near the PIPA and within areas we recommend be added to the study area (see Section 2.1). We recommend contacting Jon King with EDAW for a recent compilation of tricolored blackbird colony data (Leo Edson personal communication to RH).

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.

Fish. 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. 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. Land cover maps from remotely sensed data can provide extremely important information about riparian areas, which strongly influence fish and aquatic communities. Specific attention to riparian areas is essential (in contrast to only broader watershed assessment of land cover) for assessing and projecting the trajectories of aquatic ecosystems. The mapping and characterization of watersheds discussed in Section 3.3 and characterization of flow regimes and barriers discussed in Section 4.2 may help with predicting potential distributions for certain species (with and without restoration actions). We recommend consulting with species experts (e.g., P. Moyle, R. Yoshiyama) 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.

Vernal Pool Species. We do NOT recommend employing habitat suitability models to attempt predicting the distribution of vernal pool species, which respond to micro-scale habitat variables (and perhaps stochastic events) not generally available in GIS coverages. 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 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 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 habitats within this planning region should therefore be assumed to house some unique biological resources until definitive field surveys prove otherwise.

4.2 Assessing Aquatic Habitats

Most impacts of plan implementation on aquatic species will likely be indirect effects due to changes in ecological processes, rather than direct take of species. Such indirect effects can be difficult to estimate. We recommend measuring current conditions of stream ecosystems using one or more of several commonly used assessment indices and models. The state of California and the USGS NAWQA program are employing these types of assessments in the area covered by the NCCP/HCP. 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 existing knowledge about the condition of streams and rivers in the area and address how best to monitor changes in aquatic resources and habitat quality during plan implementation.

4.2.1 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 a 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.

4.2.2 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 in the planning area, 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 (e.g., fish, as recreation opportunities) (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.

4.3 Scenario Modeling

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, especially considering changes in climate, water availability, crop prices, regulations, and other uncertainties. Projections of future change are therefore never exact, but likely scenarios can be developed and used as a basis for community discussion and planning. The counties need a system for (1) projecting likely future changes and land use patterns and (2) assessing the consequences of those changes on target resources. Such a framework will provide guidance for mitigation policies and assessing NCCP/HCP achievement of goals.

We recommend that NCCP/HCP participants develop plausible future scenarios and use resource professionals or natural resource models to assess the incremental effects of community actions on target resources. Scenario analyses would include formal analysis of alternative future scenarios that account for major changes (e.g., climate change, change in water availability, community growth and expansion, change in land uses and economic base) and some simple indices and models (e.g., indices of biotic integrity, water budgets, habitat conditions, abundance and richness of biological communities).

5 Conservation and Reserve Design Guidelines

Given the existing degree of conversion of natural habitats to agriculture and other unnatural land covers in the study area, and the existing constraints to natural river corridors, the advisors do not believe that traditional landscape-level "reserve design" approaches will be very practicable here (e.g., relying explicitly on core-linkage-buffer concepts or reserve selection computer algorithms, like SITES or MARXAN). Rather, we recommend that reserve planning be based on three broad principles:

1. Maximal retention (as well as restoration and management) of the few remaining natural habitats in the plan area—with no further loss of vernal pools, natural wetlands, or valley oak woodlands, and maximal retention of remaining annual grasslands and other upland communities. Included in this principle is the design of a network of restoration sites for these habitats that strategically utilizes land with suitable characteristics (e.g. appropriate soil characteristics) to support the restoration of vernal pools, native wetlands, and valley oak woodlands.
2. 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. Examples of such management include (1) rice management to foster wintering waterfowl and suitable habitat conditions for giant garter snake, (2) water conservation, (3) organic or other farming methods that minimize reliance on pesticides and chemical fertilizers, and (4) restoration of native vegetation along roads and ditches to minimize the need for exotic weed control. Incentives for maintaining and properly managing private duck clubs may also be useful, because these provide habitat for diverse wildlife and are especially important in District 10, where 40 duck clubs are present.
3. Restoration and maintenance of riverine/riparian corridors, with particular attention to restoring wide "nodes" of riparian habitat at strategic locations and maintaining and enhancing aquatic and wetland connectivity.

The following sections provide additional guidance for implementing these general principles.

5.1 General Siting Guidelines for New Development

Future development should preferentially be concentrated in the following locations:

- Adjacent to existing development (e.g., clustering and avoiding "leap–frog" or exurban development).
- Along existing roads and especially at/near existing road intersections (to avoid need for additional habitat-fragmenting roads to serve "leap-frog" development).
- Away from rivers and out of floodplains or other restorable habitat areas.
- Outside of identified or probable habitat of listed or sensitive species.

5.2 Resources that Should be Maximally Conserved

The following natural communities or landscape features are very rare and ecologically important in the plan area, and should be maximally conserved throughout the planning area, and wherever possible restored.

- Vernal pools and their watersheds
- Emergent wetlands
- Confluences of riparian/riverine systems (i.e., nodes where tributaries enter larger streams or rivers, which serve as biodiversity hotspots)
- Valley oaks/valley oak woodlands
- Mature riparian forest
- Wide (>100 m) riparian areas
- Functional or potentially restorable floodplain riparian areas (e.g., land situated between old, degraded levees near the river 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)

In most cases conserving and properly managing these resources would require including them within ecological reserves, although we recognize that some (e.g., valley oaks scattered in agricultural areas) may be better conserved on private lands by incentives or regulations (e.g., conservation easements or oak tree protection ordinances).

5.3 Land Cover Types with Some Allowable Impacts

Some development projects could occur in the following areas without severe impacts to biological resources, so long as development follows reasonable guidelines to minimize and mitigate impacts:

5.3.1 Grasslands

Minimize incursions into existing grasslands, with development concentrated along existing edges and near existing roads. Always avoid impacts to grassland areas supporting vernal pools or narrow endemic species, and grasslands on or near the interface with oak woodlands and savannahs. Avoid fragmenting large grassland areas by roads or other developments, which can have severe effects on area-dependent species, like American badger. Internal fragmentation also constrains management measures that can be used in grasslands, such as prescribed fire and managed grazing.

5.3.2 Croplands

To benefit wildlife diversity, development on existing agricultural lands should preferentially be focused in orchards, which have lower biotic diversity and lesser benefits to species of concern than rice fields (important to wintering waterfowl, giant garter snake), or alfalfa and row crops (foraging habitat for Swainson's hawks). One exception to this rule may be orchards adjacent to wide riparian areas, which may be used by yellow-billed cuckoos (T. Beedy personal communication).

5.4 Addressing Ecological Values of Agricultural Types for Conservation and Mitigation

We anticipate that the plan may include some sort of compensation mitigation formula (e.g., using variable mitigation ratios) for the conversion of natural habitats or agricultural lands to developed uses (new urban areas, roads, etc.). If so, we recommend basing mitigation ratios on the relative ecological values and costs involved in such conversions or of maintaining certain areas in particular types of agriculture. The ecological costs may include such factors as the amount of water, pesticides, petrochemicals, etc., that must be used to maintain a particular crop type. Moreover, the value of certain agricultural types to wildlife can vary with landscape context (some examples are listed below). These considerations can be used to advantage in setting conservation and mitigation formulas; for example, to establish mitigation ratios that vary with landscape context in a manner that creates incentives for maintaining biologically valuable landscape mosaics. Some examples to consider in establishing conservation and mitigation guidelines include the following:

- Rice fields offer habitat value for a greater diversity of target species than do orchards or row crops, and they may offer the greatest value when in relatively large, contiguous blocks, rather than scattered smaller blocks (because many wintering or nesting waterbirds avoid disturbance by concentrating away from edges).
- Alfalfa fields near Swainson's hawk nests offer high-value foraging habitat, but maintaining alfalfa also requires relatively high use of water, pesticides, and petrochemicals relative to some other crop types. Thus, conservation and mitigation incentives may be set in a way that favors retention of alfalfa near potential Swainson's hawk nest trees, but not necessarily everywhere throughout the region.
- Fallow grain fields may serve as habitat for various grassland species, such as burrowing owl, but the effects of alternately using and fallowing the lands need to be considered in determining their value as conservation or mitigation sites.
- Orchards adjacent to wide riparian forests may be used by foraging yellow-billed cuckoos, whereas in general orchards offer low value to native birds (T. Beedy personal communication).

Note that these are just a small sample of how different crop types or contexts may affect biological values. We recommend a thorough review of how different land uses may affect biological values, all things considered (temporal dynamics, management methods, etc.), before settling on any particular conservation or mitigation formulas for agricultural lands.

5.5 Specific Locations of Known Biological Value and Restoration Potential

Based on our review of available information and observations during the August 11 field tour, the advisors recommend the following locations as worthy of special attention in conservation, restoration, and enhancement measures:

- The confluence of the Bear and Feather Rivers appears to be a biodiversity hotspot and is important to aquatic connectivity and functionality in both rivers. Data from fish surveys indicate a high number of fish species, a pattern that is common in rivers of the western United States (Gregory et al. 2002). This confluence provides a critical link between these two river systems, a refuge during natural disturbance, a critical nexus in the migration of aquatic and terrestrial species, and a complex habitat for riparian vegetation. The NCCP/HCP should highlight management options and local guidance on maintaining and restoring the role of this major confluence and other junctions in the river system.
- Coon Creek is a major tributary in the southern portion of the planning area that provides habitat for steelhead and other fish species. However, water quality (e.g., temperature, turbidity) limits the quality of this stream for aquatic communities. We recommend that the NCCP/HCP address the importance of Coon Creek and actions to protect and restore the riparian areas and corridor that Coon Creek provides between the uplands and lowlands in the planning area.
- Yuba River Goldfields—The stretch of the Yuba River extending through and somewhat beyond the area of hydraulic mining debris has important pool-run-riffle habitat with gravel and cobble substrates that are considered important chinook spawning habitat (CALFED 2000).
- Grasslands near Beale AFB and Spenceville, which are relatively large and unfragmented, may support vernal pools, and represent important connections into Sierra Nevada foothill habitats. These grasslands may also provide important habitat for a number of declining grassland-associated bird species, such as burrowing owl, grasshopper sparrow, and area-dependent grassland species, such as American badger.
- District 10 rice fields and managed wetlands provide important habitat for a variety of migratory birds, including tundra swan - this is also one of the most important wintering areas in California for trumpeter swan – (David Yee, personal communication to RH) and hunted waterfowl, wintering black-crowned night heron, white-faced ibis, bald eagle, and peregrine falcon, and possibly for giant garter snakes.

5.6 Guidelines for Siting Riparian Conservation and Restoration Areas

The advisors strongly recommend that conservation, restoration, and enhancement of riverine corridors strive to create continuous riparian vegetation corridors along the Feather River 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 (given that continuously broad riparian vegetation may not be possible along the length of the system). All else being equal, if the amount of riparian vegetation that can be maintained and restored is limited, it should be distributed according to the conceptual design in Figure 1A.

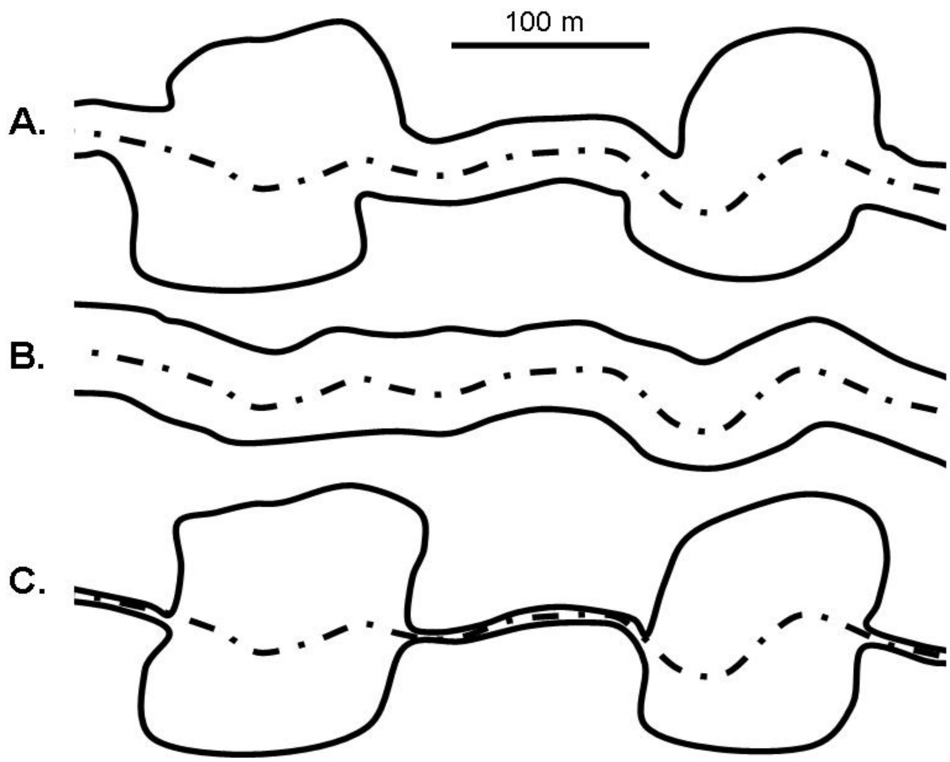

Figure 1. Comparison of 3 conceptual reserve design alternatives along a riparian corridor. The 3 reserves enclose roughly the same acreage, but in differing arrangements. **A**. Superior design combining wide biodiversity "nodes" (large enough to support nesting yellow-billed cuckoos) as well as continuous 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).

5.7 Wetland Buffers

The various wetland communities in the study area would benefit from having upland habitat buffers. For example, many streams in the study area have a narrow band of riparian vegetation that abuts abruptly with agricultural fields, which extend to the very rim of the incised stream bank. Having natural upland buffers between agricultural fields and the stream banks would greatly improve ecological integrity in the area's riparian and aquatic systems. Potential benefits would include reduced pesticide drift into aquatic systems; filtering of sediments, excess nutrients, or other pollutants out of the runoff entering streams; providing habitat for species that require both upland and wetland habitats; providing escape cover for some species during periods of high water; sheltering wetland species from noise or human disturbance; and buffering these systems against some invasive exotic species.

Unfortunately, establishing necessary or ideal widths for such buffers is not easy, because few scientific studies of buffers are available for situations directly applicable to this plan area and its mix of land uses and species of concern (many more buffer studies apply to commercial timber lands and forest species). Certainly, wider buffers are always better, but a width sufficient to meet particular goals is difficult to quantify. We therefore recommend a thorough review of the types of benefits to target species that might accrue from various types and widths of wetland buffers, based on expert opinion and the available literature. At the very least, we recommend establishing some conservative guidelines for establishing upland buffers along riparian corridors that could be created using incentive-based conservation tools, such as conservation easements.

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 hydrologically 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 buffers for this system.

5.8 Maintaining or Restoring Hydrological Connectivity

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 ERP for Feather River/Sutter Basin Ecological Management Zone) to identify possible opportunities to improve natural hydrological connectivity through mitigation for future projects, including flood-control or transportation upgrades or repairs. For example, the ERP identifies as a significant mortality factor 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 help rectify such problems.

5.8.1 Minimizing Barriers to Fish Passage

Roads and culverts potentially create barriers to upstream movements of anadromous fish in Sutter and Yuba Counties. The plan should thoroughly assess barriers to fish movement and contribute, if appropriate, to removing, minimizing, or mitigating them. We recommend further evaluation of these 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/). It may be possible to modify or retrofit culverts to improve fish passage over a wider range of stream flows. Many of the barriers may create partial or potential blockages at different stream discharges. While state regulations may improve the design of future bridges and culverts, many existing stream crossing are likely to be inadequate for fish passage.

6 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.

6.1 Species Take Analyses

Analyzing effects on target species populations is a critical component of 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 accurately as possible using 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. We urge recognition that point and acreage counts 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 4.1). 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 most 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 entails systematically assessing each known or likely 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 program 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. 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. We recommend that this structure be modified 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, we recommend replacing qualitative with quantitative assessments, and applying quantitative factor weights to reflect the relative influence of each limiting factor on species population size or sustainability.

Hypothetical Example Conservation Analysis for Swainson's Hawk

Limiting Factors	Net Effect*	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 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 should have a small net positive effect on population size and carrying capacity.

* 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.

6.2 Effects on Ecological Processes

As discussed in Section 6.1, 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):

- 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. 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 eastern portion of the 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. 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 7, 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, 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.

Another approach that may be useful for certain habitats or species is the construction of ecological community models. For example, aquatic ecologists have developed models of aquatic communities (collections of co-occurring species) that would be expected in reference habitat conditions within the region (e.g., RIVPAK) (Wright et al. 1984, Wright et al. 1993). The observed communities of aquatic organisms are then compared to the expected communities based on the model of reference sites. The ratio of observed to expected communities provides a rigorous measure of the degree of biological alteration at a site. One or more ecological community models may help in assessing NCCP/HCP effects on target resources, and especially in monitoring future changes in target resources as conservation, management, and mitigation actions begin to take effect.

Section 7.7 further addresses use of conceptual ecological community or ecosystem process models as they are applied in an adaptive management context (Atkinson et al. 2004). We suggest reviewing Atkinson et al. (2004) for further ideas on how useful conceptual models may be developed both as tools for analyzing likely plan effects on biological resources and for how they may help guide development of the adaptive management and monitoring program.

6.3 Use of Scenario Analyses

The NCCP/HCP must analyze the effects of actions within the planning area, both positive and negative, on populations of potential species of concern. One of the greatest challenges for an NCCP/HCP is to quantitatively assess adverse effects on potentially covered species from multiple resource uses or management actions. Land use patterns and environmental conditions in Yuba and Sutter County are certain to change over the life of the NCCP/HCP—including changes in the human population, climate, demands on water, production and treatment of wastes, economic sectors, and allocation of land to different uses. The NCCP/HCP is designed to provide assurances that resource management will be able to address the pressures on communities and species. 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 et al. 2004, 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.

Future changes in the landscape and human population of Yuba and Sutter 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. 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. These models can produce thousands of possible future landscapes, and thus can represent the statistical likelihood of various alternatives. These models have the advantage of producing large numbers of scenarios and being able to quickly run the projection of new alternatives.

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 Yuba and Sutter County include population growth and where those people live and work, resource demands, water availability and potential climate change.

Recent analyses have refined global climate models for California (Hayhoe et al 2004). These regional predictions bracket roughly 70% of predicted climate scenarios and associated uncertainty. Major impacts of the climate predictions for water flow will be volume, timing, and demand. The counties need to consider the consequences and planning options for these climate projections when developing the NCCP/HCP, regardless of whether they decide develop explicit scenario assessments.

6.4 Representation Analyses

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).

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.

6.5 Effects of Global Warming

Regional climate change models predict a range of outcomes for temperature and precipitation changes in California's Central Valley. Recent analyses indicate that temperatures could increase by 2° C to 4° C, precipitation would either increase or decrease according to time period and model assumptions, seasonal timing of precipitation would shift, snowmelt would occur earlier, inflows to reservoirs would generally decrease, and frequency of extremely hot days would almost double (Hayhoe et al 2004). If realized, such changes would have profound impacts on agriculture, energy use, aquatic habitat, fire frequency, terrestrial vegetation, wildlife, fish and other aquatic species, human consumption of water, and the complex interactions between these critical aspects of the human and natural systems in the Central valley. Any plan for future management of natural resources must account for potential climate change.

One plausible outcome described by climatologists is that both winter precipitation and temperatures will increase. This is particularly important for the conservation of vernal pool habitats. Using this scenario, Pyke (2005) 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.

7 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, 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.

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.

7.1 Levee Maintenance

It appears that current levee management actions in Yuba and Sutter Counties 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 conservation plans, 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.
- If levees are no longer needed or have deteriorated because of construction of outer levees, the abandoned levees should be removed and revegetated to restore floodplain function.
- The improvement of one levee system generally increases the chance of levee failure in another place, whether inside or outside of the NCCP/HCP study area. Thus, management of the levee system for the maintenance of open space and habitat, or for housing, requires consideration of effects on adjoining jurisdictions.

7.2 Vernal Pools and Annual Grasslands

Management of vernal pool and annual grassland areas 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 most of 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 traditional 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 species richness of native plant and aquatic invertebrates in the vernal pools declined with grazing removal. Shortened inundation periods in vernal pools may eliminate suitable habitat for vernal pool species, 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 or not sensitive species are responding positively to the management changes. In particular, grazing regimes should be chosen that do not harm rare vernal pool grasses.

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 on cover and diversity of native species when used in combination rather than separately.

7.3 Blue Oak Woodlands and Savannahs

Blue oak woodland and savannah habitat play an important ecological role in California's Central Valley and surrounding foothills. Blue oak 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 provide 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 for a number of reasons and likely burned some of these sites on an annual basis. McClaren and Bartolome (1989) showed that higher fire frequency might have favored oak regeneration. 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.

7.4 Riparian and Riverine Systems

The floodplains and riparian forests of Yuba and Sutter Counties are essential for aquatic communities and many species of terrestrial plants and wildlife. Although the riparian forests of the Feather, Yuba, and Bear Rivers are heavily impacted and fragmented by altered land uses, they nevertheless continue to support areas of high biological value. In particular, the existing wide riparian forests in the upper portion of the Feather River are critical for bird communities, including populations of yellow-billed cuckoo.

Invasive species have replaced many native species in the riparian forests and present major management challenges for the NCCP/HCP. In particular, removal of black locust (*Robinia pseudoacacia*) and management of fire adjacent to and within riparian areas both need thorough consideration as potential mitigation actions and as ongoing adaptive management actions.

The NCCP/HCP should fully describe and evaluate plans for riparian restoration and protection of existing floodplains and riparian areas. This should include an evaluation of the relative likelihood of success for current management and the changes that will be necessary to accommodate population growth, land use change, climate change, changes in water consumption, and changes in patterns and frequency of fire.

7.5 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 the species. For example, educating field workers about giant garter snakes and instructing them not to kill snakes they encounter while farming would be helpful. Farming practice modifications, particularly for 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 include:

- Any canal maintenance that is necessary should be done during the period of activity for giant garter snakes, May through September.
- Canal bank vegetation should be managed to encourage native wetland plants; removal of wetland plants from canals should be discouraged. 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).

7.6 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 should be encouraged.
- 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 while minimizing maintenance costs.

7.7 Preliminary Monitoring Recommendations

We recommend using the approach presented in Atkinson et al. (2004) to guide development of the adaptive monitoring program. 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.

7.7.1 Monitoring Recommendations for Select Species

While it would be nice to know actual population sizes and precise trends for all species at all times, limitations of time, money, expertise, and access make this impossible. Moreover, this level of monitoring intensity can actually harm some species, and 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 those 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 and threatened 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 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. As an example, if acreage of alfalfa habitat or number of nest trees falls below a specified threshold then actions and more detailed monitoring would be required.

Invasive Species. Distribution and relative abundance should be monitored for some invasive species. A few of the many species of concern include perennial pepperweed, Argentine ants, New Zealand mud snails, bullfrogs, 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 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 and perhaps other corvids (D. Airola personal communications).

8 List of Additional Questions and Research Recommendations

The advisors recommend obtaining, reviewing, or otherwise considering the following information sources to help shape Phase II of the planning process. In some cases these are questions that may require additional research, perhaps as part of plan implementation.

- Maps of historic versus current floodplains, water conveyances, levee systems, etc., along with any existing plans for upgrades, repairs, or restoration of the flood control and water conveyance systems (e.g., from CALFED program, DWR, FEMA). These should be researched to identify possible conflicts and synergies between NCCP/HCP goals and water conveyance capital improvement projects.
- Maps or plans for existing and proposed restoration and mitigation sites (Jeff Finn, CDFG).
- Maps of mercury concentrations or other pertinent contaminants.
- Williamson Act lands in plan area.
- Results of transportation and development build-out models for Yuba and Sutter Counties prepared by Dr. Robert Johnston, UC-Davis.
- Information on the use of Sutter Bypass by large mammals (e.g., cougar, mule deer), especially as a movement corridor between other habitat areas (e.g., Sutter Buttes and Feather River).
- Instream flow records (hydrographs) for streams and rivers, for effects on species and ecological processes, and to identify mitigation opportunities (e.g., increased flows during critical life periods).
- Additional information on salmonid populations and response to instream flows (contact John Baker, NOAA Fisheries).
- Results of any wildlife surveys or other data on wildlife use in the Yuba Goldfields, as well as any data or plans concerning chemical contamination, reclamation, or restoration in this area.
- Pertinent CalFed Ecological Restoration Program (ERP) Plan Reports to identify how the NCCP/HCP can contribute to achieving Restoration Targets and Programmatic Actions they define.
- Map of Beale AFB noise contours that are being considered for base realignment.
- Latest published models of climate change for the Central Valley and Sierras, for how they will affect natural communities and species distributions in the plan area.
- CDFG data on radio-collared cougars, mule deer, or other pertinent species in or near the study area, to identify possible wildlife-movement corridors and mitigation actions (e.g., as part of future road or levee improvements).

- Any applicable state, federal, or county guidelines for road siting, road construction, and development restrictions along roads, as they may affect future development patterns and constraints on conservation and development planning.
- Any existing resource-protection ordinances, such as oak-protection ordinances, that can be modified to further NCCP/HCP goals, such as retention of Swainson's hawk nesting trees?
- Contact Jeff Finn, Dan Gifford, and Jenny Marr for additional information on Swainson's hawk.
- Research relationships between ground water and surface water in the planning area as they pertain to water balance in vernal pools and other wetlands.
- The distribution of giant garter snakes is unknown in all but the southern part of the plan area. Surveys should be conducted to determine the current distribution and abundance of giant garter snakes in the plan area. Such information would be useful in designing habitat reserves, identifying suitable areas for habitat restoration, identifying areas important for connectivity among habitats, and delineating those areas where maintenance of irrigation supply and drainage canals should be evaluated (see Section 7.5 above). This information would also be useful in determining areas in which giant garter snakes are not a planning and development concern.

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Attachment A
Biographies of Advisors

Stanley Gregory, Ph.D., Professor, Department of Fisheries & Wildlife, Oregon State University. Dr. Gregory has been involved in the development of interdisciplinary ecological studies at Oregon State for more than two decades. He has participated in the International Biological Program and the Long-Term Ecological Research Program at the H.J. Andrews Experimental Forest. Dr. Gregory has directed the stream research program informally known as the Stream Team since 1986. This interdisciplinary research program has been recognized for its contributions in teaching and research by the College of Agricultural Sciences, the College of Forestry, and the U.S. Forest Service. His research now includes nutrient dynamics, hyporheic restoration, wood and habitat relationships, fish assemblages in large rivers, riparian management and restoration, and analysis of alternative future scenarios for large river basins. He serves as Co-Chair of the Independent Multidisciplinary Science Team for Oregon.

Robert Hansen, Biology Department, College of the Sequoias; Owner and Principal Biologist, Hansen's Biological Consulting, Visalia, CA; President, Tulare Basin Wildlife Partners; Vice President, Sequoia Riverlands Trust. Mr. Hansen is a leading local expert on San Joaquin Valley native species, particularly birds and their habitats. He has conducted over 100 wildlife surveys in seven San Joaquin Valley counties and has led hundreds of tours and field trips in the area. He has experience as a land manager of valley oak woodland, vernal pools, grassland, freshwater marsh, riparian forest, and desert scrub habitats in Tulare and Kern Counties, and has participated in a number of HCPs.

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, 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.

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 Yuba-Sutter 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 is 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 in the Yuba/Sutter and Yolo County efforts in habitat conservation planning.

Attachment B

Initial Questions
Addressed by Science Advisors

Yuba and Sutter Counties
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.

Geographic Area

If the boundaries of the planning area were to be expanded, what natural, political, or other boundaries should be considered? Are there natural breaks, gradients, or boundaries within these counties that would assist in defining reserve areas, analyzing plan effects, or otherwise achieving plan goals (e.g., watershed units, geological discontinuities, topographic breaks, etc.)?

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?