The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

Project Information

1. **Proposal Title:**

   The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

2. **Proposal applicants:**

   Gregory Golet, The Nature Conservancy
   Michael Marchetti, California State University Chico
   David Wood, California State University Chico
   Geoffrey Geupel, Point Reyes Bird Observatory
   Nadav Nur, Point Reyes Bird Observatory
   Stacy Small, Point Reyes Bird Observatory
   Steven Greco, University of California Davis
   Marcel Holyoak, University of California Davis
   James Quinn, University of California Davis
   Karen Holl, University of California Santa Cruz
   Karen Loik, University of California Santa Cruz
   Elizabeth Crone, University of Montana

3. **Corresponding Contact Person:**

   Wendie Duron
   The Nature Conservancy
   500 Main St. Chico, Ca. 95928
   530 897-6376
   wduron@tnc.org

4. **Project Keywords:**

   Bioindicators and Biomonitoring
   Geographic information systems (GIS)
   Wildlife Ecology

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Riparian Habitat

8. **Type of applicant:**

   Joint Venture

9. **Location - GIS coordinates:**

Latitude:	39.679
Longitude:	-122.009
Datum:	

   Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

   The Project ranges from just above the town of Colusa at the southern end (river mile 144) to the town of Red Bluff at the northern end (river mile 244). The east and west edges are set at the boundaries of the Sacramento River Conservatio Area (SRCA).

10. **Location - Ecozone:**

    3.2 Red Bluff Diversion Dam to Chico Landing, 3.3 Chico Landing to Colusa

11. **Location - County:**

    Butte, Colusa, Glenn, Tehama

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    2 & 3

15. **Location:**

    California State Senate District Number: 1 & 4

    California Assembly District Number: 2 & 3

16. **How many years of funding are you requesting?**

    3

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

    No

    If no, list single overhead rate and total requested funds:

    Single Overhead Rate: 22 (however subrecipient overhead rates differ in some cases)

    Total Requested Funds: 2,989,412.33

    b) Do you have cost share partners already identified?

    No

    c) Do you have potential cost share partners?

    No

    d) Are you specifically seeking non-federal cost share funds through this solicitation?

    No

    If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

    No

    Have you previously received funding from CALFED for other projects not listed above?

    Yes

    If yes, identify project number(s), title(s) and CALFED program.

97-N02	**Ecosystem and Natural Process Restoration on the Sacramento River: Floodplain Acquisition and Management**	**Ecosystem Restoration Program**
97-N03	**Ecosystem and Natural Process Restoration on the Sacramento River: Active Restoration of Riparian Forest**	**Ecosystem Restoration Program**
97-N04	**Ecosystem and Natural Process Restoration of the Sacramento River: A Meander Belt Implementation Project**	**Ecosystem Restoration Program**

98-F18	**Floodplain Acquisition, Management and Monitoring on the Sacramento River**	**Ecosystem Restoration Program**
2000-F03	**Floodplain Acuisition and Sub-Reach/Site Specific Management Planning: Sacramento River (Red Bluff to Colusa)**	**Ecosystem Restoration Program**

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

    No

    Have you previously received funding from CVPIA for other projects not listed above?

    Yes

    If yes, identify project number(s), title(s) and CVPIA program.

00FG200173	**Acquisition of Southam Orchard Properties for Preservation of Riparian Habitat**	**AFRP**
1448-11332-7-G017	**Hartley Island Acquisition**	**AFRP**
11332-0-G014	**Singh Walnut Orchard**	**b-1 other**

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

    No

    Please list suggested reviewers for your proposal. (optional)

21. **Comments:**

Environmental Compliance Checklist

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No

   b) Will this project require compliance with NEPA?

      No

   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      This proposal is for research only.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   <u>CEQA Lead Agency:</u> None
   <u>NEPA Lead Agency (or co-lead:)</u> None
   <u>NEPA Co-Lead Agency (if applicable):</u> None

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Land Use Checklist

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   This proposal is for research only.

4. **Comments.**

   Appropriate permits will be sought prior to conducting reseach on all state, federal and private lands.

Conflict of Interest Checklist

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Gregory Golet, The Nature Conservancy
Michael Marchetti, California State University Chico
David Wood, California State University Chico
Geoffrey Geupel, Point Reyes Bird Observatory
Nadav Nur, Point Reyes Bird Observatory
Stacy Small, Point Reyes Bird Observatory
Steven Greco, University of California Davis
Marcel Holyoak, University of California Davis
James Quinn, University of California Davis
Karen Holl, University of California Santa Cruz
Karen Loik, University of California Santa Cruz
Elizabeth Crone, University of Montana

Subcontractor(s):

Are specific subcontractors identified in this proposal? No

Helped with proposal development:

Are there persons who helped with proposal development?

No

Comments:

All principal investigators (those listed as applicants) assisted in the writing of the proposal. Drafts were reviewed by various staff from the Nature Conservancy.

Budget Summary

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

State Funds

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	VEGETATION	720	16429	6079		2000	288834.80	46000		359342.8	79055.42	438398.22
2	ELDERBERRY-ASSOCIATED INSECTS						106384.35			106384.35	23404.48	129788.83
3	BIRDS						157810			157810.0	34718.20	192528.20
4	FISH						157279.2			157279.2	34601.42	191880.62
5	SYNTHESIS	100	2983	1104			152622.2			156709.2	34476.02	191185.22
6	DATA MANAGEMENT AND DISSEMINATION						35523.87			35523.87	7815.25	43339.12
7	PROJECT MANAGEMENT	560	16704	6180	3000					25884.0	5694.48	31578.48
		1380	36116.00	13363.00	3000.00	2000.00	898454.42	46000.00	0.00	998933.42	219765.27	1218698.69

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	VEGETATION	740	17774	6576		1000	135473.10			160823.1	35381.08	196204.18
2	ELDERBERRY-ASSOCIATED INSECTS						127143.18			127143.18	27971.50	155114.68
3	BIRDS						145660			145660.0	32045.2	177705.20
4	FISH						110279.2			110279.2	24261.42	134540.62
5	SYNTHESIS	200	6195	2292			153967.8			162454.8	35740.06	198194.86
6	DATA MANAGEMENT AND DISSEMINATION						36233.39			36233.39	7971.35	44204.74
7	PROJECT MANAGEMENT	560	17346	6418	3000					26764.0	5888.08	32652.08
		1500	41315.00	15286.00	3000.00	1000.00	708756.67	0.00	0.00	769357.67	169258.69	938616.36

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	VEGETATION	290	7285	2695		1000	96232.59			107212.59	23586.77	130799.36
2	ELDERBERRY-ASSOCIATED INSECTS						107990.58			107990.58	23757.93	131748.51
3	BIRDS						150796			150796.0	33175.12	183971.12
4	FISH						71279.2			71279.2	15681.42	86960.62
5	SYNTHESIS	540	17346	6418			156152.9			179916.9	39581.72	219498.62
6	DATA MANAGEMENT AND DISSEMINATION						37206.68			37206.68	8185.47	45392.15
7	PROJECT MANAGEMENT	560	17989	6656	3000					27645.0	6081.90	33726.90
		1390	42620.00	15769.00	3000.00	1000.00	619657.95	0.00	0.00	682046.95	150050.33	832097.28

Grand Total=2989412.33

Comments.

Budget Justification

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

Direct Labor Hours. Provide estimated hours proposed for each individual.

Position Hours Science Specialist II 3080 Science Specialist I 350 Conservation Planner 420 Program Assistant II 420

Salary. Provide estimated rate of compensation proposed for each individual.

Position Hrly Rate Science Specialist II $31 Science Specialist I $24 Conservation Planner $22 Program Assistant II $17

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

37% for all categories

Travel. Provide purpose and estimate costs for all non-local travel.

Funds are requested ($3,000 per year) to cover travel to and from meetings, workshops and conferences. Much can be gained through the exchange of information and ideas with others involved in this and related projects.

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Field supplies: $2000 are requested for the first year to cover the cost of specialized data gathering equipment (field instruments, binoculars, etc); $1000 are requested for years 2 and 3 for similar purposes. No funds are requested for office or laboratory supplies.

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

To determine the hourly rate I took the total amount that each subrecipient requires to complete the specified task(s)(assuming assuming state funds) and divided this by the total amount of time that it will take to complete the work. Note that all PIs have multiple people working with them on the proposed projects. Task 1, PI:Crone, $104049.57/1095 days = $95.02 Task 1, PI:Greco, $167512.00/365 days = $458.94 Task 1, PIs:Holl/Loik, $165238.00/1095 days = $119.03 Task 1, PI:Wood, $83740.86/1095 days = $150.90 Task 2, PI:Holyoak, $341521.12/1095 days = $311.89 Task 3, PI:PRBO, $454266.00/1095 days = $414.85 Task 4, PI:Marchetti, $338837.60/1095 days = $309.44 Task 5, PI:Crone, $210577.89/1095 days = $192.31 Task 5, PI:Quinn, $207165.01/1095 days = $189.19 Task 5, PI:PRBO, $45000.00/1095 days = $41.10 Task 6, PI:Quinn, $108963.93/1095 days = $99.51 The following is a breakdown of how the funds for each task will be allocated. Each PI is listed separately. Respective overhead (OH) rates are also provided: Task 1, PI: Crone, salaries:$56556.63, travel:$15000.00, supplies:$1000.00, housing:$1500.00, Task 1, PI:Greco, salaries:$143284.00, travel:$2500.00, supplies:$6500.00, OH:state 10.0%, fed 48.5%. Task 1, PIs:Holl/Loik, salaries:$108195.00, travel:$19525.00, supplies:$5750.00, lab services:$7560.00, OH:state 24.4%, fed 24.4%. Task 1, PI:Wood, salaries:$51284.00, travel:$6000.00, supplies:$12500.00, OH:state 20%, fed

45%. Task 2, PI:Holyoak, salaries:$258468.40 travel:$22937.06, supplies:$11500.00, lab services:$19414.50, OH:state 10%, fed 26%. Task 3, PI:PRBO, salaries:$313244.00, travel:$24000.00, supplies:$14900.00, OH:state 29%, fed 29%. Task 4, PI:Marchetti, salaries:$281837.60, travel:$4000.00, supplies:$53000.00, OH:state 20%, fed 45%. Task 5, PI: Crone, salaries:$133377.50, travel:$1500.00, supplies:$6000.00, housing:$9000.00, OH:state 40.5%, fed 40.5%. Task 5, PI:PRBO, salaries:$34883.72, OH:state 29%, fed 29%. Task 5, PI:Quinn, salaries:$169577.46,travel:$2787.25, supplies:$15967.12, OH:state 10%, fed 26%. Task 6, PI:Quinn, salaries:$86417.76, travel:$818.55, supplies:$11821.81, OH:state 10%, fed 26%.

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Three items: 1)Trimble GPS unit: $46,000. This is a survey-grade GPS unit that provides elevation data with an accuracy of +/- 20 mm. Although purchased through task 1, this item will facilitate collection of data that is critical to ALL OTHER TASKS. It is needed to develop stage-discharge relationships, determine innundation patterns, and study erosion and sediment deposition, among other things. 2)Miniature Infrared Nest Surveillance Video Cameras and 24-hour time-lapse VCRs:$12,600. Items are required to identify nest predators (task 3). A pilot investigation conducted in the 2001 breeding season demonstrated this to be a feasible means to observe predation events and document predators. Nest predation accounts for the majority of nest failure for passerines on the Sacramento River, yet little information on the identity of predators exists. 3)Electro-shocking boat:$47,000. This item is required to permit access to shallow habitats for fish and invertebrate sampling (task 4).

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Dr. Golet, Senior Ecologist of TNC's Sacramento River Project will serve as overall coordinator of this project. He will be assisted by TNC staff (including Wendie Duron, Grants Specialist and Carol Wong, Attorney). Duties and associated costs of project management are as follows: 1)Organize and lead meetings with researchers to coordinate details of sampling efforts for different tasks and further define roles and responsibilities ($15,000) 2)Work with Grants Specialist and Attorney to write task orders and subrecipient contract agreements, ensuring that all scopes of services are reasonable, accurately stated, and can be performed within the times specified ($25,000). 3)Organize and lead annual meetings to share results and interpretations and arrange schedules for additional sampling and for modeling and synthesis efforts($20,000). 4)Facilitate meetings of smaller groups of PIs to share data, and integrate results ($5,000). 5)Work with Grants Specialist on agreement administration; ensure that only allowable costs are billed ($3,000). 6)Inspect work in progress; ensure that deliverables are completed ($10,000). 7)Prepare and submit reports ($15,000). 8)Prepare and give presentations ($5,000). Total cost: $98,000.

Other Direct Costs. Provide any other direct costs not already covered.

none

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

The Nature Conservancy (TNC) has a Negotiated Indirect Cost Rate (NICRA) of 22% which was negotiated and approved by TNCs cognizant agency, USAID, and calculated in compliance with the requirements of OMB Circular A-122, and bound into our annual OMB Circular A-133 audit reports. TNCs indirect cost per the NICRA includes salaries, fringe benefits, fees and charges, supplies and communication, travel, occupancy, and equipment for general and administrative regional and home office staff. These costs are reflected in the Indirect Costs category of this proposal and are not reflected anywhere else in the proposal budget. Direct staff costs are reflected in the salary and benefits categories of the proposal budget.

Executive Summary

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

The Nature Conservancy's Sacramento River Project, as lead in a joint venture partnership with scientists from universities and non-profit conservation organizations, requests $2,989,412 to conduct research on the Sacramento River (ERP Ecological Management Units 3.2 & 3.3). A better understanding of ecosystem response is needed if we are to maximize the efficiency and long-term success of restoration efforts. We can address this problem by conducting integrated research and monitoring studies and developing empirical models. On the Sacramento River, the large replicated restoration experiments previously undertaken present us with an unparalleled opportunity to test the degree to which ecosystem response is a function of the scale and location at which restoration actions are implemented. Our project tests the hypothesis that the relative distribution, abundance and biological performance of native vs. non-native invasive species at individual sites can be predicted based upon local site characteristics, the surrounding landscape matrix, and the degree to which natural physical processes (flooding, sediment deposition, etc.) are maintained. Our goal is to identify (1) the important predators, prey, and habitat requirements of a suite of floodplain-dependent sentinel species (native birds, fish, and insects), and (2) the biological (including NIS) and physical influences that shape their population dynamics and the riparian community at large. A primary objective of our project is to use statistical modeling techniques to integrate these factors to predict both local and regional patterns of species occurrence, and other indices of restoration success. The work we propose will provide a decision-making framework that managers may use in deciding what restoration actions are most appropriate for sites that differ in their physical and biological settings. Furthermore, it will help us better understand what natural processes are most important to maintain and/or promote to make remnant habitats and restoration sites most supportive of key wildlife species and biological communities. Important goals that our project will help achieve include PSP MR-1, SR-4, SR-7, ERP Goals 1, 3, 4, CVPIA Goal (a), and AFRP Objective 4.

Proposal

The Nature Conservancy

The Effects of Local Site Characteristics and Landscape Factors on Restoration Success at the Sacramento River: A Multi-Disciplinary Study Using Statistical Modeling and GIS

Gregory Golet, The Nature Conservancy
Michael Marchetti, California State University Chico
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THE EFFECTS OF LOCAL SITE CHARACTERISTICS AND LANDSCAPE FACTORS ON RESTORATION SUCCESS AT THE SACRAMENTO RIVER: A MULTI-DISCIPLINARY STUDY USING STATISTICAL MODELING AND GIS

Principal Investigators:
The Nature Conservancy
Dr. Gregory H. Golet, Senior Ecologist, Sacramento River Project, Chico, CA 95928, phone (530) 897-6386, fax (530)342-0257, ggolet@tnc.org

California State University Chico
Dr. Michael P. Marchetti, Assistant Professor, Department of Biology
Dr. David M. Wood, Professor, Department of Biology

Point Reyes Bird Observatory
Geoffrey R. Geupel, Director, Terrestrial Program
Dr. Nadav Nur, Director, Population Ecology
Stacy Small, Landbird Biologist, Ph.D student (University of Missouri-Columbia)

University of California Davis
Dr. Steven E. Greco, Assistant Professor, Department of Environmental Design, Landscape Architecture Program
Dr. Marcel Holyoak, Assistant Professor, Department of Environmental Science and Policy
Dr. James F. Quinn, Professor, Department of Environmental Science and Policy

University of California Santa Cruz
Dr. Karen D. Holl, Associate Professor, Department of Environmental Studies
Dr. Michael E. Loik, Research Scientist

University of Montana
Dr. Elizabeth E. Crone, Assistant Professor, Wildlife Biology Program

Project Description: Project Goals and Scope of Work

A1. Problem

Background. The Sacramento River is a fundamental state water source that drains 24,000 square miles of the northern Central Valley and supplies 80% of freshwater flowing into the Bay-Delta (CA State Lands Commission 1993). Historically, the river was lined by approximately 800,000 acres of riparian forest (Katibah 1984). Over 95% of this habitat has been lost, however, to selective logging, agriculture, urban development, and flood control and power generation projects. Cumulatively, these changes have greatly stressed the Sacramento River and associated species. The loss and degradation of riparian habitat has greatly diminished the river's ability to support viable wildlife populations and encouraged the invasion and proliferation of non-native invasive species (NIS). Two-thirds of the linear extent of the river's banks have been modified and confined by levees and riprap. Channelization, bank protection and the construction of the Shasta Dam degraded many habitats by restricting the dynamic forces that promote natural habitat succession and regeneration along the river. The loss of high-quality habitat has caused populations of many native species to become critically endangered. Important at-risk species include the Sacramento splittail (*Pogonichthys macrolepidotus*), green sturgeon (*Acipenser medirostris*), chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), Swainson's hawk (*Buteo swainsoni*), least Bell's vireo (*Vireo bellii pusillus*) and Valley elderberry longhorn beetle, hereafter VELB (*Desmocerus californicus dimorphus*) (CALFED MSCS 2000).

Although severely degraded, the Sacramento River is still the most diverse and extensive river ecosystem in California, composed of a rich mosaic of aquatic habitats, oxbow lakes, sloughs, seasonal wetlands, riparian forests, valley oak woodlands, and grasslands. In an effort to improve ecosystem health in the region, state-government and non-government organizations have begun to implement a series of management programs along the river. The CA State Legislature, in 1986, passed Senate Bill 1086, which mandated the development of a management plan for the Sacramento River and its tributaries to protect, restore and enhance fisheries and riparian habitat. The Sacramento River Conservation Area (SRCA) non-profit organization formed and set as its primary goal the preservation of remaining riparian habitat and reestablishment of a continuous riparian corridor along the Sacramento River from Red Bluff to Colusa. CALFED specified collaboration with the SRCA as a priority for the Sacramento River region (PSP, p. 25). Over the past 13 years, The Nature Conservancy (TNC) has worked to implement many of the conservation initiatives outlined in the SRCA handbook (CA Resources Agency 2000). TNC has planted a suite of native woody species (trees and shrubs, Alpert et al. 1999), and more recently, forbs and grasses on 2,800+ acres of floodplain habitat in an effort that may represent the most extensive replicated horticultural restoration ever undertaken anywhere **(Fig. 1).** Concurrently TNC and its partners have taken significant steps to restore natural river processes through the removal of levees and bank protection, activities which reconnect the river to its historic floodplain and restore a limited meander.

Statement of the Problem. Although many of these restoration activities have produced positive outcomes, it is widely recognized that a better understanding of ecosystem response is needed if we are to maximize the efficiency and long-term success of our restoration efforts. This speaks to a central problem in restoration ecology, which is that the potential for restoration and the vulnerability to degradation (especially that caused by NIS) of particular sites is not well predicted by theory. We can address this problem by developing empirically-derived models. To date most studies in restoration ecology have drawn on results from single sites (NRC 1992), but on the Sacramento River, the large replicated restoration “experiments” previously undertaken present us with an unparalleled opportunity to test the degree to which ecosystem response is a function of the scale and location at which restoration actions are implemented, thereby advancing our own technical expertise as well as the science of restoration ecology.

Here we propose a series of integrated studies designed to inform and direct the decision-making process of resource managers in the region. The research project we propose develops and implements an ecosystem response monitoring and assessment program to support adaptive management of the middle Sacramento River (ERP Ecological Management Units 3.2 & 3.3). Our intent is to gather and analyze data collected over a wide geographic area (from Red Bluff to Colusa, **Fig. 1**) to develop and refine empirical models of ecosystem function.

Specifically, our goal is to identify (1) the important predators, prey, and habitat requirements of a suite of floodplain-dependent sentinel species (native birds, fish, and insects), and (2) the biological (including NIS) and physical influences that shape their population dynamics and the riparian community at large. Because the various studies share sampling matrices, data structures, and environmental attribute data, and the various statistical models developed will be compared for applicability over the different taxa, the net worth of this project far exceeds the sum of its individual parts. The information we gather will significantly advance our ability to identify appropriate restoration strategies for sites that differ in their physical and biological settings. Furthermore, it will help us better understand what natural processes are most important to maintain and/or promote to make remnant habitats and restoration sites most supportive of key wildlife species and biological communities.

Figure 2 illustrates the potential that integrated research and monitoring studies have to improve restoration success on the Sacramento River. Recognizing the unparalleled opportunities for cutting-edge research, our consortium of internationally-renowned scientists from a suite of universities and conservation organizations have begun integrating work across traditional disciplinary boundaries. Our team is well-versed in the analytical and field methods proposed, and many have past research experience in this ecosystem. The proposed work represents a logical next step of scientific inquiry that was conceptualized by our team of researchers who are well-informed of the information needs of the restoration practitioners in this important watershed.

A2. Justification

A common theme has emerged among studies of ecosystem response to restoration; namely, that there is a great deal of variability in how different sites within an ecosystem respond to the same management actions depending on both site-specific and landscape-scale factors (Parker & Pickett 1997). Variable outcomes in restoration may be attributable to fundamental differences in the landscape matrices within which projects are imbedded (Hansson et al. 1995), but may also represent unmeasured environmental differences on-site. Furthermore, many ecological processes are highly responsive to the scale and location at which habitat and processes are altered (Wiens 1989). Despite the difficulty in predicting restoration outcomes, ecologists are increasingly called upon in restoration projects to engineer specified “desired future conditions”.

As first steps toward meeting this challenge, we propose to conduct a series of highly integrated research and monitoring studies to resolve key ecological uncertainties, and to use the information gathered therein to construct empirical models of ecosystem function. Although models appropriate to a few species in riparian systems in the semi-arid west have previously been developed (e.g., Mahoney & Rood 1998), they have not been adequately tested to determine the generality and range of conditions in which they apply.

Our project is designed to test the <u>general hypothesis</u> that the success of restoration efforts at particular sites can be predicted based upon analyses of local site characteristics and landscape-scale factors (Table 1). Specifically we will test whether the relative distribution, abundance and biological performance of native vs. non-native invasive species at individual sites can be predicted based upon local site characteristics, the surrounding landscape matrix (including the proximity of remnant natural habitats), previous land use, and the degree to which natural physical processes (flooding, sediment deposition, etc.) are maintained. As noted by Ehrenfeld & Toth (1997), there is a need for process-level ecosystem research in restoration projects that includes a variety of taxa and processes. Our proposal embraces this notion.

Our approach combines monitoring with modeling (**conceptual model**, **Fig. 3;** details provided in Task 5). We will monitor native and non-native taxa, and will measure a range of local and regional physical and biotic variables thought to influence these species. **A <u>primary objective</u> of our project is to use statistical modeling techniques to integrate these variables to predict both local and regional patterns of species occurrence, and other indices of restoration success.** Indices will vary depending upon taxa, but in general will be developed from data describing the distribution, abundance, health, and fitness of a given species or population. Restoration success indices will focus on both desirable and undesirable taxa (including those that serve as habitat, food, predators and/or parasatoids for faunal species of concern). Growth rate, fecundity, and survival will be among the parameters used in the development of indices.

Local and regional ecosystem factors will be measured within both restored and natural remnant sites and estimated across landscapes using a geographic information system (GIS). **A <u>secondary objective</u> of our project is to compare the usefulness of ecological models that are based upon widely available data for extensive areas (products of image analyses) with models that are based upon highly site-specific data from intensive site assessments.** By comparing such models we hope to identify what parameters are most important to assess when selecting restoration strategies for particular sites, what the quality of the currently available extensive data layers are, what benefits may come from conducting more detailed site-specific surveys, and what additional information may be most important to build into existing data bases.

After determining the relative predictive capabilities of models built solely from landscape-scale variables with those that are constructed from both landscape and site-specific attributes, we will predict the level of restoration success at additional, independent restoration sites within the project area. Surveying these sites will test predictions and advance model development. In addition to advancing our understanding of the factors that shape floodplain community dynamics, the iterative process of data collection and model refinement will enable us to refine our restoration prescriptions for particular sites--a pressing need in this highly heterogeneous environment.

A3. Approach

Table 2 lists all proposed tasks, subtasks and associated program leads. Due to similarities in study designs, similar statistical analyses will be used for Tasks 1-4. These are discussed once (**p.11**) rather than with respect to individual tasks.

General Sampling Protocol. We will conduct intensive integrated data collection at 5-6 sites where horticultural restoration has taken place (3 older sites, and 2-3 newer sites, hereafter collectively referred to as "restoration sites"). Each of these sites will be paired with a nearby and physically similar (i.e., similar elevation, distance to river, etc.) site that contains remnant riparian habitat (hereafter called "reference sites"). Collectively these 10-12 sites make up the "core sites". Additional research and monitoring activities will take place at other locations within the study area (**Fig. 1**), as dictated by the nature of the particular investigations.

TASK 1: VEGETATION.
Introduction. Although the main targets of restoration on the Sacramento River are primarily fauna (e.g., bird communities, listed fish species, and the VELB), restoration efforts typically focus on planting vegetation and restoring physical processes, as it is assumed (but generally untested) that fauna will recover if suitable habitats and the processes that maintain them are restored. As vegetation is a critical component of wildlife habitat, it is essential to understand how and why riparian vegetation develops on a site if we are to understand what factors affect the recovery of targeted animal species (**Fig. 3**). More specifically, on the Sacramento River there is a critical need to better understand what factors influence the survival and growth of planted species and the subsequent natural colonization and establishment of native species and NIS. It is well recognized that vegetation community response in riparian areas is driven by both physical parameters (e.g., soil characteristics, flood frequency, water availability) and biological factors (e.g., competition with or facilitation by NIS, dispersal of seeds by birds, insect herbivory) but the order of importance of these factors and how they vary with heterogeneous site conditions in California riparian floodplains is unknown. Our vegetation studies are aimed at resolving these critical uncertainties. This work will help us understand how to match plant designs to individual sites and what natural disturbance regimes (hydrologic and geomorphic processes) are needed to promote desired floodplain vegetation communities to support important animal taxa.

<u>Subtask 1: Growth and Survival of Planted Woody Species</u>

As stated previously, current horticultural restoration practices on the Sacramento River floodplain involve planting a suite of woody species (trees and shrubs), forbs and grasses. This subtask will focus on identifying those physical and biological factors that determine the growth and survival of planted woody species. To make these linkages, we will (1) continue ongoing monitoring of growth and survival of planted species; (2) collect data on various abiotic parameters **(Table 1)**; and (3) take physiological measurements of a few focal species. Our measurements will allow us to formulate physiological models relating photosynthetic performance to soil water availability. These models will provide baseline data that can be used to guide riparian water management policies and anticipate impacts of future climate change.
Study Design/Field Methods. To assess planted woody species survival and growth we will conduct one-time sampling (during years 1 and 2) of long-term plots (n = 106) previously established by TNC at restoration sites planted between 1989 and 1995. A subset of these plots are located at the core restoration sites where highly detailed site-specific data will be collected (see below). Growth and survival will be determined by analyzing newly collected data in conjunction with historical data collected at the end of the maintenance phase (when irrigation and weed control is halted).

This subtask will be responsible for collecting the majority of the site-specific variables (**Table 1**) that are required for analyses in other tasks under this proposal. In addition, we will compile existing data on weather, soil stratigraphy, elevation, slope, flood frequency, previous land use, and restoration actions (for the restoration sites). All sites will be surveyed using a high precision survey-grade GPS (vertical accuracy ± 20 mm), and water-line markers will be put in place at flood events of varying magnitudes to develop stage-discharge relationships. Ground water wells and soil moisture probes will be installed at all core sites. Depth to groundwater and soil moisture will be monitored twice monthly during the first two years of the study. Surface soil samples will be collected at core sites and analyzed for macronutrients, organic matter, cation exchange capacity and texture at the Division of Agricultural and Natural Resources Lab at UC Davis.

For five species (*Populus fremontii*, *Quercus lobata, Salix lasolepis*, *Sambucus mexicana*, and *Acer negundo*) we will mechanistically link abiotic parameters with survival and growth. We will conduct detailed measurements of river, soil, and groundwater characteristics, and study soil and plant water relations and photosynthetic performance to explain observed patterns of plant establishment. We will monitor woody seedling growth and survival annually for these species on each of the core sites. Soil and plant water potential and photosynthetic carbon assimilation will be evaluated quarterly for two years to link physical conditions to riparian soil water availability, and in turn, to plant survival and growth. To better understand water use patterns for focal species, and evapotranspirational costs incurred by restoration efforts, we will measure use of groundwater, river water, and rainfall, based on soil and plant water stable isotope signatures. We will compare ^{18}O and ^{2}H for source and plant water using mass spectrometry to determine the mixing ratio for the relative amounts of groundwater, river water and precipitation used by plants in summer and winter. This will allow us to assess the relative importance of seasonal flow and runoff effects on water availability and plant growth.

Subtask 2: Colonization and Succession of Naturally Recruiting Species

Restoration success cannot be judged solely by the performance of planted species. This is because the collection of planted species is insufficient by itself to meet the complex life history requirements of the animal taxa targeted for recovery. Consequently, the success of restored habitat for focal faunal species depends to a degree on the natural colonization and establishment of desired plant species. This requires successful dispersal from source populations, suitable site conditions, and the ability to outcompete widespread NIS. This subtask will identify factors that affect the establishment of important native species and NIS at both restoration sites and reference sites. We will test hypotheses that seek to identify which physical (e.g., water availability, soil nutrients, disturbance regime) and biological (e.g., competition) parameters most influence observed establishment patterns, and to what degree colonization and successional trajectories are the function of site-specific vs. landscape-scale variables (**Table 1**). Our approach is to combine studies of the vegetation community at large with detailed studies of a few focal plant species that are of particular importance to animal taxa.

Study Design/Field Methods. Vegetation community sampling methods will be identical to those used by Dr. David Wood as part of a related study of community transitions in natural riparian forest (CALFED 2000-F03 administered by TNC). Plots of standard forest ecology size (20 x 50 m) will be established at each of the core sites. Within each plot trees, shrubs, and herbs will be measured using a stratified random sampling procedure. Data collected will provide information on species composition and structure to determine habitat suitability for fauna. In the first year woody seedlings will be counted and permanently tagged. In year three these plots will be resurveyed to determine survival and growth of the seedlings and to quantify recruitment. In addition to studying woody species, we will study establishment of three native herbaceous species (*Artemisia douglasii*, *Rubus ursinus,* and *Carex barbarae*) that: (1) are not planted; (2) are pervasive in natural riparian forests; (3) represent important wildlife bird habitat and/or food resources; (4) are representative of different life-history strategies; and (5) differ in their establishment patterns on restored sites. A fourth species (*Rubus discolor*) will be studied to compare life history differences between the native species and this widespread exotic congener.

We will conduct surveys for these herbaceous species in year one at the core sites. Distribution will be analyzed as a function of both site-specific and landscape-scale variables (**Table 1**). We will monitor seed rain, seed germination, seedling survival, and reproductive output of the herbaceous species during years one and two. Based on our results, we may conduct a few small experiments to evaluate how competitive interactions between plants vary as a function of local site conditions (e.g., open canopy of young forest vs. closed canopy of older forest).

Subtask 3: Vegetation Transitions at Large Scales

Detailed on-the-ground measurements as described in the above two subtasks are essential for a mechanistic understanding of riparian vegetation development but a larger spatial context is also required to translate vegetation patterns documented by field sampling (Subtask 2) to a sufficiently large scale to do modeling for faunal species of concern (Task 5). In this subtask we will use a GIS to map vegetation patterns throughout the study area and refine a set of empirical suitability models describing the spatial distribution of riparian plant communities. A state-and-transition model will be refined to formally define the rules for vegetation community transitions (Plant et al. 1999). Special attention will be paid to key NIS, so we may better assess the role they have in altering community trajectories both at horticultural restoration sites and at remnant habitats.

Study Design/Field Methods. We will create time series maps of the vegetation patch structure of at least 6 subreaches (each 5-8 river miles long) within the study area. Most, if not all, of the core sites will be aligned with these subreaches. A 20 m minimum mapping unit will be applied to all time periods represented by historical aerial photos archived at the Landscape Analysis and Systems Research Laboratory at UC Davis. The precise location and time series resolution (i.e., the number of time periods mapped) of the subreach analyses will be determined following the completion of an ongoing mapping project being conducted by Dr. Greco (funded through the California Department of Water Resources). We will classify habitats based on the community series described by Sawyer and Keeler-Wolf (1995), and validate these classifications by analyzing community composition data compiled from on-the-ground surveys (Subtasks 1 and 2, plus additional data from Dr. Wood). If necessary a few additional sites will be surveyed to ensure adequate coverage of the represented plant communities. To develop the state-and-transition model, floodplain elevation will be entered into the GIS for all sites by using a high resolution digital elevation model derived from US Army Corps of Engineer data. Additional information that will be gathered for development of the model includes rates of vertical growth and lateral spread of vegetation patches (by species). These rates will be determined using photogrammetric software that measures changes in vegetation height over time.

Required Equipment. Trimble GPS unit: $46,000 *(This item will facilitate collection of data that is critical to all other tasks)*; Dynamax soil moisture probe $5,000.

Integration. We will conduct detailed vegetation surveys at the same sites as insects, birds, and fish are studied. These parallel efforts will allow us to compare and contrast the habitat characteristics that are important for these species (**Fig. 3**). Detailed site assessments will allow us to ground truth, calibrate and refine remote landscape mapping efforts. The vegetation maps will be used in the modeling exercises (Task 5) to evaluate habitat quality for focal animal taxa. For example, the distribution of elderberry will be used as input into the VELB habitat model.

TASK 2: ELDERBERRY-ASSOCIATED INSECTS

Introduction. Criteria for successful restoration have often focused on the recovery of particular target species. While this approach is necessary to protect sensitive species, it provides little insight into whether non-target species are also restored and which factors determine their recovery. We propose to identify the factors responsible for restoration success through coordinated monitoring of a group of target and non-target insect species. The wide range of natural histories and trophic and functional groups occupied by insects make them likely to respond to changes in environmental conditions and well-suited for assessing restoration success.

Site and landscape variables (**Table 1**) are expected to influence the colonization potential of certain insect taxa within restored sites. Within-site variables will also influence the persistence and abundance of each colonizer. Landscape-scale variables are most likely to indirectly affect insect communities through their influence on vegetation and sediment properties.

We will assess the role of local and regional-scale ecosystem factors on the restoration success of insect communities located in and around elderberry (*Sambucus mexicana* and *S. caerula*). We will focus particular attention on two habitat specialists, the federally threatened Valley elderberry longhorn beetle (VELB) and twig-nesting hymenoptera. To maintain tractability, we limit the scope of the study primarily to insects associated with elderberry, but also draw linkages, where possible, between insects and species that are the focus of other tasks (plants, birds and fish).

Subtask 1: Response of the VELB to Restoration Efforts

This subtask will identify factors that affect restoration of VELB populations. VELB Mitigation efforts have been hampered by to a lack of information about the species' habitat requirements (Collinge et al. 2001). Current mitigation guidelines call for increasing the amount of available habitat through planting elderberry, yet 75% of existing sites in the Central Valley remained uninhabited by the VELB (Collinge et al. 2001). This discrepancy suggests that variables other than elderberry density influence the success of the VELB. These variables may include distance from source populations, elderberry size and nutritional quality.

Study Design/Field Methods. We will quantify: (1) VELB abundance by surveying elderberry and looking for the distinctive emergence holes created by the beetle; (2) availability and distribution of potential VELB habitat (elderberry branch diameter, branch length, height and canopy volume); and (3) elderberry nutritional quality (concentration of nutrients and plant defense compounds). Field sampling will take place a minimum of one time at each core site during the grant period. We will analyze the relationship between these measures and important site and landscape-scale characteristics, including most variables in **Table 1**, and proximity to nearest remnant riparian habitat with elderberry as an index of habitat connectivity (Schumaker 1996).

Subtask 2:Response of the Elderberry-Associated Insect Community to Restoration Efforts

This subtask will identify the multi-scale ecosystem factors that affect the restoration of the insect community associated with elderberry. By examining environmental conditions combined with insect community structure and diversity and abundance measures, insight will be gained into the trajectory of recovery. Comparing species lists will indicate specific differences between sites and provide benchmarks for tracking changes through time at individual sites. High-level taxonomic or functional (e.g., trophic and reproductive) groups will be used to identify site characteristics that are important to consider during restoration. For example dominance of efficient dispersers in isolated sites would lead us to infer that site proximity is important.

We will use habitat specialists to test for indirect effects of horticultural restoration. Elderberry is a pollen and nectar resource for pollinator species, and a nesting site for twig-nesting bees (e.g., Megachilidae, Apidae) and wasps (e.g., Sphecidae, Pompilidae; Krombein 1967). Twig-nesting species commonly inhabit burrows created by Cerambycid beetles such as the VELB. Thus the presence of elderberry and VELB is likely to encourage establishment and maintenance of important insect pollinators and predators. Pollinators, in turn, may affect both the successful establishment of riparian plants and the successful fruiting of surrounding agricultural crops (Richards 1993).

Study Design/Field Methods. We will survey insect communities at all core sites during years one and two using three methods: (1) pitfall traps placed at the base of elderberry trees (conducted for 1 week at quarterly intervals); (2) sticky traps (1 week quarterly); and (3) trap-nest sampling blocks attached to trees (monthly, February to September). We will identify all specimens to genus or species, as appropriate. The natural history and life-history of each taxon will then be used to determine major functional or feeding groups (parasitoids, pollinators, predators, herbivores, detritivores). Twig-nesting bees and wasps will be monitored using trap-nests. Our trap-nests are wood blocks containing holes of three standard diameters in which bees and wasps can nests (Barthell et al. 1998). Blocks containing nests will be collected and incubated at ambient temperature. Insects that emerge from each block will be collected (Frankie et al. 1998) and identified to species. Nest activity and offspring production of each species will be compared among sites.

Subtask 3: Spread of the Argentine Ant and its Effect on Native Insects

This subtask will identify the ecosystem factors that affect the spread of the predatory and invasive Argentine ant (*Linepithema humile*), and its effect on the native insect community. Consideration of non-indigenous invertebrates has been absent from riparian mitigation plans and needs to be addressed. The Argentine ant is rapidly spreading through the riparian corridors of California (Ward 1987); its success depends upon proximity to water. Therefore, the role of landscape-scale variables (e.g., distance from creek, hydrologic regime) may be as important as among-site (e.g., distance from source population) and within-site (e.g., irrigation, plant cover) variables in the success of this species. The ant displaces native insect assemblages including the VELB (Huma & Gordon 1997, Huxel 2000). The mechanism by which Argentine ants displace VELB is unknown but could be due to the ants preying upon VELB eggs and larvae or interfering with adult feeding and oviposition. These ants have been observed nesting in VELB burrows and may additionally interfere with the colonization of these burrows by native species such as arboreal ants and twig-nesting pollinators.

Study Design/Field Methods. We will investigate the occurrence of Argentine ants within all core sites and quantify its effects on VELB and other elderberry-associated insects. During years one and two insects (including ants) will be caught in pitfall and sticky traps, and baited petri dishes (Ward 1987). In sites where VELB and Argentine ants co-occur, we will study habitat use to determine the likely long-term impact of the ant on VELB populations, and whether it is possible to manage or select sites to favor the VELB but not Argentine ants.

Required Equipment. Drying oven: $1000; top-loading balance: $1000.

Integration. Analyses will draw on data collected as part of Task 1. Insect data will be used as biological habitat variables in analyses of the effects of environmental variables on birds and fish. Data on elderberry, VELB and Argentine ant distribution will be used to validate landscape models.

TASK 3: BIRDS

Introduction. Loss and degradation of riparian habitats may be the most important cause of population decline of land bird species in Western North America and California (DeSante & George 1994, RHJV 2000). In the Central Valley, large-scale destruction of riparian breeding habitat combined with agricultural land conversion and an altered flood regime has resulted in the disappearance or critical decline of many bird species (Gaines 1977, CDFG & PRBO 2001). Such physical alterations have not only directly eliminated breeding habitat, but have also brought about the invasion of nest predators and exotic plants. Horticultural and process-based restoration activities may present the most effective management alternatives for restoring viable populations of songbirds to the Sacramento River; however, research is needed to better understand how these activities are mechanistically linked to bird demographic patterns. Studies of the avian community can also provide meaningful characterizations of riparian habitat quality and overall ecosystem health because birds occupy diverse and overlapping niches (Martin 1995). The proposed research builds on an extensive research and monitoring data set collected by PRBO over a ten year period.

Subtask 1: Response of Birds to Restoration Efforts

We will identify microhabitat and landscape variables (**Table 1**) that influence songbird occurrence, colonization, population trends and components of biological fitness on restoration and reference sites. Bird metrics will be related to dynamic characteristics of the sites including plant composition, predator populations, insect community composition, and hydrologic characteristics.

Study Design/Field Methods. Biological response of songbirds to restoration and management practices will be tested at both the community and population levels, using multiple response variables that offer different degrees of resolution (Thompson et al. 2000). At the community level, the response variables will be species richness and abundance (Nur et al. 1999). At the population level, we will measure a suite of biological fitness parameters that fall along a gradient of sensitivity to the environment. In ascending order of predicted sensitivity these are adult survival, nest survivorship, annual fecundity, and nestling condition. Nestling condition (measured as nestling weight near the time of fledging) and growth rate vary with ecological conditions and may influence juvenile survival (Hochaka & Smith 1991).

In addition to testing for restoration effects and estimating restoration trajectory over time, we will analyze songbird population response in relation to microhabitat and landscape variables (most variables listed in **Table 1**). Microhabitat variables of primary interest will be vegetation structure and microclimate. Landscape variables of primary interest will be surrounding land use, amount of surrounding riparian forest, and flood regime. We will use path analysis (Sokal & Rohlf 1995) to identify the causal linkages between songbird responses and both site and landscape-scale variables.

Riparian bird communities will be surveyed during all years of the grant at all core sites plus additional locations by conducting point counts and weekly spot map censuses (Ralph et al. 1993). These data will be used to calculate species richness and determine species-habitat associations. To track fecundity and survival of adults, individuals will be marked with unique combinations of colored leg bands following capture in mist nets. Nest monitoring will take place at all core sites for all years of the grant. We will record nest locations with a GPS unit, and monitor nests according to widely accepted protocols (Martin & Geupel 1993). Adult survival will be calculated with program MARK using mark-recapture data obtained from mist-netting and re-sighting of color-banded individuals (Nur et al. 1999).

Subtask 2: Nest Predation as a Factor Limiting Recovery

Nest predation accounts for the majority of nest failure for passerines on the Sacramento River (Small et al. 1999), yet little information on the identity of predators exists. Understanding the relationships among nest predator densities and activities and songbird reproductive success as they relate to habitat structure, landscape context, and natural processes (e.g., flooding) is key to developing conservation management strategies. The primary objective of this subtask is to identify native and non-native nest predators (including mammals, reptiles, birds, and ants) that impact riparian songbird nest success and quantify how predation varies by microhabitat and surrounding landscape features. Through statistical demographic modeling we will assess the impact that predation has on the population dynamics of a subset of riparian songbird species.

Study Design/Field Methods. We will identify nest predators at core sites during all three years of the project with unobtrusive miniature infrared video cameras and 24-hour time-lapse VCRs (McQuillen & Brewer 2000). A pilot investigation conducted in the 2001 breeding season demonstrated this to be a feasible means to observe predation events. During years two and three we will survey predator populations directly. Field methods will vary depending upon the taxonomic group targeted. Small mammal abundance may be assessed through live trapping techniques and with smoked aluminum track stations. Reptilian predator abundance may be assessed by using plywood coverboards and by conducting systematic searches of woody debris. Relative abundance of avian predators will be determined through point count surveys (Subtask 1). We will coordinate with Task 1 in the collection of physical and biological data to describe site-specific characteristics of all nest site locations.

Required Equipment. Nest cameras $12,600; videotape $300; banding equipment $700.

Integration. As illustrated by **Figure 3**, analysis of factors influencing bird community composition, population dynamics, and predator distribution, will draw on data collected by Task 1 (abiotic variables and vegetation structure), Task 2 (insect community composition), and Task

5 (GIS landscape analyses). In turn, data collected under this task will feed into modeling efforts conducted by Task 5 (synthesis). Aside from integrating with other studies under this grant, we will integrate with PRBO studies conducted elsewhere in the CALFED focus area (Cosumnes and San Joaquin Rivers, Clear Creek and San Francisco Bay, **Table 5**).

TASK 4: FISH

Introduction. Current research suggests that floodplain habitats are important for juvenile native fishes of many species, including salmonids (Sommer et al. 2001b). Furthermore, recent work conducted in the Central Valley has demonstrated that floodplain areas have the potential to be managed in ways that provide measurable benefits to native fishes (Sommer et al. 2001a). Nonetheless, much remains to be learned about the relative benefits of different floodplain habitat types. This task seeks to identify important site and landscape characteristics that influence the distribution and abundance of a suite of native fishes on the Sacramento River. The work we propose focuses primarily on identifying factors that affect chinook salmon early rearing and growth, although our studies are also directed at describing the habitat characteristics that are important for other fish species, including salmonid predators (many of which are NIS). We will study fishes occupying a variety of habitat types including main channel areas, backwaters, agricultural areas, restoration sites and reference areas.

Subtask 1: Growth and Rearing

We propose to investigate the ecological processes responsible for successful growth and rearing of chinook salmon in the middle Sacramento River. Previous work in the Yolo Bypass (Sommer et al. 2001a) suggests that juvenile chinook salmon occupying slow-water floodplain habitats have improved growth rates and survival compared with chinook salmon rearing in in-channel habitats. We will compare growth and survival of chinook salmon inhabiting a variety of floodplain habitats including the main channel, seasonally inundated restoration sites of varying ages, reference sites (both open and closed canopy), and agricultural sites. We hypothesize that relatively open areas imbedded in a remnant riparian habitat matrix will harbor fishes that have the highest growth rates of all habitat types. These areas are likely to have high levels of food availability due to significant terrestrial inputs and increased levels of primary productivity.

Study Design/Field Methods. Where possible sampling for the fish studies will take place at the core sites; however, additional locations will be sampled as necessary. We will determine daily growth rates of juvenile fall run chinook salmon using otolith microstructure daily incremental growth rate analysis (Campana & Thorrold 2001). Field work will be conducted during the first two years of the grant. Fish will be collected from multiple locations (habitat types described above) at the core sites. To identify mechanisms responsible for differences in growth and to assess trophic selectivity (Sommer et al. 2001a), we will determine the taxonomic composition of all identifiable stomach contents in the juvenile fishes collected for growth analyses. We will classify all food items as endogenous (aquatic) or exogenous (terrestrial) to assess the relative importance of these food sources. To assess prey availability we will measure aquatic invertebrate abundance with plankton drift nets. An index of terrestrial insect abundance will be provided by studies conducted in Task 2. To examine movement patterns and determine the amount of time juvenile salmon spend in shallow backwater habitats we will bulk tag fish and use passive weirs (Gowan & Fausch 1996).

Subtask 2: Fish Habitat Associations.

This subtask will examine the multi-scale habitat characteristics that influence the distribution and abundance of fish species in backwater and floodplain habitats (including agricultural, restoration and reference sites). Data collected in this subtask will be used to parameterize spatially explicit habitat models designed to predict species occurrences (Task 5, synthesis).

Study Design/Field Methods. Species occurrences will be documented in field studies described under Subtasks 1 and 3. This subtask will be responsible for measuring the aquatic variables listed in **Table 1**, which will be used in conjunction with many of the site and landscape variables collected by Task 1 (e.g., canopy cover, distance to tributary confluence).

Subtask 3: Predation as a Factor Limiting Recovery

Juvenile salmon share the river with a suite of other fish species, including the predatory Largemouth bass (*Micropterus salmoides*), a NIS, and the native Sacramento pikeminnow (*Ptychochelius grandis*). We hypothesize that although some backwater habitats may provide more food resources for juvenile salmon, they also harbor more predators. This subtask seeks to identify the major predators of chinook salmon in backwater habitats and examine how predation rates vary both spatially and temporally. We will determine which site-specific characteristics and landscape factors (including many of the aquatic and terrestrial parameters listed **Table 1**) influence predator distribution and abundance. Particular attention will be paid to backwater habitats of varying hydraulic and geomorphic configurations as well as to the dominant management regime of the site (restored, agricultural and reference).

Study Design/Field Methods. Field work will be conducted during the first two years of the grant. To identify salmon predators and quantify the proportion of their diets that juvenile salmon compose, we will collect fishes in a variety of habitats (listed above) and examine their stomach contents. All otoliths (including those of juvenile chinook salmon) and other diagnostic prey items will be recorded. Utilizing passive weirs and bulk tagging, we will assess the diurnal and seasonal movement of identified fish predators in and out of the shallow water habitats. This will allow us to generate estimates of the spatial and temporal distribution of predators in the varying habitat types.

Required Equipment. Electro-shocking boat (to permit access to shallow habitats for fish and invertebrate sampling): $47,000.

Integration. Information collected on the ecology of juvenile salmonids and their predators will be combined with environmental data, vegetation coverage (Task 1), insect abundance (Task 2), and other site- and landscape- scale data to parameterize spatially explicit models predicting the extent of high quality habitat along the Sacramento River for the rearing of juvenile salmonids.

Statistical Analyses (TASKS 1-4). Similar statistical approaches will be used for Tasks 1-4, as all tasks will be collecting both community composition and population demographic data and analyzing these data as a function of site- and landscape-variables. Not all response variables listed below will be appropriate to all tasks. We will use ANOVA to compare univariate continuous variables (e.g., species diversity, abundance, biomass, ratio of native species to NIS, abundance of focal species) in intensively sampled restoration and references sites. Where these variables are collected at additional sites, response variables will be regressed (logistic regression or log-linear modeling for categorical data, Agresti 1990) on a suite of preselected site and landscape variables (**Table 1**) suitable for specific taxa. Community composition of each target group (vegetation, insects, birds, fish, predators) will be assessed using multivariate statistics to compare restoration and reference sites. Multivariate statistical ordination (CANOCO, DECORANA) will be utilized to relate abundance of specific taxa to environmental data (Marchetti & Moyle 2001) and to assess environmental conditions associated with successful growth and survival. For fish, growth data and data from otolith microstructure will be analyzed using standard linear regression and ANCOVA approaches. Diet selectivity and invertebrate abundance will be examined using non-parametric rank abundance tests.

TASK 5: SYNTHESIS

Introduction. Information from each component of the monitoring program (vegetation, birds, insects and fish) will be integrated using a combination of spatial and demographic empirically-based models. Spatial and demographic models each have advantages and disadvantages (Nur & Sydeman 1999). Demographic models assume that populations are dynamic, and not necessarily at equilibrium with current habitat availability, which is probably the case with most populations of conservation concern. However, most demographic models used in population viability analysis ignore or make arbitrary assumptions about movement and spatial variation, and are not able to incorporate effects of further habitat alteration, such as habitat restoration. Spatial models are explicitly designed to predict the effects of habitat alteration. However, they often ignore demographic rates, and assume ideal free matching of species distribution to habitat quality and subsequent carrying capacity (Boyce & MacDonald 1999); in fact, habitat preferences in many bird and fish species have evolved such that preferred habitats are at present sink habitats. Together, spatial and demographic models will be used to: (1) assess the success of restoration efforts; (2) make specific predictions about where to restore riparian forest to achieve viable populations of native plant species, songbirds, VELB, and salmon; (3) assess the extent to which optimal restoration strategies for each taxa overlap; and (4) quantify our uncertainty about the consequences of habitat restoration.

Spatial models will employ GIS-based statistical models to extrapolate predictions of species occurrences and measures of restoration success. The general methodology is to identify the environmental variables that are correlated with species occurrences by stacking environmental predictor layers in a GIS to create an "environmental envelope" (Guisan & Zimmermann 2000, Lindenmeyer et al. 1991). At least four models of this kind are currently under development or in use by investigators in this and related projects, but they have not been parameterized consistently and compared to test their accuracy and applicability for different species and habitat types. To inform restoration efforts, this methodology will then be used to identify potential locations for restoration where a species could occur and to estimate (extrapolate) regional likelihood of restoration success from plot-based measures.

Demographic models will incorporate measures of age- and stage- specific growth and survivorship, measured in the monitoring studies described above. These will be used to predict current rates of population growth, stability, or decline for target taxa. In addition, building on methods E. Crone has developed to incorporate environmental heterogeneity (Crone et al. 2001, Crone & Gehring 1998) and habitat selection (Crone & Schultz, in press) into demographic models, we will develop empirical models that use both habitat features and demography to assess implications of restoration strategies for population viability.

We will quantitatively assess the utility for predicting restoration success of both spatial models (which are more commonly used in restoration ecology) and demographic models (which have more commonly been used in wildlife and fisheries management). Within each modeling approach, we will assess the relative importance of different environmental features using information criterion statistics (AIC and related statistics; Burnham & Anderson 1998), and models with various levels of environmental information. Finally, we will qualitatively compare the suite of site- and landscape- features identified as important for each taxa by the spatial and demographic models, and the suite of site- and landscape-features identified for each taxa, across plants, insects, birds and fish.

Methods. This task will be responsible for calculating most landscape-scale parameters (**Table 1**) from existing GIS layers and newly inputted data. The parameters will be used for modeling efforts, as well as analyses for all other subtasks. Statistical modeling through GIS will be used to extrapolate results gained from our studies of riparian system function. Such maps will facilitate restoration by suggesting suitable areas for starting restoration projects as well as indicating the types of management activities to be performed at restoration sites. The methodology will be to: (1) identify key plot-based measures of riparian function and restoration success from our monitoring projects; (2) overlay the plot localities on regional-scale GIS layers to determine the patterns of association between the plot variables and the regional environmental variables; and (3) map out these patterns of association in a GIS. The regional-scale GIS datasets will include layers such as the Chico/Dept. of Water Resources riparian mapping of the Sacramento River, UC Davis models of stream meanders and vegetation habitat models (Task 1, Subtask 3), high-resolution DEMs from the Army Corps of Engineers, soils data from USDA NRCS, and the PRISM climate data, as well as other datasets contingent on availability. Comparable data exist for the Cosumnes River (**Table 6**), and results from the two can be cross-validated. There are many possibilities for statistical models including logistic regression, genetic algorithms, and classification and regression trees.

Field data collected in the monitoring programs for planted and naturally-colonizing vegetation, VELB, songbirds, and salmon include size- and/or age-specific estimates of individual growth, survivorship, and fecundity. We will test for density feedback and incorporate vital rates into habitat-specific models of population dynamics (e.g., Caswell 1989, Crone & Gehring 1998, Nur & Sydeman 1999). In addition, each monitoring program includes site-specific estimates of recruitment (understory plant, native bee and VELB colonization, tree seedling recruitment, avian nest success and recruitment) and/or mortality (fish and songbird predation), and/or habitat preference (use vs. availability for animal taxa) that will be used to assess the influence of site- and landscape- factors on demographic rates. In brief, we will conduct GIS analyses with spatially-explicit data on vital rates substituted for key plot-based measures of riparian function to select appropriate habitat features, and quantify relationships between landscape features and vital rates (recruitment, survivorship, preference). We will then substitute functional relationships between landscape features and vital rates into spatial models of population dynamics at sets of connected sites to develop empirically-parameterized source-sink models (Holt 1985).

Required Equipment. None.
Integration. This task incorporates data from Tasks 1-4, to make long-range predictions thus helping to fulfill CALFED mandates of comparing modeling approaches and quantifying uncertainty. Our approach integrates data from individual taxa and sites to inform restoration efforts throughout the study area. The iterative process of testing models and making modifications based on results is a cornerstone of science-based adaptive management planning.

A4. Feasibility

The assembled team has extensive experience working on multi-disciplinary collaborative research projects. The principal investigators are experts in their fields. Most have conducted important research in this study system, and have past experience applying the described methodologies. The work we propose can be completed in the time allotted, as many analyses will draw on existing data and most proposed methodologies have been tested in this system. Although much of the work would be enhanced if flood events occur during the duration of the grant, the project has been designed not to depend on them. As in the past, we will apply to the USFWS and CDFG for special-use permits before conducting research on agency lands.

A5. Performance Measures

A central focus of this project is to develop performance measures, referred to in this proposal as “restoration success indices”. In addition to simply developing these indices, however, our project is designed to test what factors the various indices are most influenced by, thereby prioritizing areas for future data collection. The information gained in this project will permit a more thorough evaluation of the cumulative effects of restoration actions on ecosystem structure, processes and associated stressors, thereby enabling managers to more accurately assess progress and refine actions to advance restoration goals.

A6. Data Handling and Storage

Data management and dissemination will be handled by the Information Center for the Environment (ICE) and the Landscape and Systems Research (LASR) Laboratory. The ICE and LASR Lab are housed within the College of Agriculture and Environmental Sciences at UCD. James Quinn is the co-director of the ICE and Steven Greco is the director of the LASR Lab. The ICE plays a key role in developing and applying natural resource science to environmental issues of local, regional, and national significance, and coordinates data management for other CALFED related projects, especially in the Cosumnes basin. As central data repositories and dissemination mechanisms for this project, ICE and the LASR Lab will provide GIS, database, and modeling development and support, and develop mechanisms to allow the public to easily access a wide variety of environmental information through the ICE Web server. The ICE Web server (http://ice.ucdavis.edu/) hosts data, maps, models, reports, and other related products.

A7. Expected Products/Outcomes See **Table 3.**

A8. Work Schedule

See **Table 4.** Due to the synthetic nature of the proposed work, none of the proposed tasks can be separated out without compromising the overall project outcome. If it is not possible to fully fund this project, it would be our preference to trim the budgets of all tasks as opposed to cutting one or more individual tasks. That said, the project could go forth and generate meaningful results if one of Tasks 2,3, or 4 were not funded.

B. Applicability to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities

B1. ERP and Science Program and CVPIA Priorities

A primary focus of The Nature Conservancy's Sacramento River Project is to "develop and implement management and restoration actions in collaboration with local groups such as the Sacramento River Conservation Area Non-Profit Organization." (SR-1). The five coordinated proposals submitted by the Sacramento River Project in this PSP complement each other and are all directed at protecting and restoring the Sacramento River meander corridor between Red Bluff and Colusa (see section B5 for a description of the Sacramento River Projects programmatic structure). These proposals are designed to stand alone, however, the fullest appreciation of how our project seeks to advance CALFED and CVPIA goals comes when they are viewed collectively. Specific CALFED's Implementation Plan goals and CVPIA priorities that our project addresses include PSP Sacramento Region Priorities 1, 3, 4, 7, ERP Goals 1, 2, 4, 6, plus the Key CALFED Science Program Goals and CVPIA Goals.

This proposal addresses a subset of the above-mentioned goals and priorities. By developing and implementing an ecosystem monitoring and assessment program to evaluate the performance of ongoing riparian habitat restoration projects between Red Bluff to Colusa we will gather information that can be used by resource managers to reduce the impacts of NIS (MR-1) and ensure the recovery of at-risk species by developing a conceptual understanding and models of processes that cross multiple regions (SR-7). Individual tasks address the following: **Task 1** focuses on determining both the physical and biological factors important in the recovery of native vegetation communities in restored and natural sites. (MR-1, SR-4, ERP Goal 4). **Task 2** examines the local and regional factors affecting the restoration on the Federally threatened VELB. This information will help to achieve recovery of a critical at-risk species (ERP Goal 1) by fulfilling the study needs for this species as specified in the 2001 CALFED Implementation Plan (pg. 144) by determining the maximum distance VELB can disperse from occupied (natural remnant) to unoccupied (restoration site) habitat. **Task 3** continues and expands upon work that has been conducted on TNC's restoration sites since 1993. Data collected in these efforts will improve our understanding of how species and habitats respond to restoration efforts (ERP Goals 1 and 4). **Task 4** asks what ecological and physical parameters affect salmon early rearing and growth in the northern Sacramento River, and how this varies across habitats. Data collected in this task will help us better manage floodplain and instream habitats to benefit this species (and other native fishes) thereby addressing ERP Goals 1,3, and 4, PSP MR-1, SR-7, CVPIA Goal (a), and AFRP Objective 4. **Task 5** directly addresses restoration priority SR-7 by analyzing historic data and developing and evaluating conceptual models and restoration performance measures.

B2. Relationship to Other Ecosystem Restoration Projects

TNC's Sacramento River Project is part of a public-private partnership whose goal is to re-establish an approximately 30,000-acre riparian corridor with limited meander within the Sacramento River Conservation Area (SRCA). This partnership is formalized under a Memorandum of Agreement with project activities coordinated through the SRCA non-profit organization. Public and private partners include the local governments, stakeholders, U. S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Parks and Recreation, California Department of Water Resources, U.S. Army Corps of Engineers, Riparian Habitat Joint Venture, Sacramento River Preservation Trust, Sacramento River Partners, Northern California Water Association, and the Farm Bureau, among others.

Our proposed project complements a suite of proposed and ongoing research and monitoring projects in the CALFED area. **Table 5** details a subset of those projects in which participants in this proposal are PIs. An overview of how science is being used to evaluate restoration efforts and ecosystem health on the Sacramento River Project is provided in Golet et al. (*in review*).

B3. Requests for Next-Phase Funding

This is not a phased project.

B4. Previous Recipients of CALFED Program or CVPIA funding

To date TNC's Sacramento River Project has been awarded 5 CALFED and 3 CVPIA grants to further the goals of protection and restoration within the Sacramento River Conservation Area. Two grants focused on restoration planning, and the remaining 6 grants have been used to plan and implement protection and restoration actions on approximately 2,985 acres. Project titles and numbers, specific accomplishments, and progress to date are summarized in **Table 6.**

B5. System-Wide Ecosystem Benefits

TNC's Sacramento River Project is working with public and private organizations to restore a riparian corridor with limited meander within the Sacramento River Conservation Area. Our project has four programmatic phases that form a synergistic approach to implementing conservation in an adaptive management framework (**Fig. 4**): (1) cooperative integrative floodplain management planning; (2) habitat acquisition and baseline assessment; (3) horticultural and process restoration; and (4) ecosystem response monitoring. TNC proposals submitted in response to the ERP represent efforts to expand our project in each of these four programmatic directions. In addition to coordinating our efforts internally we have worked to ensure that all proposed work complements the extensive restoration activities already underway on the Sacramento River (see **Table 5** for a list of research and monitoring projects that this particular proposal complements).

Collectively the four programs of our project offer substantial system-wide benefits to the Sacramento River ecosystem. These benefits include increased aquatic and terrestrial habitats and improved ecological function. By employing both horticultural and natural-process restoration in an adaptive management framework we are successfully restoring the viability of native species and reducing the proliferation and adverse impacts of NIS.

C. Qualifications

Dr. Golet, will serve as overall coordinator of this project. He will be assisted by TNC staff (including Wendie Duron, Grants Specialist and Carol Wong, Attorney).Dr. Golet will serve as overall coordinator of this project. Project management activities are described in **Table 4.** Principal Investigators will be responsible for the tasks listed in **Table 2.**

Biographical Sketches

Elizabeth E. Crone is an Assistant Professor of Wildlife Biology at the University of Montana. Initially trained in botany (B.S., 1991, The College of William and Mary) and theoretical population biology (Ph.D., 1995, Duke University), Dr. Crone received an NSF postdoctoral fellowship to develop statistical methods to link theoretical population models with kinds of data that are typically available for species of conservation concern. Her 15 peer-reviewed publications span theoretical ecology, experimental plant and insect ecology, and empirically-based population models of riparian wildflowers, prairie butterflies, and field voles. Ongoing research projects include an NSF Biocomplexity incubation grant to begin modeling linkages between hydrological and biological processes in Sacramento River riparian forests, an NSERC-funded study of population dynamics of sage-steppe wildflowers, and a WWF-funded analysis of spatial variation in sage grouse population regulation and population viability.

Geoffrey R. Geupel has a degree from Lewis and Clark College (BS Biology 1978) and has been employed as a biologist at PRBO for 21 years. He is currently Director of the PRBO's Terrestrial Program and has over 20 years experience in ornithological monitoring and research. He has authored over 30 refereed publications, and has helped define bird-monitoring protocols now used throughout North America. Current areas of interest include breeding and population biology, bird response to habitat restoration, and conservation planning. He is currently: Co-Chair of California Partners in Flight, Chair of the Riparian Habitat Joint Venture's Science Committee, Board member of the Central Valley Joint Venture, and member of both the National Cowbird Advisory Council and Important Bird Area (IBA) National Technical Committee.

Gregory H. Golet has degrees from Bates College (B.S. Biology 1987), and the University of California, Santa Cruz (M.S. Marine Sciences 1994, Ph.D. Biology 1999). His doctoral research focused on the behavioral and physiological adjustments that long-lived birds make during breeding, and the effects these adjustments have on subsequent survival and future fecundity. Dr. Golet was a wildlife biologist for the U.S. Fish and Wildlife Service before joining TNC's Sacramento River Project as senior ecologist. His current research efforts focus on defining ecosystem responses to management actions. He has 11 refereed publications, and has extensive experience coordinating and conducting research in California and Alaska.

Steven E. Greco has degrees from the University of California, Davis (B.S. Landscape Architecture 1987, M.S. Ecology 1993, and Ph.D. Ecology 1999). Currently he is an assistant professor in the Landscape Architecture Program in the Department of Environmental Design at the University of California, Davis. His research interests include ecological restoration, patch dynamics, historical landscapes, and spatial modeling of terrestrial and hydrological processes using GIS computer technology. Dr. Greco has worked on a variety of projects that integrate landscape architecture, planning and design with ecological principles. He has extensive experience with the Sacramento River ecosystem and its landscape dynamics.

Karen D. Holl has degrees from Stanford (B.S. Biology 1989) and Virginia Polytechnic Institute and State University (Ph.D. 1994). She was a postdoctoral fellow at Stanford University and joined the faculty at the University of California, Santa Cruz in 1996 where she is now an associate professor. Her research interests are broadly based in restoration ecology with a specific interest in the spatial scale at which ecosystem recovery is regulated. Dr. Holl has done research on restoration and management of a range of ecosystems including eastern hardwood forest, tropical forest, and chaparral, grassland, and riparian ecosystems. She has 23 refereed publications and has managed a number of federal grants, including a recent NSF Biocomplexity Incubation Grant modeling linkages between hydrology, vegetation, and birds on the Sacramento River.

Marcel Holyoak has a B.Sc. in biology (1989) and a Ph.D. in ecology from the University of London (Imperial College, 1992). He was a postdoctoral fellow at the Centre for Population Biology (Silwood Park, U.K., 1992-1993), the University of Kentucky (1993-1994), and a research ecologist at the University of California, Davis (1994-2000). For the last year he has been an assistant professor in Environmental Science and Policy at the University of California at Davis. Holyoak's research addresses the influence of spatial habitat factors on population and community ecology. His NSF-funded research program uses statistical and empirical modeling, together with field experiments and long-term observational studies, to assess how habitat factors influence population dynamics and community structure. Major current projects address the insect population viability and the effects of habitat fragmentation on community structure.

Michael E. Loik has degrees from the University of Toronto (B.Sc. Zoology 1984, M.Sc. Botany 1986) and University of California, Los Angeles (Ph.D. Biology 1992). He was a postdoctoral fellow at University of California, Berkeley, and has been a Research Scientist and

Lecturer at the University of California, Santa Cruz since 1998. Dr. Loik's research interests focus on how plant and ecosystem functions are constrained by resources and conditions from molecular to regional scales. His research projects include investigations of plant responses to elevated carbon dioxide and altered climate due to human activities. This work has been conducted in the Chihuahuan, Great Basin, Mojave, and Sonoran Deserts, the subalpine ecosystems of the Rocky Mountains and Sierra Nevada, and the rainforest of Costa Rica.

Michael P. Marchetti has degrees from Bucknell University (B.A Biology/B.A. Chemistry 1990) and the University of California, Davis (M.S. Ecology 1994, Ph.D. Ecology 1999) and was a post-doctoral researcher at University of California, Davis (1999-2000). Currently he is an assistant professor at California State University, Chico. Dr. Marchetti has 12 years experience working on lotic ecosystems in California, primarily in the Central Valley. His research interests include native fish ecology, larval fish ecology, aquatic conservation biology, restoration biology, neurobiology of salmonids and multivariate statistical techniques applied to stream ecology. His research lab is currently working on a number of ecological projects in the upper Sacramento River Watershed. Dr. Marchetti has 12 refereed publications.

Nadav Nur has degrees from Duke University (Ph.D. in Zoology 1981) and an MS in Biostatistics from the University of Washington in 1991. He was Alexander von Humboldt Research Fellow, at the University of Tübingen from 1986-1987. From 1989 to the present Dr. Nur has served as the quantitative and population ecologist for the Point Reyes Bird Observatory. In January 2000 he became the Directory of Population Ecology at PRBO. He is also an adjunct professor at San Francisco State University since 1998. Dr. Nur's research interests focus on population modeling, quantitative ecology and statistical analysis of landbirds, seabirds, shorebirds and marine mammals. He has been a PI on over 20 grants from federal, state and private funding sources (including NSF, EPA, USGS NBS, USFWS, CDF&G, and CALFED). Dr. Nur is author or co-author of over 50 scientific publications, including *A Statistical Guide to Data Analysis of Avian Monitoring Programs*, published in 1999 by the USFWS. He has served on two working groups of the CMARP arm of CALFED.

James F. Quinn has degrees from Harvard (A.B. Biology, 1973) and the University of Washington (PhD, Zoology, 1979). He joined the faculty of the University of Pennsylvania in 1979, and moved to the UC at Davis in 1981, where he is now a full professor. He has worked on habitat fragmentation on species diversity and extinction risk, strategies for inventory and monitoring studies, the design of systems of nature reserves, and estimation of demographic rates for fisheries management, and is the author of more than 60 scholarly publications. Dr. Quinn also directs the Information Center for the Environment (ICE) at UC Davis. Under his direction, the ICE has developed an extensive internet accessible database and GIS data catalog of CA watershed information, and the principal biodiversity databases for U.S. National Parks, UNESCO Biosphere Reserves worldwide and a variety of public and private lands in California.

Stacy Small has a degree from Evergreen State College (BAS Ecology), where she specialized in riparian ecology, with emphasis in ornithology and restoration ecology. She is currently pursuing a Ph.D. in Avian Ecology at the University of Missouri-Columbia, focusing her research on demographic patterns of riparian landbirds utilizing Sacramento River restoration sites. She has been employed with PRBO since 1995 and has intensive field experience in landbird and reptile monitoring. She has trained over 200 interns, students, and professional biologists across many habitats in California and Latin America. In her fourth year as leader of PRBO's Sacramento River Project, she has authored several reports to TNC, USFWS and CALFED addressing the current status of breeding riparian bird populations on the river and providing restoration management recommendations.

Neal Williams is a David Smith Postdoctoral Fellow with The Nature Conservancy, working through the Department of Ecology and Evolutionary Biology at Princeton University. He is also a visiting researcher at University of California-Davis. Dr. Williams began his training in entomology and botany (BSc Zoology and Botany 1992, Univ. of Wisconsin). He received his doctorate in Ecology and Evolution (SUNY- Stony Brook 1999) during which he used empirical and modeling approaches to investigate foraging specialization in native bees. During 2000-2001, he held a Killam Postdoctoral Fellowship at the University of Calgary where he studied pollination and pollen movement by different insect species using a GMO crop species. His current interests are in combining pollinator biology and behavior with plant reproductive biology to understand the functional role of native pollinators in agro-natural systems. His current research program is centered in the Capay and Sacramento Valleys, CA.

David M. Wood has degrees from U.C. Davis (B.A. Zoology 1975), California State University Fresno (M.A. Biology 1982) and the University of Washington (Ph.D. Botany 1987). He was a postdoctoral research associate at the Institute of Ecosystem Studies in Millbrook, NY from 1987 to 1988. He then joined the faculty of Wheaton College in Norton, MA as an assistant professor in 1988. In 1990 he joined the faculty at California State University Chico where he is now a full professor. Dr. Wood's research interests are centered in community and ecosystem ecology, with special interests in ecological succession and ecosystem recovery from disturbance. Dr. Wood has conducted field research on Mount St. Helens, on eastern deciduous forest in New York, and on the Sacramento River. He has 14 refereed publications. Dr. Wood has received grants from several organizations including TNC and the NSF.

D. Cost

D1. Budget See submitted forms.

D2. Cost-Sharing

Much of the infrastructure cost for data management at ICE is covered by long-term grants from the USEPA, the USGS, and CalTrans, and recurring costs (e.g., licenses, data purchases) are shared by multiple projects. A portion of the time of the involved faculty is contributed by the various universities.

E. Local Involvement

We presented our proposal to the SRCA organization at meetings of both the Board of Directors and the Technical Advisory Committee. Our proposal has also been reviewed and is supported by the Sacramento River NWR (much of the proposed work will be conducted on refuge lands). We participate in numerous advisory committees and technical workgroups within the CALFED region.

F. Compliance with Standard Terms and Conditions See **Table 7**.

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Table 1. Partial list of physical and biotic parameters to be assessed (independent variables to be used in statistical analyses and modeling). Site-specific parameters will be compiled or collected by Task 1 group, except for aquatic parameters (Task 4). Landscape parameters will be calculated for study sites from GIS coverages, assembled under Tasks 1 and 5.

Site-Specific Parameters	Landscape Parameters
- soil stratigraphy - soil moisture - soil nutrients - water table depth - stage-discharge relationship - flood frequency - elevation - slope - age (time since planting, or time since deposition or scouring) - species present (including abundance measures) - canopy cover - aquatic parameters (temperature, conductivity, pH, DO, turbidity, substrate) - weather (including temperature and rainfall)	- distance to remnant riparian habitat - distance to source populations (for particular species of interest) - surrounding land use - previous land use - habitat area - habitat shape - index of habitat connectivity - distance to tributary confluence

Table 2. Tasks, Subtasks and associated Program Leads

Tasks and Subtasks	Program Leads
TASK 1: VEGETATION - growth and survival of planted woody species - colonization and succession of naturally recruiting species - vegetation transitions at large scales	Elizabeth Crone, Gregory Golet, Steven Greco, Karen Holl, Michael Loik and David Wood
TASK 2: ELDERBERRY-ASSOCIATED INSECTS - response of the VELB to restoration efforts - response of the elderberry-associated insect community to restoration efforts - spread of the Argentine Ant and its effect on native insects	Marcel Holyoak Neal Williams (post-doctoral researcher)
TASK 3: BIRDS - response of birds to restoration efforts - nest predation as factor limiting recovery	Stacy Small (Ph.D. student), Geoffrey Geupel and Nadav Nur
TASK 4: FISH - growth and rearing - fish habitat associations - predation as a factor limiting recovery	Michael Marchetti
TASK 5: SYNTHESIS	Elizabeth Crone, Gregory Golet, Nadav Nur and James Quinn
TASK 6: DATA MANAGEMENT AND DISSEMINATION	James Quinn and staff (ICE)
TASK 7: PROJECT MANAGEMENT	Gregory Golet and staff (TNC)

Table 3. Expected products/outcomes by Task assuming start date is September 2002. ***The majority of the listed products will be presented as articles in peer-reviewed scientific publications and at conferences.***

	Deliverable Date
TASK 1: VEGETATION	
- an updated vegetation map (20 m minimum mapping unit) for the entire study area classified by height class and series (dominant species);	Sept. 2005
- a set of refined empirical models describing the range of floodplain positions of each of the dominant woody species and associated flooding regimes;	Sept. 2005
- a report of factors affecting survival of five planted woody species;	Sept. 2005
- a report of factors affecting colonization of four non-woody perennial species;	Sept. 2005
- a report comparing and contrasting succession at restoration and reference sites;	Sept. 2005
- a state-and-transition model for riparian vegetation on the middle Sacramento River;	Sept. 2005
- a revised TNC planting manual.	Sept. 2005
TASK 2: ELDERBERRY-ASSOCIATED INSECTS	
- a report revising and improving the mitigation and restoration practices for the VELB;	Sept. 2005
- a report to the USFWS suggesting revisions to the VELB species recovery plan;	Sept. 2005
- a tested spatial model of population viability in the VELB that can be used to investigate how different habitat placement and management scenarios influence population persistence;	Sept. 2005
- a report describing the extent to which restoration site selection can improve management of the invasive predatory Argentine ant;	Sept. 2005
- a report comparing the influence of restoration practices on different taxonomic and functional groups of insects.	Sept. 2005
TASK 3: BIRDS	
- a report evaluating bird community response over time to restoration and management;	Sept. 2005
- a report addressing bird population (demographic) response to microhabitat and landscape features comparing restoration and forest sites;	Sept. 2005
- a report evaluating the impact of nest predation on riparian bird populations, identifying primary nest predators and describing predator distribution in relation to landscape factors.	Sept. 2005
TASK 4: FISH	
- a report contrasting chinook salmon growth and rearing in a variety of floodplain habitats with suggestions for restoration and management;	Sept. 2004
- a report addressing predatory effects of native and introduced fish species on juvenile chinook salmon in floodplain habitats with suggestions for restoration and management;	Sept. 2004
- a report relating site-specific and landscape-scale factors to fish species occurrences.	Sept. 2005
TASK 5: SYNTHESIS	
- empirically-based population viability models of four native understory plants, the VELB, chinook salmon, and two or more avian species;	Sept. 2005
- a report comparing site and landscape factors in relation to physical and biological correlates of population viability of different taxa;	Sept. 2005
- a report predicting areas of high abundance of particular species and contrasting predictions made from 3 or more spatial-statistics models;	Sept. 2004
- a report comparing data needs and results of static vs. dynamic models;	Sept. 2005
- management recommendations for simultaneously optimizing health of valued vegetation, fish, insect, and avian populations through restoration activities.	Sept. 2005
TASK 6: DATA MANAGEMENT AND DISSEMINATION	
- Conceptual design for data interoperability and preliminary webpages;	Nov. 2002
- Schema (Document Type Definitions) for interoperable elements;	Jan. 2003
- XML-based webpages and data interchange system;	May 2002
- Integration of project data into GIS, databases and webpage.	On-going

Table 4. Work schedule

Year	Schedule
TASK 1: VEGETATION	
1	Survey understory plant species locations, monitor demographic parameters, conduct physiological and water isotope measurements;
2	Begin understory manipulative experiments, monitor demographic parameters, finish physiological experiments, conduct GIS analyses of habitat distribution;
3	Revisit plots to assess woody seedling survival, finish understory manipulative experiments, work on synthetic modeling with faunal components, finish data analysis.
TASK 2: ELDERBERRY-ASSOCIATED INSECTS	
1	March-June: survey elderberry, VELB and Argentine ants within all restored and remnant sites, conduct plant chemical analyses; Feb.-Sept: put out trap nests for bees; Remainder of year: survey other natural areas with elderberry to determine which sites have the potential to be sources of VELB colonists;
2	As year 1, but also track changes in VELB abundance, habitat availability (elderberry characteristics), and colonization;
3	Conduct final surveys, calculate restoration success indices, perform statistical analyses of colonization timing, and population viability and spatial modeling of demography.
TASK 3: BIRDS	
1	Survey bird community, measure nest success, fecundity, and nestling weights, sample vegetation at nest and survey points, collect video data at nests, map nest locations and breeding territories, capture and band adults;
2	As year 1, but also initiate predator surveys based on year 1 nest video results, recapture and resight adult birds;
3	As year 2, but also perform statistical analyses of population viability and spatial modeling of demography.
TASK 4: FISH	
1	Winter and spring: collect juvenile fishes, sample salmonid predators, set up passive weirs, collect aquatic/terrestrial invertebrate and environmental data; Late spring and summer: begin laboratory work including daily incremental growth analysis of otolith microstructure, gut content analysis, invertebrate sorting and identification;
2	As year 1 schedule, but also begin statistical analyses;
3	Conduct final surveys, continue statistical analyses of data and parameterization of spatially-explicit habitat models, and integrate results.
TASK 5: SYNTHESIS	
1	Meet with Task 1-4 groups to discuss model structure and data collection, develop model framework, perform literature search and meta-analysis for salmon demographic parameters;
2	Use initial field data to parameterize models, begin GIS mapping and distribution analyses;
3	Incorporate complete field data into demographic models and prepare PVA reports, complete GIS analyses and compare dynamic models, prepare management recommendations based on analyses of all species.
TASK 6: DATA MANAGEMENT AND DISSEMINATION	
1	Develop GIS and XML framework;
1-2	Construct queriable website;
2	Develop web-based interactive mapping;
1-3	Provide GIS / GPS technical assistance.
TASK 7: PROJECT MANAGEMENT	
1	Organize and lead meetings with researchers to coordinate details of sampling efforts for different tasks and further define roles and responsibilities, work with Grants Specialist and Attorney to write task orders and subrecipient contract agreements, ensure that all scopes of services are reasonable, accurately stated, and can be performed within the times specified;
2-3	Hold annual meetings to share results and interpretations and set up timeline for additional sampling and data sharing for modeling and synthesis efforts (smaller groups of PIs will meet more often to integrate results);
1-3	Work with grants Specialist on agreement administration, ensure that only allowable costs are billed, prepare and submit reports, give presentations, ensure that deliverables are completed.

Table 5. Related research and monitoring projects that principal investigators of this proposal are involved with.

Project	PIs (those in bold are on this proposal)	Project description
Linking large-scale hydrological and biological processes in restoring riparian forest ecosystems	**Elizabeth Crone** **Karen Holl** Matt Kondolf **Nadav Nur**	National Science Foundation. Biocomplexity Incubation Grant. (Term: Jan. 1, 2001-Dec. 31, 2001) This grant is aimed at beginning development of models linking hydrology, vegetation, and bird communities along the Sacramento River, but provided no funding for data collection. The preliminary models developed as part of the Biocomplexity project will serve as starting point for the modeling efforts outlined in this proposal.
The influence of flood regimes, vegetative and geomorphic structures on the links between aquatic and terrestrial systems: Applications to CALFED restoration and watershed monitoring strategies	**James Quinn** Graham Fogg Mary Power Mark Schwartz Edwin Grosholz **Nadav Nur** Kyaw Tha Paw William Rainey	CALFED 01-A205. Approved but not yet funded project in the Cosumnes floodplain to link groundwater dynamics, growth and restoration of riparian vegetation, effects of flooding and terrestrial primary productivity on arthropod productivity, and populations of birds and bats as consumers and indicators of restoration success. The project also examines contributors to species invasions. This proposal will share data systems with comparable efforts in the Cosumnes.
Linking hydrogeomorphic-ecosystem models to support adaptive management: Cosumnes-Mokelumne Paired Basin Project	Jeffery Mount Peter Moyle **James Quinn** Levent Kavvas Graham Fogg Gregory Pasternak Geoffrey Schladow Theodore Grosholz Mark Schwartz Randy Dahlgren	CALFED 99–B190 and Packard-supported efforts to examine roles of flooding, sedimentation, and nutrient movement on geomorphology and aquatic populations in the Cosumnes Floodplain. Strong emphasis on hydrologic processes and role of sediment transport. This proposal will share data systems with comparable efforts in the Cosumnes.
Riparian Landscape Modeling and Impact Assessment on the Sacramento River	**Steven Greco**	California Department of Water Resources, Off-stream Storage Investigation (Term: 7/1/00-6/30/01, Contract No. 4600000736) The goal of the riparian landscape modeling on the Sacramento River is to develop a set of tools to quantify and assess potential ecologically significant changes to the riparian ecosystem resulting from changed flows caused by the operation of an off-stream storage facility.
Ecosystem and Natural Process Restoration on the Sacramento River: Floodplain Acquisition and Management	**TNC** Subcontracting Subtask 3 to: Karin Hoover **Michael Marchetti** **David Wood**	CALFED 97-NO2 (Term: 1/1/98-12/31/01) This subtask focuses on resolving key ecological uncertainties to aid in the development of short- and long-term management and monitoring plans. Objectives include developing field-tested protocols to 1) quantify salmonid use of floodplain habitats, 2) document successional dynamics of riparian vegetation, and 3) calibrate an ecological model describing riparian recruitment.
Ecosystem and Natural Process Restoration on the Sacramento River: Active Restoration of Riparian Forest	**TNC** Subcontracting Subtask 3 to: David Brown **David Wood** **PRBO**	CALFED 97-NO3 (Term: 12/1/98-6/30/02). This subtask focuses on assessing ecosystem response to horticultural restoration by investigating wildlife response (birds and terrestrial arthropods) groundwater quality, nutrient cycling and soil development. Comparisons are being drawn between restoration sites of varying ages and natural remnant habitats.
Genetic Identification of Watershed-Dependent Species of Special Concern in the Central Valley	Sonya Clegg **Geoffrey Geupel** **Nadav Nur** Brad Scahffer Tom Smith	CALFED funded project utilizing molecular genetic techniques to determine taxonomic relationships of populations of concern. Information will be used to identify and prioritize populations and watersheds for conservation and management actions.

Table 6. Specific accomplishments and progress made on previous CALFED grants to TNC's Sacramento River Project.

Project Title	CALFED Program/ CVPIA Project	Term	Progress and Accomplishments	Status
Ecosystem and Natural Process Restoration on the Sacramento River: Floodplain Acquisition and Management	CALFED 97-NO2 ERP	1/1/98-12/31/01	Four properties along the Sacramento River totaling approximately 1,628 acres have been purchased (Kaiser, Dead Man's Reach, Gunnhill, RX Ranch). Task orders are in progress to fund portions of the purchase of two additional properties: 238-acre Ward property purchased in April 2001, and 77-acre Clendenning property under option and anticipated to close in September. Start up stewardship activities are underway, including preliminary hydrologic and geomorphic modeling that will help identify short and long-term conservation and management actions for these properties.	The Clendenning property will complete the acquisition terms of this grant. Restoration of 3 of the purchased properties is the subject of a 2002 CALFED proposal. A request was recently approved by CALFED for an extension of the term date and the shifting of funds under the agreement from Task 1 (direct acquisition costs) to Task 3 (Startup Stewardship) in order to complete the management and monitoring plans called for under Task 3.
Ecosystem and Natural Process Restoration on the Sacramento River: Active Restoration of Riparian Forest	CALFED 97-NO3 ERP	12/1/98-6/30/02	Site preparation and planting of two sites (River Vista and Flynn) to riparian habitat totaling 264 acres is complete. Ecosystem response studies conducted for 2 field seasons, annual reports filed.	Restoration terms of this grant are completed; monitoring is currently in progress. Maintenance will be complete fall of 2001.
Ecosystem and Natural Process Restoration on the Sacramento River: A Meander Belt Implementation Project	CALFED 97-NO4 ERP	2/25/98-12/1/01	The 94+ acre Flynn property and adjacent levee were purchased in December 1998. The levee was subsequently removed; as a result this site now supports one of the largest bank swallow colonies recorded on the Sacramento River. Restoration was implemented under CALFED 97-NO3 and 97-NO4.	Acquisition and restoration terms of this grant are complete; monitoring is currently in progress. Maintenance will be complete in the fall of 2001.
Floodplain Acquisition, Management and Monitoring on the Sacramento River	CALFED 98-F18, FWS Agreement #11420-9-J074 ERP	7/20/99-6/30/02	Funding was awarded for the acquisition portion of this grant. The 104+ acre Jensen property located in Colusa County was purchased in July 2000. This property is located within the setback levees of the Sacramento River Flood Control Project. Two additional properties, totaling 183+ acres will be wholly or partially funded under this agreement upon official approval of the agency, including: the 129 acre Boeger property scheduled to close by December, and 54 acre Hays property purchased in May 2001.	The Boeger and Hays properties will complete this acquisition grant. Additional CVPIA funding has been obligated to complete the purchase of the Boeger property.

(continued next page)

Table 6. (continued)

Project Title	CALFED Program/ CVPIA Project	Term	Progress and Accomplishments	Status
Floodplain Acquisition and Sub-Reach/Site Specific Management Planning: Sacramento River (Red Bluff to Colusa)	CALFED 2000-F03, FWS Agreement #11420-1-J001 ERP	6/1/01-5/31/03	Funding was awarded to implement the Sub-reach/Site Specific Planning portion of this proposal. Four tasks are currently in progress to develop comprehensive conservation and management strategies for multiple benefits and uses of the river floodplain. Under Task 1 data collection is in progress, and the Beehive Bend Hydraulic analysis has been completed for RM 167-172. Under Task 2, a Socioeconomic Assessment for the riparian corridor of the SRCA between Red Bluff and Colusa is in progress with involvement from SRCA, stakeholders and local governments. Under Task 3 a newsletter went out to all stakeholders; stakeholder meetings have been conducted; updates are regularly provided to the SRCA.	During the first year of this 3-year grant, all tasks were initiated and are making good progress. A report to be developed under Task 4 will outline future conservation and management actions for the Beehive Bend sub-reach based on information developed within Tasks 1 – 3.
Acquisition of Southam Orchard Properties for Preservation of Riparian Habitat	CVPIA grant, BuRec Agreement #00FG200173 b(1)"other"	9/12/00-9/30/02	A portion of the grant was applied to the purchase of the 76+-acre Southam property, purchased in July 2000. The remainder of the funding was applied to the purchase of the 238-acre Ward property purchased in April 2001.	The grant is complete. Additional funding was used to purchase each of these properties. CVPIA (AFRP) and private funding was used to complete the purchase of the Southam property. CALFED 97-NO2 and private funding was used to complete the Ward purchase.
Hartley Island Acquisition	CVPIA grant, FWS Agreement #1448-11332-7-G017 AFRP	8/14/97-9/30/01	Funding was used toward the purchase of two parcels on Hartley Island, including the 321-acre Sandgren parcel. The remaining funds available were applied to the purchase of the 76+-acre Southam parcel.	The grant is complete.
Singh Walnut Orchard	CVPIA grant, FWS Agreement #11332-0-G014 AFRP	9/18/00-12/31/01	Completed tasks for this pre-acquisition and planning grant includes: pre-acquisition due diligence and signed option for Singh property, baseline assessment, and local stakeholder meeting conducted to discuss restoration plans.	A report will be submitted fall 2001 that outlines baseline and ecological considerations with restoration alternatives. This will complete the terms of this grant. Acquisition and restoration of this property is the subject of a 2002 CALFED proposal.

Table 7. Compliance with Standard Terms and Conditions

Attachment D, Section 4 *Expenditure of Funds*
TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC: "Contractor shall expend funds in the manner described in the approved Budget. As long as the total contract amount does not increase, the Contractor may adjust (1) the Budget between individual tasks by no more than 10% and (2) the Budget between individual line items within a task by no more than 10%. Any other variance in the budgeted amount among tasks, or between line items within a task, requires approval in writing by CALFED or NFWF. The total amount to be funded to Contractor under this Agreement may not be increased except by amendment of this Agreement. Any increase in the funding for any particular Budget item shall mean a decrease in the funding for one or more other Budget items unless there is a written amendment to this Agreement."
Attachment D, Section 5 *Subcontracts*
TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC: "Contractor is responsible for all subcontracted work. Subcontracts must include all applicable terms and conditions as presented herein. An approved sample subcontract is attached as [an exhibit]. Contractor must obtain NFWF's approval prior to entering into any subcontract that will be funded under this Agreement, which approval shall not be unreasonably withheld if (1) contracted work is consistent with the Scope of Services and the Budget; and (2) the subcontract is in writing and in the form attached to this Agreement as [an exhibit]. Contractor must subsequently provide NFWF with a copy of the signed subcontract. Contractor must (a) obtain at least 3 competitive bids for all subcontracted work, or (b) provide a written justification explaining how the services are being obtained at a competitive price and submit such justification to NFWF with copy of the signed subcontract. Notwithstanding the foregoing, the CALFED Program has acknowledged that the Contractor generally does not use a subcontract for routine land appraisals, surveys, and hazardous materials reports. For these one-time services, Contractor uses a group of vendors on a regular basis and pays no more than fair market value for such services by one-time invoice rather than written contract. Contractor will not be required to obtain competitive bidding for such services or to provide any further justification to NFWF."
Attachment D, Section 9 *Rights in Data*
TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC: "All data and information obtained and/or received under this Agreement shall be publicly disclosed only in accordance with California law. All appraisals, purchase and sale agreements and other information regarding pending transactions shall be treated as confidential and proprietary until the transaction is closed. Contractor shall not sell or grant rights to a third party who intends to sell such data or information as a profit-making venture. Contractor shall have the right to disclose, disseminate and use, in whole or in part, any final form of data and information received, collected, and/or developed under this Agreement, subject to inclusion of appropriate acknowledgment of credit to the State, NFWF, to the CALFED Program, and to all cost-sharing partners for their financial support. Contractor must obtain prior approval from CALFED to use draft data. Permission to use draft data will not be unreasonably withheld. CALFED will not disseminate draft data, but may make draft data available to the public upon request with an explanation that the data has not been finalized."
Attachment D, Section 13 *Termination Clause*
TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC: "Default and Remedies: 1) In the event of Contractor's breach of any of Contractor's obligations under this Agreement, NFWF shall deliver to Contractor written notice which shall describe the nature of such breach (the "Default Notice"). If Contractor has not cured the breach described in a Default Notice prior to the expiration of the twenty (20) day period immediately following Contractor's receipt of such Default Notice, or, in the event the breach is not curable within such twenty (20) day period, Contractor fails to commence and diligently proceed with such cure within such twenty (20) day period, then Contractor shall be deemed to be in default under this Agreement, and NFWF shall have the right, after receiving approval from CALFED, to terminate this Agreement by delivering to Contractor a written notice of termination, which shall be effective immediately upon receipt by Contractor (the "Termination Date"). Upon and following the Termination Date, NFWF shall be relieved of the obligation under this Agreement to make any payments to Contractor for any work that has been performed prior to the Termination Date; however, NFWF shall continue to be obligated to make any payments to Contractor for work properly performed and invoiced in accordance with the terms and conditions of this Agreement prior to the Termination Date. In no event shall Contractor be required to refund to NFWF, CALFED, the Agency or DWR any of the funds that have been forwarded to Contractor under this Agreement, except as provided in Section 10.I.2 below. 2) In the event of any termination of this Agreement by NFWF pursuant to Section 10.I.1 above prior to close of escrow of Contractor's acquisition of any real property interest funded by this Agreement, NFWF's sole remedy shall be to obtain the return of those funds that have been forwarded to Contractor under this Agreement to fund Contractor's acquisition of the Property. "

Figure 1. Map of study area showing horticultural restoration sites and years of planting

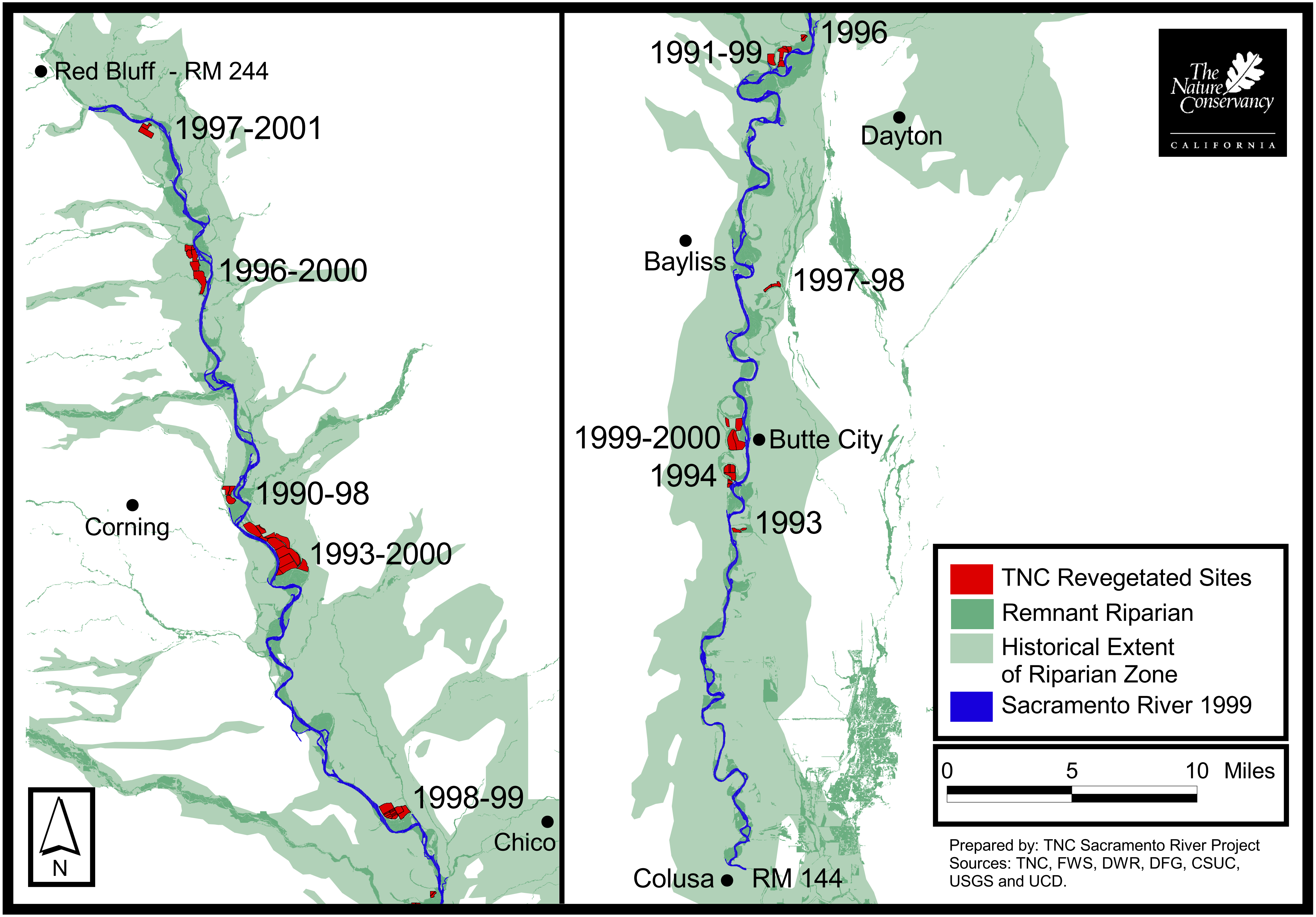
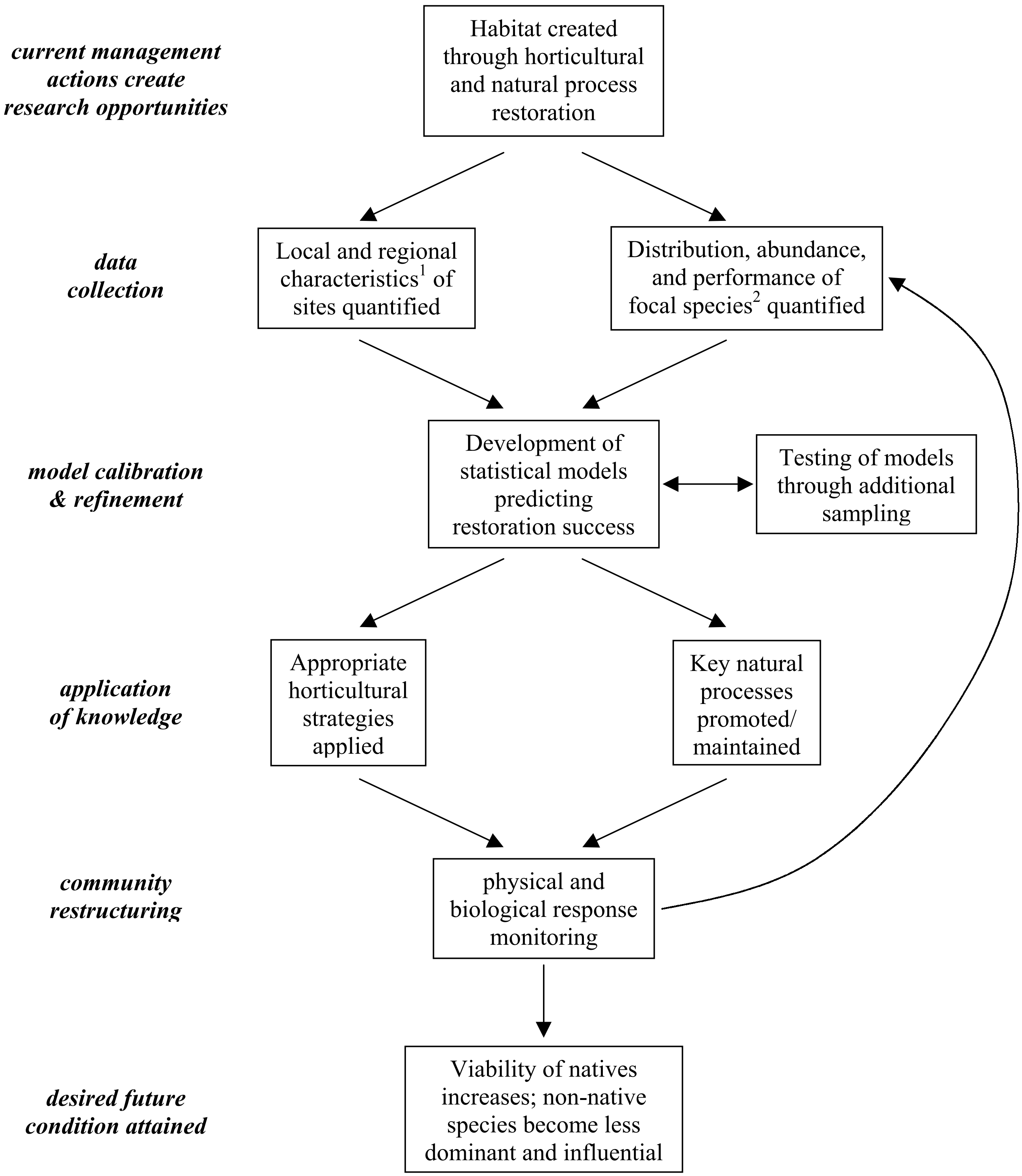


Figure 2. Conceptual model illustrating how integrated research and monitoring studies inform adaptive management of the Sacramento River



[1]independent variables to be used in modeling exercises, see Table 1.
[2]dependent variables to be used in modeling exercises.

Figure 3. Conceptual model of our study's approach which combines empirical monitoring of key ecological uncertainties with modeling.

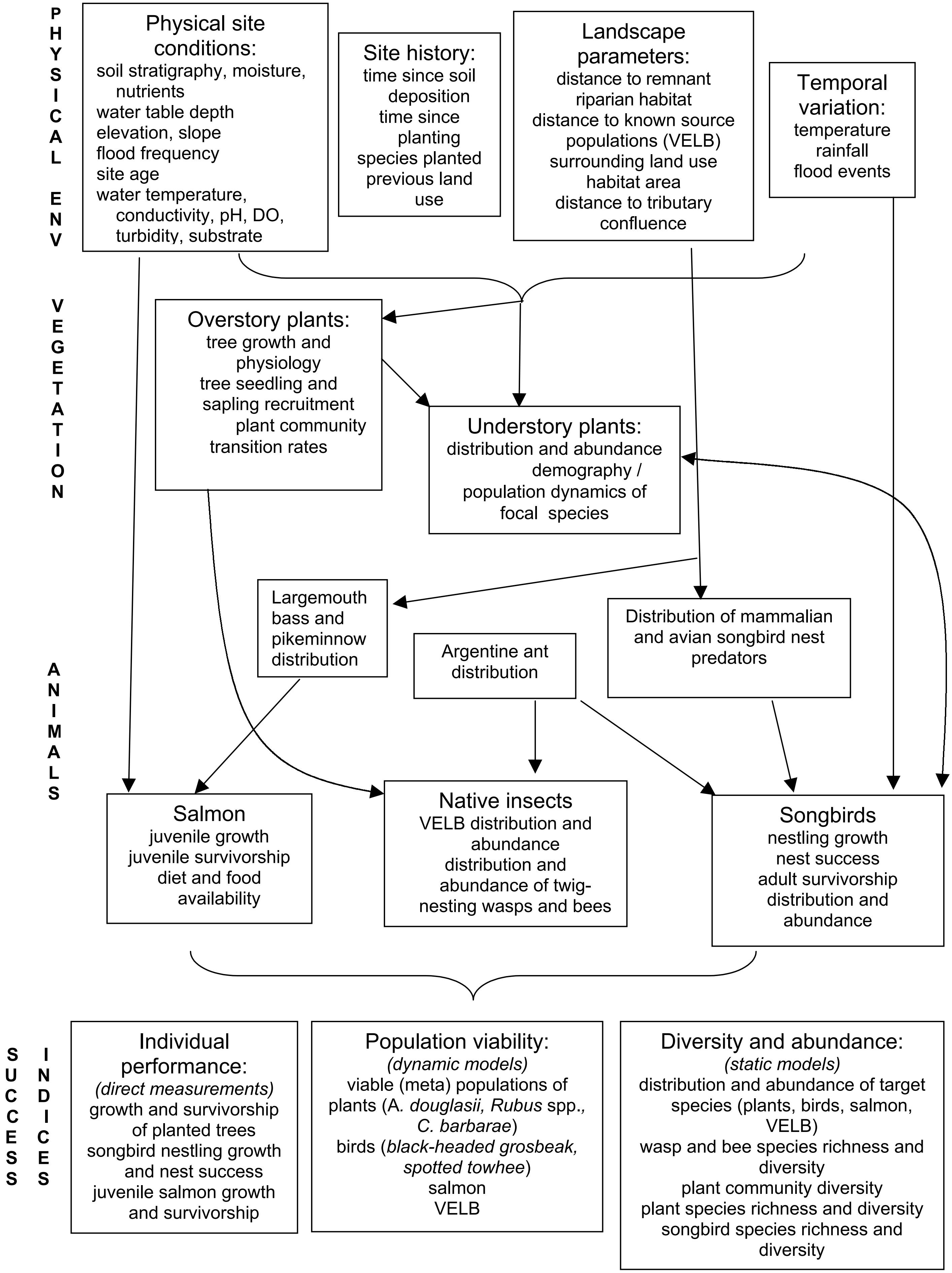


Figure 4. Conceptual Model of TNC Sacramento River Project's programmatic structure