RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

Project Information

1. **Proposal Title:**

   RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

2. **Proposal applicants:**

   NIALL McCARTEN, Environmental Science Associates
   G. MATHIAS KONDOLF, UNIVERSITY OF CALIFORNIA, BERKELEY
   JOHN KING, LONE PINE RESEARCH
   DAVE BROWN, CALIFORNIA STATE UNIVERSITY, CHICO

3. **Corresponding Contact Person:**

   NIALL McCARTEN
   ENVIRONMENTAL SCIENCE ASSOCIATES
   700 UNIVERSITY AVENUE, SUITE 130 SACRAMENTO, CA 95825
   916 564-4500
   nmccarten@esassoc.com

4. **Project Keywords:**

   Flow, Instream
   Fluvial Geomorphology
   Riparian 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:**

Private for profit

9. **Location - GIS coordinates:**

Latitude:	40.18624172
Longitude:	-122.229518
Datum:	

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

THE PROPOSED PROJECT WILL INCLUDE STUDY SITES ALONG THE SACRAMENTO RIVER FROM CHICO LANDING, NEAR THE CITY OF CHICO, NORTH TO REDDING. SPECIES SITE LOCATIONS HAVE NOT BEEN DETERMINED. ADDITIONAL STUDY SITES WILL OCCUR ON THE COSUMNES RIVER WITHIN 2 MILES OF INTERSTATE 5 IN SOUTHERN SACRAMENTO COUNTY.

10. **Location - Ecozone:**

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

11. **Location - County:**

 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:**

 3rd

15. **Location:**

 California State Senate District Number: 4

 California Assembly District Number: 2

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

3 years

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:	0%
Total Requested Funds:	$694,375

    b) Do you have cost share partners <u>already identified</u>?

    No

    c) Do you have <u>potential</u> 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.

F23	**SOUTH NAPA RIVER TIDAL SLOUGH RESTORATION**	**HABITAT RESTORATION**

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?

No

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)

CONSTANCE MILLAR	**U.S. FOREST SERVICE**	**510/559-6435**	**cmillar@fs.fed.us**
JEFF MOUNT	**UNIVERSITY OF CALIFORNIA, DAVIS**	**530/752-7092**	**mount@geology.ucdavis.edu**

21. **Comments:**

Environmental Compliance Checklist

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

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 IS A SCIENTIFIC RESEARCH PROJECT THAT IS NOT A PROJECT AS DEFINED UNDER CEQA OR NEPA.

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

   CEQA Lead Agency:
   NEPA Lead Agency (or co-lead:)
   NEPA Co-Lead Agency (if applicable):

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:	Required
Permission to access state land. Agency Name: CA DEPARTMENT OF FISH AND GAME, CA DEPARTMENT OF PARKS AND RECREATION, AND US FISH AND WILDLIFE SERVICE	Required
Permission to access federal land. Agency Name: US FISH AND WILDLIFE SERVICE	Required
Permission to access private land. Landowner Name: THE NATURE CONSERVANCY	Required

6. **Comments.**

Land Use Checklist

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

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 IS A RESEARCH PROJECT ONLY.

4. **Comments.**

Conflict of Interest Checklist

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

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):

NIALL McCARTEN, Environmental Science Associates
G. MATHIAS KONDOLF, UNIVERSITY OF CALIFORNIA, BERKELEY
JOHN KING, LONE PINE RESEARCH
DAVE BROWN, CALIFORNIA STATE UNIVERSITY, CHICO

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

G. MATHIAS KONDOLF	UNIVERSITY OF CALIFORNIA, BERKELEY
JOHN KING	LONE PINE RESEARCH
DAVE BROWN	CALIFORNIA STATE UNIVERSITY, CHICO

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

JOHN CAIN NATURAL HERITAGE INSTITUTE

BRUCE ORR STILLWATER CONSULTING

Comments:

Budget Summary

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

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.

Independent of Fund Source

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	RIPARIAN VEGETATION	1,152	92,320		3,500	2,000	760		10,050	108630.0		108630.00
2	TREE-RING STUDY	424	33,600		500	550	43,880			78530.0		78530.00
3	GEOMORPHOLOGY AND HYDROLOGY	128	12,000		100	150	89,900			102150.0		102150.00
4	SEDIMENT DEPOSITION	96	8,360		100	225	12,690			21375.0		21375.00
		1800	146280.00	0.00	4200.00	2925.00	147230.00	0.00	10050.00	310685.00	0.00	310685.00

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	RIPARIAN VEGETATION	1,160	91,640		4,500	500	960		10,100	107700.0		107700.00
2	TREE-RING STUDY	190	16,220		250	200	56,000			72670.0		72670.00
3	GEOMORPHOLOGY AND HYDROLOGY	52	4,680		50	100	7,950			12780.0		12780.00
4	SEDIMENT DEPOSITION	20	1,960		50	175	2,050			4235.0		4235.00
		1422	114500.00	0.00	4850.00	975.00	66960.00	0.00	10100.00	197385.00	0.00	197385.00

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	RIPARIAN VEGETATION	852	77,080		1,850	500	1,580		6,825	87835.0		87835.00
2	TREE-RING STUDY	320	29,920		500	300	67,750			98470.0		98470.00
3	GEOMORPHOLOGY AND HYDROLOGY									0.0		0.00
4	SEDIMENT DEPOSITION									0.0		0.00
		1172	107000.00	0.00	2350.00	800.00	69330.00	0.00	6825.00	186305.00	0.00	186305.00

Grand Total=694375.00

Comments.

Budget Justification

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

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

ENVIRONMENTAL SCIENCE ASSOCIATES: MATTHEW ZIDAR - OFFICE DIRECTOR: 158 HOURS NIALL McCARTEN - PROJECT MANAGER/SR. BOTANIST: 1288 HOURS CHRIS ROGERS ECOLOGIST: 144 HOURS MARK FOGIEL BOTANIST: 800 HOURS STAFF BOTANIST: 1824 HOURS ADMINISTRATIVE STAFF: 188 HOURS

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

ENVIRONMENTAL SCIENCE ASSOCIATES: MATTHEW ZIDAR - OFFICE DIRECTOR: $20,330 NIALL McCARTEN - PROJECT MANAGER/SR. BOTANIST: $133,200 CHRIS ROGERS ECOLOGIST: $14480 MARK FOGIEL BOTANIST: $57200 STAFF BOTANIST: $130,080 ADMINISTRATIVE STAFF: $12,600

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

NONE.

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

INCLUDES FIELD TRAVEL FROM ENVIRONMENTAL SCIENCE ASSOCIATES (ESAs) SACRAMENTO AND OAKLAND OFFICES TO THE COSUMNES RIVER AND SACRAMENTO RIVER STUDY SITES. TRAVEL EXPENSES FOR SUCONTRACTORS ARE INCLUDED IN THEIR BUDGETS. TOTAL ESA TRAVEL COSTS FOR 3 YEARS: $11,575

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

FIELD SUPPLIES INCLUDE AERIAL PHOTOS, MAPS, AND 35 MM FILM

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.

J.KING, LONE PINE RESEARCH TASK 1- $2,340 TASL 2- $129,970 M KONDOLF, UC BERKELEY TASK 3- 58,000 IN SALARY IN ADDITION, DR. KONDOLF INCLUDES A COST OF $50,000 FOR CONTRACTING CARTWRIGHT INC TO CONDUCT PHOTOGRAMIMETRY ALONG THE SACRAMENTO RIVER FOR ELEVATIONS. D BROWN CHICO STATE UNIVERSITY TASK 4- $14,740

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.

NONE.

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.

M ZIDAR WILL SPEND APPROXIMATELY 90% OF HIS BUDGET TO ENSURE SCHEDULES ARE MET, QUARTERLY REPORTS AND TECHNICAL REPORTS ARE PRODUCED, REVIEWED AND SUBMITTED. N MCCARTEN WILL BE THE TECHNICAL PROJECT MANAGER AND HE WILL SPEND APPROXIMATELY 10% OF HIS TIME AND BUDGET TO ENSURE FIELD AND OTHER STAFF ARE CONDUCTING THE APPROPRIATE STUDIES AND DEVELOPING THE REQUIRED TECHNICAL REPORTS. HE WILL PREPARE THE QUARTERLY REPORTS FOR CALFED.

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

TOTAL = $26,975 PLANT PHYSIOLOGICAL AND ENVIRONMENTAL EQUIPMENT RENTAL FOR 3 YEARS $23,500 PURCHASE ON TREE CORING EQUIPMENT AND SUPPLIES $2,500 PURCHASE OF TWO LIGHT METERS FOR ECOPHYSIOLOGY $975

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.

NONE.

Executive Summary

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

THE DEVELOPMENT OF SHASTA RESERVOIR AND PROPOSED EXPANSION OF THE RESERVOIR, AS WELL AS FLOOD CONTROL PROJECTS, HAVE SIGNIFICANTLY REDUCED RIPARIAN VEGETATION ALONG THE SACRAMENTO RIVER. REGULATED DISCHARGE IS BELIEVED TO HAVE RESULTED IN THE REDUCTION OF RIPARIAN VEGETATION ESTABLISHMENT SINCE THE RESERVOIR WAS BUILT IN 1944. THE GROWTH RESPONSE TO SEASONAL CHANGES IN WATER LEVELS ALSO MAY BE REDUCED. CALFED HAS FUNDED PROJECTS (CH2M HILL 2000) TO DETERMINE FLOW REGIME NEEDS FOR RIPARIAN VEGETATION IN THE SACRAMENTO RIVER. HOWEVER, THOSE STUDIES DETERMINED THAT INSUFFICIENT HISTORICAL INFORMATION AND DATA ON RIPARIAN RESPONSE TO MODIFIED FLOWS WAS AVAILABLE TO IDENTIFY FLOW NEEDS. OUR HYPOTHESIS IS THAT HISTORICAL (INCLUDING PRE-RESERVOIR AND POST-RESERVOIR) INFORMATION ON RIPARIAN ESTABLISHMENT AND GROWTH RESPONSE, CORRELATED WITH HYROLOGY, GEOMORPHOLOGY, AND SEDIMENT DEPOSITION, WILL PROVIDE THE NECESSARY INFORMATION. OUR PROJECT WILL STUDY 5 SITES BETWEEN CHICO LANDING AND REDDING BASED ON HISTORICAL AERIAL PHOTOS THAT HAVE BEEN PRESENT PRIOR TO THE CONSTRUCTION OF SHASTA RESERVOIR. WE WILL MEASURE CURRENT ESTABLISHMENT AND GROWTH RESPONSE OF RIPARIAN TREES USING ECOPHYSIOLOGICAL MEASUREMENTS. WE WILL SAMPLE AND MEASURE TREE RINGS FROM DOMINANT TREE SPECIES INCLUDING FREMONT COTTONWOOD, VALLEY OAK, WILLOW, AND WHITE ALDER. THE TREE-RING DATA WILL PROVIDE THE YEAR OF ESTABLISHMENT AND ANNUAL GROWTH. WE WILL COMPARE 2 YEARS OF ECOPHYSIOLOGICAL GROWTH MEASUREMENTS WITH 2 YEARS OF TREE RINGS TO ESTABLISH A MEASUREMENT OF RELATIVE GROWTH; THAT MEASUREMENT WILL BE USED TO ASSESS RIPARIAN RESPONSE WITH HYDROLOGY IN THE HISTORICAL RECORD. WE WILL BE ABLE TO ESTABLISH CURRENT AND HISTORICAL GROWTH RESPONSE OF RIPARIAN TREES ALONG THE SACRAMENTO RIVER AND CORRELATE IT WITH GEOMORPHOLOGICAL AND HYDROLOGICAL PARAMETERS. THIS WILL PROVIDE SEASONAL HYDROLOGY FLOWS THAT ARE OPTIMAL FOR ESTABLISHMENT AND GROWTH OF RIPARIAN VEGETATION AND IDENTIFY FLOW NEEDS. AS A CONTROL SITE WE WILL USE THE COSUMNES RIVER WHICH DOES NOT HAVE REGULATED FLOWS.

Proposal

Environmental Science Associates

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN THE HYDROLOGY AND GEOMORPHOLOGICAL PROCESSES ALONG THE SACRAMENTO RIVER

NIALL McCARTEN, Environmental Science Associates
G. MATHIAS KONDOLF, UNIVERSITY OF CALIFORNIA, BERKELEY
JOHN KING, LONE PINE RESEARCH
DAVE BROWN, CALIFORNIA STATE UNIVERSITY, CHICO

RIPARIAN VEGETATION ESTABLISHMENT AND RESPONSE TO CHANGES IN HYDROLOGY ALONG THE SACRAMENTO RIVER.

A. Project Description

1. Problem

It has been estimated that in 1848 about 509,000 to 800,000 acres of riparian forest existed in the Sacramento River basin and tributaries (Roberts et al. 1980, Katibah 1984, Dawdy 1989). By 1972, settlement activities and land use practices had reduced this extensive riparian forest to less than 12,000 acres (Roberts et al. 1980). Detailed mapping and classification of riparian forests along 117 miles of the middle Sacramento River (Verona to Keswick Dam) determined that only 5,786 acres of valley oak woodland, cottonwood, mixed riparian, and willow scrub habitat was present in 1988 (McCarten 1989). Flood control projects beginning in the late 1800s, and the establishment of the California flood control project in 1914 resulted in removal of riparian vegetation and restrictions to the natural geomorphological processes of the Sacramento River (Scott and Marquiss 1984). The completion of Shasta Reservoir in 1944 and subsequent water diversion projects on tributaries to the Sacramento River added to the changes in natural hydrological and geomorphological processes (Scott and Marquiss 1984). Woody riparian vegetation is not being established at most sites along the Sacramento River, even where suitable surfaces exist for colonization. This has led to speculation that flow regulation by Shasta and other reservoirs has altered the seasonal hydrodynamics in such a way as to prevent establishment of riparian vegetation. In addition, the dams trap sediments supplied by the upstream catchments and have reduced sediment supply and deposition in the river. The proposed expansion of Shasta Reservoir may cause additional impacts to the river ecosystem and associated riparian vegetation. A recent CALFED-funded study to determine flow needs for riparian vegetation in the Sacramento River concluded that such flow needs could not be determined with confidence due to the lack of basic historical information (CH2M Hill 2000). This study determined that uncertainties relating to establishment and persistence of riparian vegetation was due to: 1) lack of data on rates of downward root growth, 2) historical flow conditions under which successful stands of riparian vegetation established, and 3) suitable stage-discharge relations at sites of potential establishment to estimate river stage from flows at nearby gauges.

The establishment and growth of riparian trees species and riparian community succession is strongly linked to fluvial processes (Stromberg 1993, Asplund and Gooch, 1988, Bradley and Smith 1986, Rood and Heinze-Milne 1989, Scott et al. 1997). Changes to the natural fluvial processes can have a profound effect on plant community structure, composition, and overall landscape patterns. Lower sediment deposition rates can reduce gravel bar formation, resulting in the loss of new habitat for riparian vegetation seedling establishment. The quantity and timing of water discharges from reservoirs has several affects, including lack of natural seasonal flooding, and rapid draw-down of water preventing germination and killing seedlings before their roots can become established (Bradley and Smith 1986, Scott et al. 1997). In addition, flooding of first-year seedlings causes high levels of mortality (McCarten and Beedy 2001a). Several studies have shown that changed and regulated riverine systems result in altered environmental gradients, reduced biodiversity, senescence of riparian communities and mortality, and lack of establishment of early successional species such as cottonwood (Miller et al. 1995, Ward 1998).

Changes in the natural fluvial processes in the Sacramento River system include reduced sandbar formation, low recruitment and establishment of riparian plants, and senescence of riparian plant communities. These same effects have been observed in other river systems. These changed processes also affect CALFED At-risk species. Species such as the yellow-billed cuckoo (*Coccyzus americanus*) require a more diverse riparian habitat. The yellow-billed cuckoo often nests in willows (*Salix* sp.) but forages for insects and tree frogs that occur in cottonwood (*Populus* sp.) tree canopies (Anderson and Laymon 1989). In part, the loss of riparian tree diversity also is due to the sensitivity of some species to seasonal drought or flooding. White alder (*Alnus rhombifolia*) is very sensitive to drought and rapid water draw-down that results in high levels of seedling mortality (Dains 1989). Alternatively, flooding during the growing season can have negative or positive results depending on the flood tolerances of individual species (McCarten and Beedy 2001a, McCarten, et al. 2001b).

Restoration projects suffer from a high degree of uncertainty due to a lack of understanding of the fluvial processes on the establishment and growth response of individual riparian tree species. Some success has been accomplished on high terraces where valley oaks (*Quercus lobata*) can be established through irrigation. However, low terraces are poorly understood.

Goals and Objectives of the Study

The principal goal of this proposed project is to better understand relations among river flows, geomorphic surfaces, and establishment and growth of riparian vegetation. We propose to undertake a study of “forensic” ecology and hydrology using dendrochronology to determine historical growth rates in relation to flow patterns along the Sacramento River. The goals of the project are to: 1) better understand the fluvial processes under which existing riparian vegetation has become established, 2) determine how riparian tree species have responded to historical conditions of managed water discharges from Shasta Reservoir, and 3) determine whether existing conditions allow for establishment and long-term persistence of riparian vegetation.

One goal of the proposed project is to create a better understanding of the fluvial processes that influence creation of habitat on establishment of riparian species. Another goal will be to determine how riparian tree species are responding to existing conditions of managed water discharges from Shasta Reservoir. Finally, we will define the changes that have occurred in the growth response of riparian tree species following the establishment of Shasta Reservoir and other water control facilities. For example, dendrochronological data determined that riparian tree growth of netleaf hackberry (*Celtis reticulata*) closely tracked seasonal river hydrology prior to the establishment of Glen Canyon Dam (Salzer et al. 1996). Following the establishment of Glenn Canyon Dam the hackberry growth was correlated with precipitation (Salzer et al. 1996). Therefore, a major goal will be to determine whether existing conditions allow for the long-term persistence and biodiversity of riparian vegetation.

2. Justification

Flow regimes in the Sacramento River are critical to the establishment and growth of riparian vegetation. A previous CALFED study conducted by Dr. Matt Kondolf and others (CH2M Hill 2000) identified a serious gap in the ability to determine flow regimes required for riparian vegetation establishment and growth. The critical problem is the lack of historical information. Understanding the hydrological and geomorphological processes and the response of riparian vegetation to those processes is needed to determine what flows are required to sustain the riparian ecosystem. CALFED programs have explicitly identified research needs to further understand ecosystem processes and to support on-going and proposed CALFED ecosystem restoration projects. Our proposed project will fill a very specific and important gap in our understanding of flow regime needs for riparian vegetation establishment and growth. We have formed an interdisciplinary team of scientists to answer important questions and identify flow regimes necessary for riparian vegetation restoration. We have developed a conceptual model (Figure 1) the shows how our project fits into the CALFED program and specifically addresses particular CALFED issues. The conceptual model shows how we will implement specific research tasks to answer questions on pre-Shasta Reservoir hydrological and geomorphological conditions and the establishment and growth response of riparian tree species. The model also shows how we will answer these same questions for years following the construction of Shasta Reservoir and for conditions that currently exist.

3. Approach

Our approach to the proposed project includes four tasks. These tasks are designed to answer key questions and confirm our hypothesis. Table 1 identifies the tasks and the questions each task proposes to answer.

Task 1 - Current Riparian Structure and Establishment

The purpose of this task is to establish a baseline of riparian vegetation characteristics. Examples include identification of community structure and species growth responses to existing conditions. This baseline data will be compared with the tree ring data obtained in Task 2. This task will measure existing riparian tree vegetation to determine plant community structure, tree diversity, physiological response to current hydrological and climatic conditions, and whether recruitment and establishment of riparian vegetation is occurring. The study along the Sacramento River will include five riparian sites (Table 2). We will coordinate with an on-going CALFED project along the Cosumnes River. The Cosumnes River project will serve as a control to compare riparian vegetation processes that do not have regulated water flows

<u>Riparian Community Structure and Diversity</u>. At the study sites on the Sacramento and Cosumnes Rivers, we will study four dominant tree species: Fremont cottonwood (*Populus fremontii*), willow, valley oak, and boxelder (*Acer negundo*). We will measure tree height, diameter at breast height (dbh), canopy width and cover area, distance from the rivers and rooting height above the river. At each study site, rectangular collection plots will be established. Each plot will be oriented perpendicularly to the river channel following the elevational gradient extending from the gravel bar thicket through the riparian forest and valley

oak woodland zones. The relative influence of long-term groundwater depths, short-term wet season/dry season groundwater fluctuations, flooding events, and regional climate effects can be assessed and will be determined by sampling along an elevational gradient. Because this study must correspond closely with the tree-ring study undertaken in Task 2, the rectangular plots will vary in size to meet the sampling criteria of 100 trees needed in the tree-ring assessment. Therefore, sample plot sizes may vary, but we will measure all 100 trees of each species for each variable identified above. We recognize that meeting the 100-tree requirement may not be achieved for all species, but specific site selection will consider the number of trees and species diversity.

Ecophysiological Response of Riparian Trees to Existing Hydrology and Climate. Diurnal and seasonal physiological responses of riparian tree are correlated with river and near surface groundwater hydrology and climatic variables (precipitation and temperature). We will correlate specific physiological responses, such as leaf transpiration rate, with tree-ring widths that will allow us to understand physiological responses to historic hydrological and climatic conditions. Tree leaf transpiration rates will be measured as stomatal conductance using a LiCor 1600 steady state porometer. Measurements will be taken on three fully lit tree leaves on five individual trees of each species at each study location. The measurements will be taken at four times during the day (8 am, 11 am, 2 pm, 5 pm) to obtain diurnal flux rates. The measurements will be taken five times during the growing season (mid-month April, June, July, August, September). The porometry measurements will simultaneously measure air temperature, humidity, light as photosynthetically active radiation (PAR), and leaf temperature. Ecophysiological measurements will be taken during two growing seasons on Fremont cottonwood, willow, and white alder. The individual trees will be tagged for the repeated measures. These same trees will be cored to obtain the tree-rings as part of Task 2, and the growth index calibrated to the transpiration rates.

Task 2 - Historical Riparian Tree Establishment and Growth Response

Members of our project team have successfully used tree-ring data to measure years of riparian tree establishment and growth associated with the South Fork of the Kern River and fluctuations in reservoir levels (see Figures 2 and 3). This task focuses on the growth response of riparian tree species to climatic variation, fluvial processes, and non-climatic factors. Specifically, we propose to employ dendrochronological techniques to develop a multispecies network of tree-ring chronologies and species- and site-specific records of mortality and recruitment. Changes in forest structure and composition will be assessed in terms of: 1) modeled relationships between tree-ring records and instrumental records of climate and river discharge, and 2) the timing and magnitude of non-climatic and disturbance events with respect to population processes.

Fieldwork. Spatial replication of dendrochronological records are key features in documenting forest dynamics, and are relevant in the extensive Sacramento River basin. A minimum of two tree-ring collection plots will be established at five study sites along the Sacramento River (Table 1). The collection plots will be oriented along elevational gradients extending from gravel bar thickets adjacent to the open floodplain, and through the riparian forest and higher-elevation valley oak woodlands (Conard et al. 1980). By sampling along elevational gradients, the relative influence of flooding events, long-term groundwater depth, wet/dry season groundwater fluctuations, and regional climate effects can be assessed. For example, vegetation patterns immediately adjacent to floodplains may reflect a history of extreme flow events while trees growing on high terrace deposits may be sensitive to other limiting climatic factors. An additional tree-ring study site is proposed along the tributary of the Cosumnes River (Table 2). The Cosumnes River tree-ring data set will be used to study the sensitivity of riparian tree species to unregulated river discharge.

Tree-ring collections will be staged to provide for preliminary assessments of sample quality, cross-dating characteristics, tree age, and climate-growth relationships. Preliminary increment core samples will be extracted from 10-15 trees of each selected species at each study site. Priority will be given to the most common Central Valley riparian tree species (i.e., Fremont cottonwood, willow species, valley oak, box elder); however, additional species may be sampled if they are found to be old growth or representative of site vegetation. Based on findings from the preliminary tree-ring collections, full collections will be initiated at each study site. Collection plot widths will be adjusted in order to collect a minimum of 100 increment cores from each available target species. A single increment core will be extracted from each live tree and all sampling instruments will be treated with denatured alcohol to reduce the risk of pathogen transmission between trees. Where present, priority will be given to the sampling of old growth trees because of their potential to provide records of presettlement vegetation response to environmental change. In addition to live tree samples, tree snags and deadwood remnants will be sampled to construct records of mortality and disturbance, and to potentially extend tree-ring records back past the relatively short life span of most riparian tree species. Flood-scarred trees, resulting from the abrasive action of flood debris, will be sampled where present and analyzed to build records of extreme flood events (McCord 1996).

<u>Laboratory Work and Chronology Development</u>. Sample preparation and initial tree-ring sequencing will be accomplished using well-established techniques (Stokes and Smiley 1968, Swetnam et. al 1985). Due to the likelihood of diffuse-porous or semi-diffuse-porous wood (Hoadley 1990), complacent growth characteristics, and short tree ages (i.e., less than 50-100 years), tree-ring sequences will be measured to the nearest 0.002 mm and a set of cross-dating techniques will be employed. Physical sample comparisons, correlation analyses, graphical time-series comparisons, and abnormal cell/ring analyses will be used iteratively to ensure exact annual control (King 2000). Objective quality control of the cross-dated tree-ring data sets will be conducted using program COFECHA (Holmes 1983). Tree-ring chronologies will be assembled by removing age-related trends from the measurement series and combining the resulting indexed series into species- and site-specific mean series chronologies (program ARSTAN Cook 1985). Conservative detrending options will initially be used to help retain potentially important low-frequency tree-ring features resulting from flooding conditions, insect infestations, logging, grazing effects, and other relevant non-climatic sources of tree-ring variation. Subsequent analysis of climate-growth relationships may require restandardization of the measurement series in order to remove these non-climatic features and enhance climate-related variation contained in the tree-ring record.

<u>Dendrochronological Analyses</u>. Principal component techniques, response function analysis and correlation analysis (Fritts et al. 1971, Fritts 1976, Guiot 1990) will be used to examine the nature and strength of relationships between tree-ring indices and climatic and hydrologic

variables (Tardif 1996). In these analyses, temperature, precipitation, and river discharge variables will be assembled from instrumental records for both current and preceding time periods in order to determine their correlation with tree growth. Both monthly and daily instrumental records will be considered based on their length, continuity, and proximity to collection sites. Based on cross-dating results and compiled tree-ring chronologies, records will be developed for recruitment, mortality, flood scars, and non-climatic growth features in order to assess the effects of extreme events and nonclimatic factors on vegetation patterns and dynamics.

Task 3 - Existing and Historical River Hydrology and Geomorphology

To provide a context for the growth patterns documented from dendrochronological analyses, we will undertake forensic geomorphic and ecological studies to document the geomorphic and hydrologic conditions preve\ailing at our study sites during establishment and growth, using a variety of historical ata sources (Kondolf and Larsen 1995). We will develop historical hydrographs for our study sites based on nearby mainstem gauges and accounting for tributary contributions.

We will etimate the date of establishment for our sampled stands from our tree ring data and, for strands less than about 60 years old, by inspecting historical aerial photographs to determine the date on which the vegetation first appeared.

We will also document water surface elevations over a arange of discharges to develop stage-discharge relations for the current channel conditions. We will survey cross sections and detailed topographic maps for the study sites following standard geomorphic procedures to provide a toopographic referance for the sampled trees, and as a refernce for the current channel conditions. While this information will provide a glimpse into the current conditions, we are equally interested in historical conditions that have influenced past growth rates.

We will reconstruct the historical channel and point bar geometry using all available evidence. We can map planform changes from the aerial photographs alone, but to get an indication of topographic changes, especially channel incision, we will conduct photogrammetry on historical aerial photographs. We will identify fixed points (such as road intersections, building corners, concrete bridge abutments, etc) that can be identified on multiple years' of aerial photographs, and survey their elevations in the field. These points can then be used to provide a frame of reference for photogrammetric analysis of sequential photos, allowing us to map topography of the channels during historical periods. This approach was used successfully on Stony Creek to map changes in channel form effected by the 1978 flood, to calibrate a sediment transport model (Kondolf and Swanson 1993). The photogrammetric analysis will be performed by a qualified firm specializing in this work.

For our analysis, the historical topographic information will be particularly valuable in reconstructing historical channel form and elevations of geomorphic surfaces (exposed bars and floodplain surfaces) when woody riparian vegetation was becoming established and growing, allowing us to compare actual establishment conditions on the Sacramento with those predicted from previous studies elsewhere (e.g. Mahoney and Rood 1998). Initial crude estimates of drawdown rates prevailing during establishment of exisiting cottonwood stands along the

Sacramento suggest that these trees are adapted to a higher range of flows and more rapid rates of stage decline than are trees along snowmelt streams reported in the literature (Kondolf et al. 2000). While photogrammetry of the historical photo cannot give us elevation and topography of the submerged bed, it will provide elevation for the water surface, which we can compare to the elevations of the surfaces on which the plants are establishing. Moreover, because we will reconstruct the river flow on the date of the photography (from our analysis of the gauging records), we have information from which to estimate historical stage-discharge relations, and thereby reconstruct at least an approximate history of stage at the vegetation establishment sites during seedling dispersal, seedling establishment, and growth over the next three years when mortality can be high due to flooding or desiccation.

We will compare our record of river flow and reconstructed record of river stage at each study site with the tree ring patterns observed, as a basis for analyzing relations between flow and ring growth, and for explaining any observed, changes in tree growth since dam construction and other human perturbations.

Task 4 - Current and Historical Sedimentation Rates and Sandbar Formation

Stands of woody riparian vegetation establish on surfaces that are available for colonization, notably accreting point bars and cut-off channels (especially chute cutoffs) (Greco 1999). The stratigraphy of the deposits left by these two processes can be different, with potential influences on the establishment success of the riparian vegetation. During low water in late summer or fall, we will core the sediments underlying our sampled cottonwood stands to document sedimentology of the substrate (to quantify its influence on plant growth) and to reconstruct the sedimentation history of the site. Where sites are inaccessible or deposits thin, we will use hand bucket augers. Where deposits are thicker and access suitable, we will use a truck-mounted or portable hollow-stem power drill coring device. In addition to documenting the sequence of deposits, we will obtain dates for strata with isotopic analysis (C^{14}, Cs^{137}, and/or Pb^{210} radionuclides, depending on the available material). This will allow us to estimate sedimentation rates in different time periods and to correlate individual strata with recorded high flows.

CSU Chico will undertake the coring and interpretation, under the direction of Professor David Brown. We anticipate approximately 20 cores from each of our six study sites.

4. Feasibility

The project team includes expertise in the fields of riparian plant ecology, tree ring analysis, geomorphology, and hydrology. All the team members have expertise and experience with the Sacramento River ecosystem and the ecological questions being asked. In addition, the project includes collaboration with local restoration ecologists that are conducting on-the-ground restoration projects. The team has been active with other CALFED projects in the geographic areas we propose to study and we have close working relationships with organizations, agencies, and individuals that will be key to implementing the study.

5. Performance Measures

Performance measures will be developed based on the correlation between riparian tree growth response and establishment, and recent tree-ring growth indices. The large sample size of tree cores is needed to develop a highly accurate tree-ring index for a species at a site that varies to the same extent as physiological data. In addition, tree-ring indices should have a high correlation with the historical hydrological and climatic data. Performance measures which demonstrate success are a high level of correlation and accuracy with respect to measure growth, hydrology, and climate. Secondarily, the correlation of riparian vegetation establishment from tree-ring dates with historical geomorphology and sediment cores will provide a measure of confidence in the data. However, the tree-ring data should have a very high independent correlation. Ultimately, it will be the ability of the tree-ring and riparian growth model, correlated with hydrology, that will determine what Sacramento River flow regimes provide conditions for establishment and growth of riparian vegetation. Our goal will be met with our ability to identify river flows that predict years of riparian vegetation establishment based on tree-rings.

6. Data Handling and Storage

Original proprietary data will be maintained in files owned/managed by the scientists that created the data and are involved in the project. Copies of all raw and processed data generated using CALFED funding will be supplied in one or more of the following forms as preferred: hard copy, Microsoft Word, Microsoft Excel, PDF, and/or HTML files on CD ROM, e-mail attachment, or web-accessible files. Additionally, copies will be stored at Environmental Science Associates in Sacramento, California. Copies of all data will be part of technical reports submitted to CALFED.

7. Expected Products/Outcomes

Our expected products and outcomes are presented in Table 3.

8. Work Schedule

Our work schedule presented in Table 3.

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

1. ERP, Science Program and CVPIA Priorities

The applicability of our proposed project to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities is presented in Table 4.

2. Relationship to Other Ecosystem Restoration Projects

CAFED 1996-M16 Sacramento River and Major Tributary Mapping Project; 1997-N04 Sacramento River Floodplain Acquisition and Riparian Forest Restoration; 1998-F18 Floodplain Acquisition, Management, and Monitoring on the Sacramento River. This project will dove-tail with a FY 2002 proposal by the Natural Heritage Institute that proposes to look at detailed biological factors associated with riparian vegetation establishment, develops hydrological models using current hydrological conditions. That study will evaluate riparian systems throughout the Central Valley. Our proposal will provide the historical perspective necessary to evaluate riparian vegetation establishment and growth response. The CALFED-funded project to determine flow regime requirements for habitat restoration along the Sacramento River between Colusa and Red Bluff (CH2M Hill 2000) identified specific information needs before key flow regimes can be determined. Our proposal will some of those needs and help identify the flows. Our data will give explicit guidance to CALFED and other restoration projects along the Sacramento River, and hopefully will give guidance on how to regulate releases from Shasta Reservoir.

3. Requests for Next-Phase Funding

Not applicable.

4. Previous Recipients of CALFED Program or CVPIA Funding

Not applicable.

5. System-Wide Ecosystem Benefits

Our proposed project will provide specific information on river flow regimes necessary for riparian vegetation establishment and growth in the Sacramento River and the relationship to discharge from Shasta Reservoir. However, the relationships between historical flows and the establishment and growth response by riparian vegetation are a system-wide issue.

6. Additional Information for Proposals Containing Land Acquisitions

Not applicable.

C. Qualifications

<u>Niall McCarten, Ph.D.</u> is senior biologist with Environmental Science Associates and Research Associate with the Section of Plant Biology at UC Davis, and the UC Jepson Herbarium at UC Berkeley. He received his B.A. in botany at UC Santa Barbara, M.A. in Ecology and Systematics at San Francisco State University, and Ph.D. in botany at UC Berkeley. He is a nationally recognized plant ecologist with peer reviewed papers and conference presentations on riparian and wetlands ecology and monitoring. He has conducted research on riparian community structure and development along the Sacramento River and conducted physiological and ecological studies on the affects of flooding on riparian trees. He also has been involved with the design and implementation of riparian and wetland restoration projects. He has served as the project manager on many large projects involving teams of scientists, resource agency staff, and consultants. He was one of the few non-public agency scientists asked to participate in the development of the original Calfed Ecosystem Restoration Program plan, participated in the development of the Calfed Natural Community Conservation Plan. He was chairman of conservation and vice-president of the California Botanical Society. He has been involved with the review and development of threatened and endangered species recovery plans and programs. He has received recognition for his work by the Smithsonian Institute and National Natural History Museum, Washington, the U.S. Forest Service, and the California Native Plant Society.

<u>G. Mathias Kondolf, Ph.D.</u> is a fluvial geomorphologist whose research concerns environmental river management, influences of land-use on rivers, notable effects of mining and dams on river systems, interactions of riparian vegetation and channel form, geomorphic influences on habitat for salmon and trout, alternative flood management strategies, and application of fluvial geomorphology to river restoration. He has published over 100 technical journal articles, book chapters, and reports on these and related topics. Dr. Kondolf is an Associate Professor of Environmental Planning and Geography at the University of California at Berkeley, where he teaches Hydrology for Planners, Restoration of Rivers and Streams, Ecological Analysis in Urban Design, and Introduction to Environmental Sciences. He received his Ph.D. in Geography and Environmental Engineering from Johns Hopkins University, M.S. in Earth Sciences from the University of California at Santa Cruz, and A.B. in Geology (*cum laude*) from Princeton University. Dr. Kondolf was an author of Strategic Plan for the Calfed Ecosystem Restoration Program, and is currently a member of the Interim Science Board for the Calfed ERP.

<u>John C. King</u> is director of Lone Pine Research in Bozeman, Montana, and a nationally recognized expert in dendrochronology. He received his B.S. degree from the University of Arizona in the Watershed Resource Program. He established and became program coordinator for the tree-ring research laboratory at Montana State University. He is a research consultant to the USDA Forest Service Pacific Southwest Research Station, Albany, California, and established a tree-ring research laboratory and provided training to Forest Service scientists. He has published in peer reviewed journals and written technical reports on tree-ring data gathering and analysis and dendrochronology. In collaboration with the principal investigator, his studies have involved research on riparian trees including Fremont cottonwood, willow, poplar, and alder. His research includes studying population growth and growth responses on riparian vegetation due to flooding, disturbance and climate.

David Brown, Ph.D., Associate Professor, joined the Geosciences Department at CSU, Chico, in August 1997. He teaches courses in hydrology and environmental science with an emphasis on interdisciplinary studies such as watershed hydrology. He supervises graduate students on a wide range of research topics, including riparian restoration hydrology, groundwater/surface water interactions, hyporheic zone processes, watershed analysis, and pesticide runoff. Since July 2000, Dr. Brown has served as the Science Director of the CSU, Chico, Bidwell Environmental Institute. Over the past four years, he has been awarded 13 funded projects totaling more than $500,00 in total grants and contracts. In addition to the topics listed above, these projects include soil and groundwater characterization, surface water sampling, nonpoint source pollution, and analysis of conjunctive use of surface water and groundwater. He received his Ph.D. from the Department of Soils Science at U.C. Berkeley.

Chris Rogers is a wetlands and plant ecologist with Environmental Science Associates. He has over 12 years' experience conducting habitat assessments, endangered species evaluations, preparation of environmental documentation and permitting applications, restoration and mitigation planning, and construction monitoring. He received his B.A. in biology (emphasis plant ecology) at San Francisco State University. He experienced in wetland restoration design and implementation, including working with riparian and wetlands ecological studies and developing and implementing restoration and monitoring programs. His restoration experience includes preparing restoration and revegetation plans for Alhambra Creek in Martinez involving extensive planting of a native cordgrass marsh, developing long-term marsh and riparian habitat restoration. In addition, Mr. Rogers has conducted numerous site assessments of wetlands and streams and feasibility studies for restoration, enhancement and water treatment applications.

Mark Fogiel is a vegetation ecologist with Environmental Science Associates. He has experience conducting ecological studies on riparian vegetation, rare plants and restoration planning and monitoring. He has an M.A. in Biology (concentration in Ecology and Systematics), and a B.S. in Biology (emphasis in Botany 0 from San Francisco State University. He has conducted physiological studies on riparian vegetation along the upper Sacramento River.

D. Cost

1. Budget

The total cost of this proposal will be $694,375.

2. Cost Sharing

Not applicable.

E. Local Involvement

Proposed project sites include local preserves and parks along the Sacramento River that are owned and managed by the California Department of Parks and Recreation, U.S. Fish and

Wildlife Service, and The Nature Conservancy. The studies along the Cosumnes River will be conducted in coordination with the Cosumnes River Preserve, its associated property owners, and the Cosumnes River Research Committee.

F. Compliance with Standard Terms and Conditions

This project will comply with all standard terms and conditions for state and federal contracts as described in attachments D and E of the Proposal Solicitation Package.

G. Literature Cited

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Table 1. List of Tasks and Key Questions

Tasks	Key Questions
Task 1 - Current Riparian Structure and Establishment	What is the growth response of mature riparian tree species to current hydrological conditions?
	What is the growth response of seedlings and saplings currently establishing on gravel bars?
Task 2 - Historical Riparian Tree Establishment and Growth Response	When did riparian tree species become established at particular sites?
	What are the demographic and growth rate responses of riparian tree species to climate variation, river discharge, and disturbance events?
	How have forest dynamics, structure, and composition changed with respect to 20th Century flow regulation?
	What portions of the Sacramento River riparian forest are most sensitive to climatic and hydrologic changes, and what are the implications for restoration and land management practices?
Task 3 - Established Historical River Hydrology and Geomorphology	What were the river flow rates prior to the establishment of Shasta Reservoir?
	What are the river flow rates under regulated releases from Shasta Reservoir?
	What geomorphological changes have occurred along the river that corresponds with the establishment of riparian vegetation?
Task 4 – Current and Historical Sedimentation Rates and Sandbar Formation	What rates of sediment deposition have occurred on low and mid elevation terraces that support riparian vegetation?

Table 2. Approximate Location of Study Sites

Study Sites			
Sacramento River	**Habitats**	**Location**	**River Structure**
Site - 1	Mixed and cottonwood riparian, valley oak	Between river mile 281 and 292	Wide meander
Site - 2	Mixed riparian	Between river mile 261 and 271	Narrow meander
Site - 3 (below Red Bluff Diversion Dam)	Mixed and cottonwood riparian, gravel bar development	Between river mile 232 and 242	Wide meander
Site - 4	Mixed and cottonwood riparian, gravel bar development	Between river mile 219 and 225	Wide meander
Site - 5	Mixed and cottonwood riparian, gravel bars	Between river mile 186 and 192	Wide meander
Cosumnes River - Control Sites			
Two sites under investigation by existing study	Valley oak, cottonwood and mixed riparian	Cosumnes River Preserve locations	Wide meander

Table 3. Product/Outcomes and Work Schedule

Products/Outcomes	Work Schedule
Task 1 - Current Riparian Structure and Establishment	
Riparian community structure at study sites	Measurements taken during year 1
Ecophysiological studies	Measurements taken during years 1 and 2
Task 2 - Historical Riparian Tree Establishment and Growth Response	
Preliminary assessment of riparian forest population processes, and species-specific growth responses	Year 1 Activities: -preliminary tree-ring collections -sample preparation, cross-dating, and preliminary chronology development -examine sample quality and tree ages -assemble climatic and hydrologic records -preliminary climate/hydrology-tree growth modeling
Recruitment and mortality patterns with special emphasis on the timing of 20th Century flow modifications	Year 2 Activities: -full tree-ring collections -sample preparation, cross-dating, and final chronology development -site- and species-specific demographics
Growth response and sensitivities of riparian tree species to climatic, hydrologic, and disturbance factors.	Year 3 Activities: -flood scar and old growth collections -supplemental tree-ring collections -final climate/hydrology-tree growth modeling
Task 3 - Existing and Historical River Hydrology and Geomorphology	
The data for this task will be incorporated into the overall study report in year 3	Hydrological measurements taken and historical aerial photos obtained during year 1
Task 4 - Current and Historical Sedimentation and Sandbar Formation	
The data for this task will be incorporated into the overall study report in year 3	Measurements taken during year 1
Reports: In addition to the CALFED quarterly reports, a single integrated report will be developed	Integrated report completed in year 3
Publications and Conferences	We will publish our findings in at least two peer-reviewed scientific journals including the Journal of Ecological Applications, and present the findings at the CALFED Science conference and at least one other conference on riparian and restoration ecology

Table 4. Goals, milestones and implementation Plan Priorities

Goals/Milestones	Implementation Plan Priorities
CALFED/ERP/CVPIA	
MSCS Research Milestone - Develop and begin implementation of a study to determine appropriate conditions for the germination and establishment of riparian woody plants along the Sacramento River.	Sacramento Region Priority 3 - Conduct adaptive management experiments in regard to natural and modified flow regimes to promote ecosystem functions or otherwise support restoration actions.
MSCS Ecological Process Milestone - Complete a fluvial geomorphic assessment of coarse sediment supply needs and sources to improve regeneration of riparian vegetation.	Sacramento Region Priority 4 - Restore geomorphic processes in stream and riparian corridors.
MSCS Sacramento Region Milestone - Develop and implement a program to establish, restore, and maintain riparian habitat to improve floodplain habitat.	Sacramento Region Priority 7. Develop conceptual models to support restoration of river, stream and riparian habitat.
Science Program Goals - 1) Advance process understanding, 2) Establish integrated science programs in complicated field settings, 3) Address landscape scale issues.	
CVPIA Habitat Restoration Program	
CVPIA Gravel Replenishment and Riparian Habitat Protection Program.	

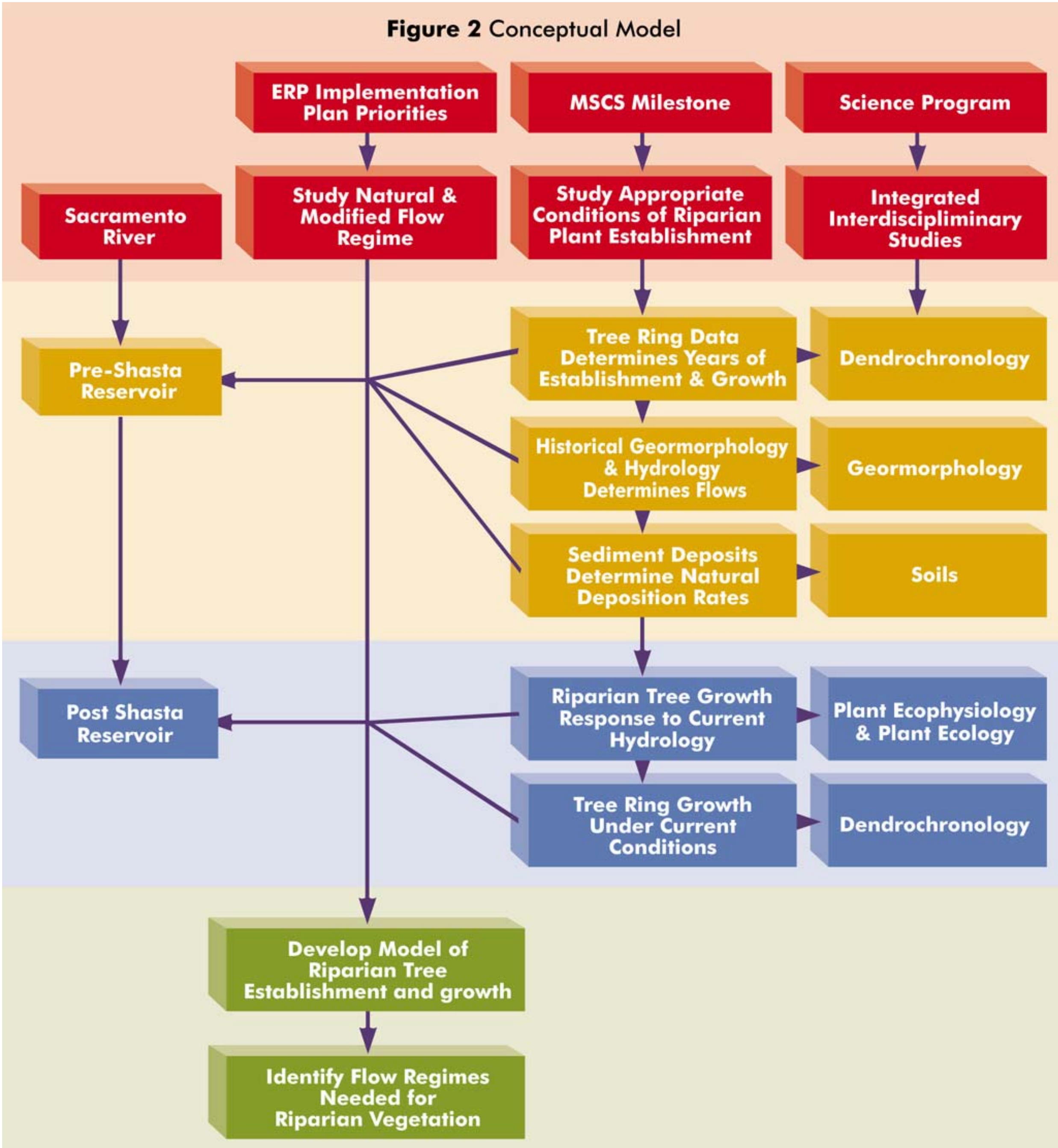
Figure 2 Conceptual Model
ERP Implementation Plan Priorities
MSCS Milestone
Science Program
Sacramento River
Study Natural & Modified Flow Regime
Study Appropriate Conditions of Riparian Plant Establishment
Integrated Interdisciplinary Studies
Pre-Shasta Reservoir
Tree Ring Data Determines Years of Establishment & Growth
Dendrochronology
Historical Geormorphology & Hydrology Determines Flows
Geormorphology
Sediment Deposits Determine Natural Deposition Rates
Soils
Post Shasta Reservoir
Riparian Tree Growth Response to Current Hydrology
Plant Ecophysiology & Plant Ecology
Tree Ring Growth Under Current Conditions
Dendrochronology
Develop Model of Riparian Tree Establishment and growth
Identify Flow Regimes Needed for Riparian Vegetation

Figure 2. Black Willow Recruitment Dates

vertical axes are number of trees

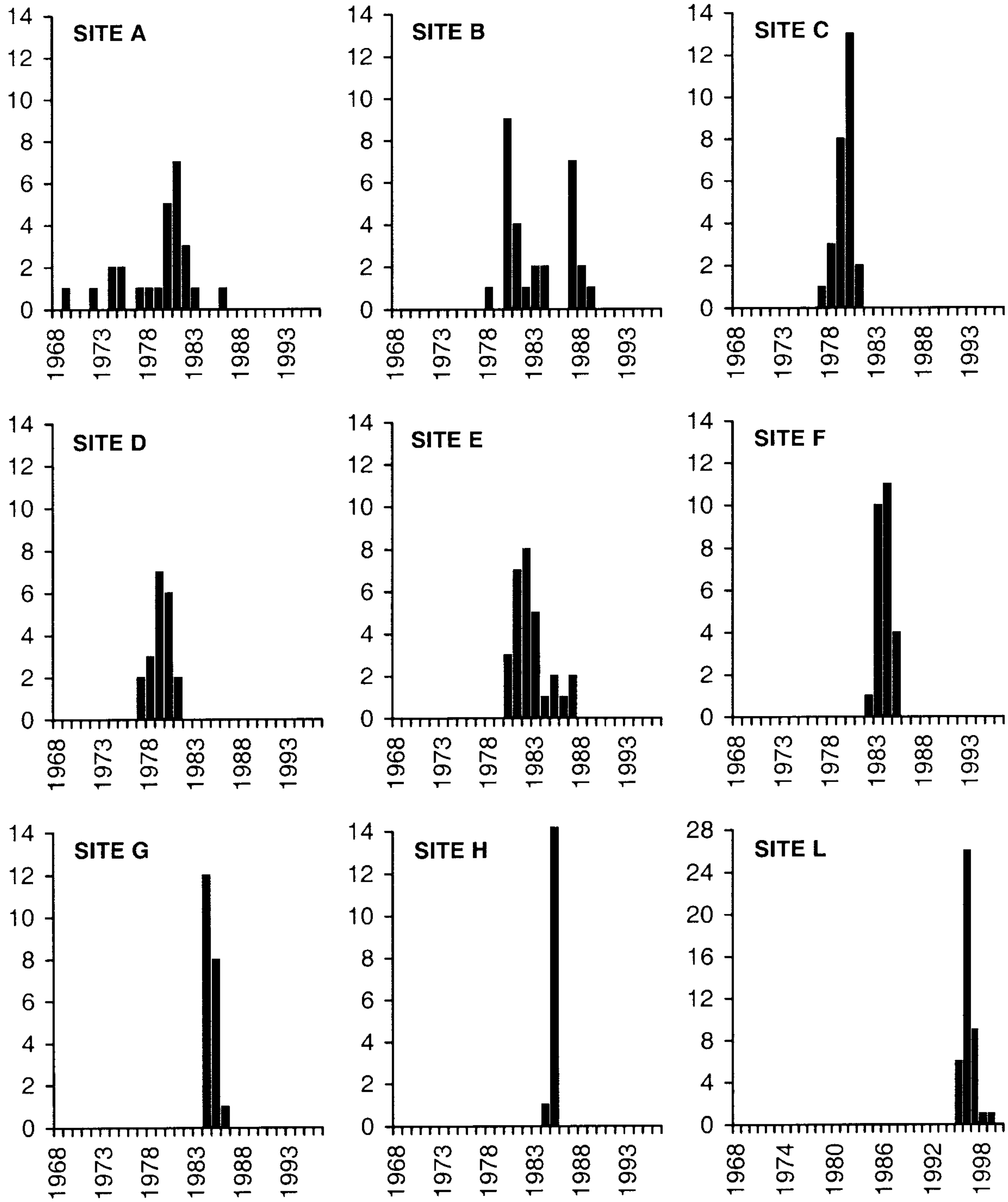

Figure 3 - Black Willow Tree Ring Growth on Kern River