SANTA ANA RIVER WATERSHED PROGRAM AGREEMENT BETWEEN ORANGE COUNTY WATER DISTRICT AND SANTA ANA WATERSHED ASSOCIATION

THIS PROGRAM AGREEMENT ("Agreement") is entered into as of 6-19-13, 2013 (the "Effective Date"), by and between the ORANGE COUNTY WATER DISTRICT, a special governmental district organized and operating pursuant to the Orange County Water District Act, Chapter 924, Stats. 1933, as amended ("OCWD"), and the SANTA ANA WATERSHED ASSOCIATION, a tax-exempt non-profit organization ("SAWA"). OCWD and SAWA are at times collectively referred to herein as the "Parties."

RECITALS

A. OCWD owns over 2,000 acres of land in the flood control basin behind Prado Dam in Riverside and San Bernardino Counties, California (such basin is referred to herein as the "Prado Basin," and such OCWD-owned lands are referred to as "OCWD Basin Lands"). The Santa Ana River waters that reach Prado Basin flow downstream to lands within OCWD's boundaries, and OCWD diverts such Santa Ana River flows to replenish the groundwater basin managed by OCWD. OCWD engages in activities and projects to enhance natural resources in the upper portion of the Santa Ana River Watershed, including the portion of the Santa Ana River Watershed tributary to Prado Dam ("Upper SAR Watershed"), and the Prado Basin as an incident to OCWD's primary purpose of conserving, managing and enhancing the quality and quantity of water resources for the benefit of the residents and lands within the OCWD boundaries.

B. SAWA develops, coordinates and implements natural resource programs that support a sustainable ecosystem and social benefits in the Upper SAR Watershed. Major areas of SAWA's focus are the removal of invasive species, native habitat enhancement and the protection of endangered and threatened species. OCWD is a member agency of SAWA and a representative of OCWD serves as a member of the SAWA board of directors.

C. The growth of invasive plant species is a significant problem throughout the Upper SAR Watershed. Infestations of the invasive weed Arundo (*Arundo donax*) and associated weeds thrive in portions of the SAR Watershed, and consume large quantities of water that would flow to OCWD's boundaries and could be put to beneficial uses. Inasmuch as Orange County is located in a semi-arid area, it is essential that all reasonable efforts be made to protect the quantity and quality of OCWD's water supplies and to provide for maximum beneficial uses for people and wildlife of that resource.

D. In furtherance of the goal to maximize water resources and in compliance with permit conditions for OCWD projects and operations, partnerships were formed to work on invasive weed control in the Upper SAR Watershed and to cooperatively manage OCWD Basin Lands with the signing of a landmark agreement among OCWD, U.S. Army Corps of Engineers ("Corps"), and the U. S. Department of Interior (including the U.S. Fish and Wildlife Service ("Service")) in 1995 (the "1995 Agreement").

E. The activities authorized by the 1995 Agreement were funded initially with mitigation funds contributed by the Corps and OCWD and held in an account initially designated as the Santa Ana River Conservation Fund ("Conservation Fund") and administered by OCWD in accordance with a Memorandum of Understanding executed by OCWD, the Corps and the Service on September 26, 1997.

F. The Conservation Fund received funds from a variety of sources, including bonds issued pursuant to State of California Proposition 13 and various sources of mitigation funds. The Conservation Fund was designated as the repository for mitigation funds received through the "Memorandum of Agreement Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program" ("SAWA ILF Program"), executed by the Corps, OCWD and SAWA on November 18, 2002 (the "2002 MOA"). A copy of the 2002 MOA is attached hereto as Exhibit A.

G. The 2002 MOA addressed several issues. First, the 2002 MOA addressed how the monies in the Conservation Fund were to be utilized going forward. Second, the 2002 MOA allocated certain responsibilities between SAWA and OCWD. Third, the 2002 MOA established the SAWA ILF Program, which provided SAWA the ability to receive mitigation funding from (or to sell mitigation credits to) persons, agencies and/or entities with mitigation requirements under Corps regulatory permits in the task areas set forth in Section II.B of the 2002 MOA.

H. Under the terms of the 2002 MOA: "The [ILF] program will be reevaluated at the end of year seven of a ten-year cycle by the Parties. At the end of each cycle, the program will be redesigned and/or renewed by the Parties and extended."

I. The funds in the Conservation Fund, totaling approximately $8,430,900.00, were transferred from OCWD to SAWA in 2006. Those transferred funds included original contributions by OCWD and the Nature Conservancy for OCWD mitigation projects, wildlife management and monitoring in the Prado Basin and Upper SAR Watershed totaling approximately $3,611,953.00 ("OCWD Funds"). The OCWD Funds are managed to earn interest to continue to fund those activities and to maximize the number of years that those activities may be sustained by the original investments, as follows: (a) a portion of the OCWD Funds has been expended for the specific purposes of invasive weed control, restoration, and wildlife management and monitoring; and (b) a portion of the OCWD Funds that were received for mitigation purposes has been held, invested, and managed for ongoing maintenance of Prado Basin habitat restoration sites, including wildlife monitoring.

J. OCWD Funds were earmarked in various prior agreements among OCWD, U.S. Fish & Wildlife Services, and the Army Corps of Engineers for use on OCWD Basin Lands designated for mitigation, including invasive weed control and wildlife management and monitoring in the Prado Basin as well as to help maintain restoration and biological management efforts in the Upper SAR Watershed.

K. In 2006, the Conservation Fund was re-designated as the "Santa Ana River Watershed Trust Fund" ("SAWA Trust Fund").

L. The value of the OCWD Funds in the SAWA Trust Fund was approximately $2,988,000.00 as of December 31, 2012. The OCWD Funds in the SAWA Trust Fund are held in a separate account referred to as the "OCWD Account".

M. The Parties acknowledge that comprehensive tracking of past and ongoing expenditures from the SAWA Trust Fund is crucial and that a third-party forensic audit of the Fund to be completed within twelve (12) months of the execution of this Agreement is critical for maintaining public accountability and to ensure compliance with all legal requirements. Costs and expenses incurred in performing the audit shall be borne equally by the Parties, as described in more detail below.

N. In compliance with an agreement with the regulatory agencies, OCWD and SAWA desire that the OCWD funds in the OCWD Account as of the Effective Date of this Agreement be utilized as follows: (i) fifty percent (50%) of the OCWD Funds will be utilized for endangered bird monitoring and management in Prado Basin and habitat restoration on OCWD Basin Lands, and (ii) fifty percent (50%) of the OCWD Funds will be utilized for wildlife monitoring and management and habitat restoration in the Upper SAR Watershed.

O. Since the 2002 MOA became effective, SAWA has received funding from a variety of sources, including: (1) funds paid by OCWD to SAWA to assist OCWD in completing regulatory mitigation for OCWD projects not covered by the 2002 MOA ("OCWD Permittee Responsible Mitigation"); (2) funds paid by third party project proponents to SAWA to assist such parties in completing regulatory mitigation for third party projects ("Third Party Permittee Responsible Mitigation"); and (3) funds paid by OCWD or third parties for the purpose of acquiring credits in the existing SAWA ILF Program ("SAWA ILF Mitigation Funds").

P. In addition to the above sources of funding, the Parties acknowledge that SAWA is currently pursuing approval of a new/updated in-lieu fee program ("New SAWA ILF Program") with the U.S. Army Corps of Engineers ("Corps"). The Parties further acknowledge that, in compliance with the "2008 Corps Mitigation Rule" (33 CFR Parts 325 and 332), the requirements for operating and administering new in-lieu fee programs are and will be more comprehensive and complex than for ILF plans adopted prior to the issuance of the 2008 Mitigation Rule. As a result, it is in the Parties' best interests to tailor this Agreement to ensure that all legal requirements are followed for funds received by SAWA from OCWD after the New SAWA ILF Program is approved and its related instrument is fully executed.

Q. In particular, the Parties acknowledge that future mitigation for OCWD projects in which SAWA is involved is likely to take one of two forms, as defined in the 2008 Mitigation Rule (see 33 CFR § 332.2; 73 Fed. Reg. 19,594, 19,601 (Apr. 10, 2008)): (1) OCWD Permittee Responsible Mitigation, under which OCWD will retain ultimate responsibility for ensuring the required regulatory permit conditions are met and for "any long-term protection and/or management of the compensatory mitigation project" (73 Fed. Reg. at 19,601), but where SAWA will assist "ad hoc" in the mitigation efforts (i.e., SAWA is effectively retained as an OCWD contractor); and (2) OCWD purchasing mitigation credits from SAWA pursuant to the New SAWA ILF Program, wherein from the date that acknowledgement of acceptance of OCWD payment is made by SAWA, SAWA alone accepts final and ultimate responsibility for ensuring that the mitigation obligations associated with the purchased credits are satisfied.

R. As discussed in more detail below, the Parties acknowledge that: (1) SAWA retains the right, in its full and complete discretion, to decide whether to participate in any future OCWD Permittee Responsible Mitigation project ("Future Project") offered to SAWA; (2) it is in the best interest of the Parties that they understand the appropriate level of control to be exercised by OCWD in each of its sponsored mitigation projects; (3) due to the requirements of the 2008 Mitigation Rule, funds paid to SAWA for purchase of credits under the New SAWA ILF Program must be placed in an account separate from the SAWA Trust Fund, including the OCWD Account, managed separately and used only to support in lieu fee projects; and (4) the 2008 Mitigation Fee Rule states that funds received by in-lieu fee programs from the sale of mitigation credits, as well as any interest from such sales, must be used only to provide mitigation under the in-lieu fee program. (*Id.*)

S. OCWD and SAWA now desire to enter into this Agreement to set forth the terms and conditions guiding the expenditure of, and accounting for OCWD's past and future contributions to the SAWA Trust Fund, as well as related issues addressed under this Agreement.

AGREEMENT

NOW, THEREFORE, in consideration of the recitals above which are incorporated into this Agreement, and the covenants, conditions and promises contained herein, OCWD and SAWA hereby agree as follows:

1. Use of OCWD Funds, Equipment and Facilities

1.1 Recitals. The Recitals listed above are fully incorporated into this Agreement.

1.2 Completed Work. The Parties acknowledge and agree that certain obligations under the previous 2002 MOA have been completed, while others remain ongoing as of the date that this Agreement is fully executed by the Parties ("Effective Date"). Exhibit B, which is attached hereto and is incorporated by reference herein, describes the obligations under the 2002 MOA that the Parties agree have been completed and for which no work or payment(s) remain outstanding as of the Effective Date. Exhibit C, which is also attached hereto and is incorporated by reference herein, describes work contemplated under the 2002 MOA that the Parties agree has not been completed or is ongoing as of the Effective Date of this Agreement.

1.3 Allocation of OCWD Funds. The OCWD Funds in the OCWD Account as of the Effective Date shall be utilized only as follows: (i) Fifty percent (50%) of the OCWD Funds shall be utilized for endangered bird monitoring and management in Prado Basin (including the costs reimbursed to OCWD pursuant to Paragraph 1.2 below) and habitat restoration on OCWD Basin Lands, and (ii) Fifty percent (50%) of the OCWD Funds shall be utilized for wildlife monitoring and management and habitat restoration in the Upper SAR Watershed. As discussed in more detail below, utilization and allocation of funding contributed by OCWD to SAWA after the Effective Date of this Agreement shall be determined jointly by OCWD and SAWA, on a case-by-case basis, in accordance with the requirements of the particular mitigation project at issue.

1.4 Fund Balance. SAWA and all agencies with directors designated to the SAWA Board shall receive written notice from SAWA's Executive Director within thirty (30) calendar days if the balance of the OCWD Account falls below the amount of two hundred fifty thousand dollars ($250,000).

1.5 Separate Accounts. After the New SAWA ILF Program is implemented, any funds received by SAWA from OCWD's purchase of in-lieu fee credits shall be placed in a SAWA in-lieu fee account that is separate from the SAWA Trust Fund and OCWD Account, and shall be managed separately and used only to support in-lieu fee projects.

1.6 Reimbursement for Prado Vireo Monitors. As part of its long-term mitigation obligations, OCWD is required by the Corps and United States Fish and Wildlife Service ("USFWS") to fund certain biological field personnel to undertake mitigation activities (the "OCWD/SAWA Field Personnel"). SAWA has also used the expertise of the OCWD/SAWA Field Personnel on other SAWA projects. As a result, the OCWD/SAWA Field Personnel spend portions of their time working on things such as: (1) mitigation projects, including OCWD mitigation projects, in which SAWA is involved; (2) SAWA projects unrelated to OCWD mitigation activities (i.e., third party mitigation projects or projects funded by the SAWA Trust Fund, but not by OCWD Funds); and (3) OCWD projects unrelated to SAWA activities.

Over time, the Parties have come to determine that, for purposes of undertaking the projects described in the first two categories listed above, OCWD approximately fifty percent (50%) of the time of the one OCWD staff biologist and one SAWA contract biologist, and 100% of the time of the OCWD vireo monitoring contractor. As a result, OCWD has historically issued an invoice to SAWA each month to cover the salaries and benefit costs for one-half (1/2) of the time of the one staff biologist and one SAWA contract biologist, and the entire cost of the vireo monitoring contractor. SAWA agrees to continue the above-described billing practice after the Effective Date of this Agreement, subject to the following: (1) The amount of time expended by the OCWD/SAWA Field Personnel on OCWD projects shall be tracked, and all related salary and benefit reimbursement paid to OCWD by SAWA shall be made from the OCWD Account; (2) the amount of time expended by the OCWD/SAWA Field Personnel on SAWA projects not involving OCWD mitigation shall be tracked, and all related salary and benefit reimbursement paid to OCWD by SAWA shall be made from the SAWA Trust Fund or from other monies available to SAWA, but not from the OCWD Account; (3) the Parties shall meet no less than once every twenty-four (24) months to determine whether the reimbursement to OCWD by SAWA of the time and benefits of the OCWD/SAWA Field Personnel under this Agreement continues to track the relative use of the personnel on OCWD projects and SAWA projects; and (4) nothing in this Agreement requires SAWA to reimburse OCWD for the time of the OCWD/SAWA Field Personnel on OCWD projects if the OCWD Funds are insufficient to cover such costs, or if SAWA utilizes the OCWD/SAWA Field Personnel less than twenty-five percent (25%) of what is contemplated under this Agreement.

SAWA shall pay each valid OCWD invoice issued under this paragraph within thirty (30) calendar days of SAWA's receipt of an invoice from OCWD. Such payment shall be made from funds in the applicable account.

1.7 OCWD Contributions for Habitat Monitoring and Management. OCWD shall contribute the following equipment and facilities to SAWA to assist in endangered bird and habitat monitoring and management activities related to this Agreement:

1.7.1 OCWD shall provide office space, a vehicle, and other logistical support, including cellular phones and computers, for the OCWD/SAWA Field Personnel at OCWD's sole cost and expense. The Three Field Personnel shall be jointly supervised by OCWD's Habitat Restoration Manager and SAWA's Lead Biologist on OCWD Projects, but exclusively by SAWA's Habitat Restoration Manager on SAWA Projects, including projects under the New SAWA In-Lieu Fee Program.

1.7.2 OCWD shall pay for supplies for cowbird traps used annually in the Upper SAR Watershed.

1.7.3 OCWD shall furnish a desk, phone, and computer for one SAWA-employed biologist at the OCWD office in Fountain Valley, California.

1.7.4 While assisting with wildlife monitoring and management in the Prado Basin, SAWA employees will be allowed to use available OCWD facilities and field equipment including but not limited to vehicles. Any SAWA employee driving an OCWD vehicle must carry proof of insurance and a valid California Driver's License and be acknowledged as a safe driver with a good driving record; OCWD reserves the right to deny any SAWA employee access to an OCWD vehicle if OCWD determines in good faith that the SAWA employee is not a safe driver with a good driving record, or that the SAWA employee lacks either adequate insurance or a valid California Driver's License.

1.8 Habitat Restoration and Related Activities.

1.8.1 Use of Contractors on OCWD Habitat Restoration Sites. When it is determined by SAWA that a contractor will be necessary for all or a portion of OCWD Work on OCWD Basin Lands or other Prado Basin lands where the owner has consented to such work and such work is being undertaken on an OCWD Permittee Responsible Mitigation Project, or where SAWA has otherwise accepted responsibility for conducting such work, SAWA will promptly inform OCWD of the need to select a contractor. SAWA shall coordinate and supervise the conduct of the work. The expenses, including salaries and costs, for the contract work will be paid using funds in the OCWD Account. In the event that OCWD disapproves of the retention of a contractor as discussed in this section, it will notify SAWA that it objects to such retention within three (3) business days from the date on which SAWA informed OCWD of the need for the contractor. In such event, OCWD and SAWA shall promptly meet in good faith in an effort to resolve any issues with respect to the retention of such contractor.

1.8.2 Permits and Approvals. OCWD shall provide technical assistance to SAWA in processing applications for and obtaining issuance of any and all governmental permits, approvals, licenses and other authorizations that may be required in connection with habitat restoration operations or activities within Prado Basin by SAWA or its contractor. SAWA shall obtain any and all such governmental permits, approvals, licenses and other authorizations. No approval or consent given under this Agreement by OCWD shall affect or limit SAWA's obligations hereunder, or be deemed to be approval as to compliance or conformance with any applicable governmental code, law, order, rule or regulation.

1.8.3 Completion of Construction. Upon OCWD and SAWA concurring that construction of the habitat restoration project is complete, SAWA shall transmit to OCWD a final invoice accompanied by a certified statement of the total costs paid by SAWA for the design and construction of the habitat restoration project. Within thirty (30) days of its receipt of such final invoice, the certified statement, and supporting documentation, OCWD shall authorize payment from the OCWD Account.

1.8.4 Access to OCWD Lands. For all work on OCWD Lands performed by SAWA under this Agreement, OCWD shall provide and allow SAWA, including SAWA's contractors, subcontractors, agents, and authorized volunteers, to have access on and over all easement areas and private property held by OCWD for the period of time necessary to complete such work.

2. <u>Accounting for Funds and Annual Audit.</u>

2.1 <u>OCWD Funds</u>. Subject to the reimbursement from the OCWD Account for associated costs, SAWA shall account for and document all of the principal and interest in the OCWD Account of the SAWA Trust Fund. SAWA may comingle the funds in the OCWD Account with other SAWA funds for investment purposes, but SAWA shall account for the OCWD Account funds separately. Provided, however, that SAWA ILF Program funds, including New SAWA ILF Program funds, shall not be commingled with the OCWD Account funds or any other SAWA or OCWD funds. Subject to the reimbursement from the OCWD Account for associated costs, the ledger and accounting of the OCWD Account will be updated monthly and available for inspection and periodic examination by OCWD. SAWA shall annually conduct an audit of the entire SAWA Trust Fund, including the OCWD Account, and provide a copy of such audited accounts records to OCWD. SAWA's annual audit is separate and in addition to, and not in lieu of, the discretionary audits that OCWD may conduct in accordance with Paragraph 4.9 below.

2.2 <u>Forensic Audit</u>. The Parties agree that a forensic audit of the SAWA Trust Fund shall be undertaken and completed within twelve (12) months of the Effective Date of this Agreement. Such audit shall include all activities associated with the SAWA Trust Fund to date. All costs and expenses in connection with the audit shall be borne equally by the Parties (i.e., SAWA and OCWD shall each pay for fifty percent (50%) of the forensic audit).

2.3 New OCWD Contributions to the OCWD Account. Any contributions by OCWD into the SAWA Trust Fund following the Effective Date will become part of the OCWD Account of the SAWA Trust Fund. The Parties acknowledge that future contributions by OCWD to SAWA may be for different purposes, including (1) SAWA assistance on future OCWD Permittee Responsible Mitigation Projects; (2) OCWD purchasing credits from SAWA under the SAWA ILF Program and/or the New SAWA ILF Program; or (3) payments by OCWD to SAWA to continue funding of mitigation obligations under OCWD's existing regulatory permits. All funds received by SAWA from OCWD for credits under the SAWA ILF Program or the New SAWA ILF Program shall be received, used, expended, and maintained in strict accordance with the Corps 2008 Mitigation Rule and kept in an account that is separate from the SAWA Trust Fund and the OCWD Funds. With respect to all work described in this paragraph, including the receipt, use, expenditure, and maintenance of all funds in connection with such work, it shall be governed by a separate agreement, which may be in the form of a project implementation agreement, services agreement, or other type of agreement as necessary and required for such work.

2.4 Return of OCWD Funds. Article VI of the SAWA Articles of Incorporation specifies the process for dissolution and winding up of SAWA, including distribution of SAWA's assets and liabilities. Specifically, Article VI, section (b), provides that upon dissolution or winding up of SAWA, the assets of SAWA that remain after payment of all of SAWA's debts and liabilities shall be distributed to a nonprofit corporation that is "organized and operated exclusively for similar charitable and educational purposes meeting the requirements for exemption provided by Section 214 of the Revenue and Taxation Code, and which has established its tax-exempt status under section 501(c)(3) of the Internal Revenue Code..." The Parties acknowledge that at the time of entering into this Agreement, the dissolution and/or winding up of SAWA is not being contemplated, and is not anticipated to occur during the term of this Agreement (including any extensions thereto). However, in the event that such dissolution and/or winding up of SAWA is contemplated by the SAWA Board of Directors while this Agreement is in effect, the Parties agree to the following:

(a) The Parties acknowledge that pursuant to section 305 of the SAWA Bylaws, SAWA is subject to certain public notice and agenda requirements under the Ralph M. Brown Act (Govt. Code, §§ 54950, et seq.) (The "Brown Act"), including the requirement to properly and timely agendize any SAWA Board discussions regarding the possible dissolution and/or winding up of SAWA in accordance with the Brown Act;

(b) At least one month before any SAWA Board of Directors meeting that occurs during the term of this Agreement (including any extensions thereto) that includes an agenda item relating to the possible dissolution and/or winding up of SAWA, SAWA shall provide written notice to OCWD that SAWA intends to place such an item on the SAWA Board agenda for discussion;

(c) Upon SAWA providing and OCWD receiving such written notice, the Parties shall promptly meet and confer in good faith to determine the amount of OCWD Funds held by SAWA at that time pursuant to this Agreement. Such meet and confer process may, at either party's election, include an accounting to establish the amount of OCWD Funds held by SAWA. Any such meetings between the Parties shall occur prior to the SAWA Board of Directors formally considering dissolution and/or winding up of SAWA;

(d) Prior to the SAWA Board of Directors voting to dissolve or wind up SAWA, SAWA shall transmit to OCWD the OCWD Funds held by SAWA, in the amount determined pursuant to the meet and confer and accounting process specified in subdivision (c) above. The Parties further acknowledge that any debts and/or liabilities of SAWA directly resulting from this Agreement, or pursuant to one or more project implementation agreements, services agreements, or other type of agreements as specified in Section 2.3 above, that were incurred prior to and/or after the meet and confer and accounting process specified in subdivision (c) above shall be deducted by SAWA prior to the return of the OCWD Funds to OCWD.

3. Future Projects.

3.1 OCWD Discretion to Initiate Future Projects. OCWD retains the right to direct future funding from sources other than the OCWD Account to SAWA for mitigation requirements associated with additional Santa Ana River water conservation, operations or other projects relating to Prado Basin or the Upper SAR Watershed (each, a "Future Project") in accordance with this Section Three. The Parties acknowledge that these Future Projects will take the form of OCWD Permittee Responsible Mitigation, as defined in the 2008 Corps Mitigation Rule. In contrast to such Future (OCWD Permittee Responsible Mitigation) Projects, OCWD may also elect to purchase credits from the New SAWA ILF Program. Such ILF purchase credit transactions shall not be considered Future Projects under this Agreement. Any OCWD purchase of ILF Program credits from SAWA shall be subject to the terms of the New SAWA ILF Program Instrument and the requirements of the 2008 Corps Mitigation Rule, including any amendments to that rule. Any such credit purchases by OCWD shall be at the same credit price offered to third parties requesting to purchase SAWA ILF program credits. OCWD payments to purchase credits shall be placed in the New SAWA ILF Program account, as required by the 2008 Mitigation Rule, and shall not be placed in the OCWD Account.

3.2 Request for Participation in Future Project. If OCWD determines to initiate a Future Project, OCWD shall transmit a written notice to SAWA setting forth the description and scope of the Future Project, including the schedule therefor, and the projected cost/budget, and requesting SAWA's performance of the Future Project. At the same time, OCWD shall also provide SAWA with a copy of a regulatory permits and habitat monitoring plans associated with such project. OCWD acknowledges that OCWD will ultimately be responsible for obtaining all regulatory agency approvals for such Future Projects, including satisfaction of all permit conditions, though SAWA may engage in ad hoc assistance on such projects consistent with the 2008 Corps Mitigation Rule.

3.3 Acceptance of Work. Within sixty (60) calendar days of its receipt of a written request from OCWD regarding a Future Project, SAWA shall notify OCWD in writing whether SAWA will agree to perform a portion or all of such Future Project, which portions SAWA will undertake (if not taking the entire Future Project), and the expected timeline for completion of work on the Future Project. The Parties understand and agree that such notification by SAWA to OCWD may be given by SAWA's execution of a project implementation agreement, services agreement, or other type of agreement as necessary and required (as specified in Section 2.3 above). OCWD may choose to accept or reject any SAWA proposal to undertake only a portion of such Future Project with fourteen (14) calendar days of receipt of SAWA's proposal. If OCWD does not respond within the 14-day period, the Parties will assume that OCWD has agreed to SAWA's proposal to undertake work (or any portion thereof) on the Future Project.

3.4 If SAWA agrees to perform the Future Project, SAWA shall coordinate and supervise the work in connection with the Future Project. OCWD shall be responsible for undertaking compliance with the California Environmental Quality Act ("CEQA") and/or the National Environmental Policy Act ("NEPA"), if applicable. In connection with SAWA's work on a Future Project:

3.4.1 Use of Contractors or SAWA Staff. SAWA shall determine whether the Future Project should be performed by a contractor or by SAWA's employees. If SAWA determines that a contractor should perform the Future Project, SAWA shall enter into a contract with a qualified and licensed contractor for the work. If SAWA determines that SAWA staff should perform the Future Project, SAWA shall prepare a budget for the Future Project, including the SAWA staff members to perform the Future Project work, their respective rates of pay and the anticipated time for the performance of the work.

3.4.2 Implementation of the Future Project. SAWA shall invoice OCWD monthly for funds to pay for the performance of the Future Project undertaken to such date, and provide OCWD with such supporting documentation as may be reasonably necessary for OCWD to review the invoice. Within thirty (30) days of its receipt of each such invoice and supporting documentation, OCWD shall transmit payment to SAWA. In the event of a dispute between SAWA and OCWD over an invoice, OCWD and SAWA shall promptly meet in good faith in an effort to resolve any issues with respect to the payment of the invoice.

4. Legal Relations and Responsibilities.

4.1 Compliance with Laws.

(a) SAWA shall keep itself fully informed of and comply with all existing and future Federal and State laws and local ordinances and regulations which in any manner apply to the activities and operations of SAWA under this Agreement. SAWA shall protect and indemnify, as required herein, OCWD, its officers, directors, employees and agents against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order or decree, whether by SAWA or any person or entity acting in the employment of, while employed by, or under contract to, SAWA.

(b) OCWD shall keep itself fully informed of and comply with all existing and future federal and state laws and local ordinances and regulations which apply to the activities and operations of OCWD under this Agreement. OCWD shall protect and indemnify, as required herein, SAWA, its officers, directors, employees, designating agencies, agents, and authorized volunteers against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order or decree, by OCWD or any person or entity acting in the employment of, while employed by, or under contract with OCWD.

4.2 Nature of Relationship. This Agreement does not create, and shall not be construed or deemed to create, any agency, partnership, joint venture, landlord-tenant or other relationship between OCWD and SAWA.

4.3 Insurance. Without limiting the Parties' respective indemnification obligations, each Party shall procure and maintain, at its sole cost and for the duration of this Agreement, insurance coverage as provided below, against all claims for injuries against persons or damages to property which may arise from or in connection with the performance of the work hereunder by such Party, its agents, representatives, employees, and/or subconsultants. In the event that either Party subcontracts any portion of the work, the contract between the Party and such subcontractor shall require the subcontractor to maintain the same policies of insurance that the applicable Party is required to maintain pursuant to this Section 5.3. To the extent that the minimum insurance coverage amounts described below result in additional cost(s) to SAWA for work paid for, in whole or in part, with OCWD Funds, SAWA shall produce evidence of such additional or new cost(s) to OCWD, accompanied by a request that such additional cost(s) be reimbursed to SAWA from the OCWD Funds. For example, if SAWA is required to provide a waiver of subrogation under this Agreement for mitigation work paid for, in whole or in part, with OCWD Funds, and such waiver of subrogation results in additional costs to SAWA, then SAWA may request that it be reimbursed from the OCWD Funds for such additional incremental cost(s). Upon receipt of a valid request from SAWA, OCWD will promptly authorize reimbursement.

4.3.1 Insurance Coverage Required. The policies and amounts of insurance shall be as follows:

(a) Commercial General Liability Insurance. Each Party shall provide and maintain commercial general liability insurance. The coverage for commercial general liability insurance shall be at least as broad as the following: Insurance Services Office (ISO) Commercial General Liability Coverage (Occurrence Form CG 0001). Each Party shall maintain limits no less than the following: Two million dollars ($2,000,000) per occurrence for bodily injury, personal injury and property damage. If Commercial General Liability Insurance or other form with a general aggregate limit or products-completed operations aggregate limit is used, either the general aggregate limit shall apply separately to the project/location (with the ISO CG 2503, or ISO CG 2504, or insurer's equivalent endorsement provided to OCWD) or the general aggregate limit and products-completed operations aggregate limit shall be twice the required occurrence limit.

(b) Automobile Liability Insurance. Each Party shall provide and maintain automobile liability insurance. The coverage for automobile liability insurance shall be at least as broad as the following: Insurance Services Office (ISO) Business Auto Coverage (Form CA 0001) covering Symbol 1 (any auto). Each Party shall maintain limits no less than the following: One Million Dollars ($1,000,000.00) for bodily injury and property damage each accident limit.

(c) Workers Compensation and Employer's Liability. Each Party and all subcontractors shall insure (or be a qualified self-insured) under the applicable laws relating to workers' compensation insurance, all of their employees working on or about the construction site, in accordance with the "Workers' Compensation and Insurance Act", Division IV of the Labor Code of the State of California and any Acts amendatory thereof. Each Party shall provide employer's liability insurance with limits of no less than $1,000,000 each accident, $1,000,000 disease policy limit and $1,000,000 disease each employee.

4.3.2. General Requirements. Each Party's insurance:

(a) Shall be issued by an insurance company, which maintains an A.M. Best's rating of "-A, VII" or higher; unless otherwise approved by both Parties;

(b) General Liability and Automobile Liability shall name the other Party (e.g., "OCWD, and its officers, officials, employees, agents, representatives and volunteers (collectively hereinafter "OCWD and OCWD Personnel") as additional insureds" and contain no special limitations on the scope of protection afforded to the other Party or its personnel. All insurance provided hereunder shall include the appropriate separate endorsement(s).

(c) Shall be primary insurance and any insurance or self-insurance maintained by the other Party or its personnel shall be in excess of the applicable Party's insurance and shall not contribute with it;

(d) Shall apply separately to each insured against whom claim is made or suit is brought, except with respect to the limits of the insurer's liability;

(e) Workers' Compensation and Employer's Liability shall be endorsed to state that the insurer shall waive all rights of subrogation against OCWD and OCWD Personnel, excluding Professional Liability;

(f) Shall have project name and/or agreement number indicated on certificate; and

(g) Shall be endorsed to state that coverage shall not be suspended, voided, cancelled, reduced in coverage or in limits, nonrenewed, or materially changed for any reason, without thirty (30) days prior written notice thereof given by the insurer to the other Party by U.S. mail, or by personal delivery, except for nonpayment of premiums, in which case ten (10) days prior notice shall be provided.

4.3.3 Deductibles. Any deductibles or self-insured retentions must be declared to and approved by the other Party prior to the execution of this Agreement by OCWD.

4.3.4 Evidence of Coverage. Each Party shall furnish the other Party with certificates of insurance with additional insured (Form 2010) including waiver of subrogation endorsement, demonstrating the coverage required by this Agreement, which shall be received and approved by the other Party not less than five (5) working days before work commences.

4.3.5 Workers Compensation Insurance. No Employees/Sole Proprietor. By his/her signature hereunder, the Parties certify that they are aware of the provisions of Section 3700 of the California Labor Code which requires every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that code, and that they will comply with such provisions before commencing the performance of the work of this Agreement. The Parties, will keep, and require their contractors and subcontractors to keep Workers Compensation Insurance for their employees in effect during all work covered by this Agreement.

4.4 Mutual Indemnification.

(a) SAWA Responsibilities. SAWA agrees to indemnify, defend, and hold harmless OCWD, its officers, officials, employees, agents, consultants, and authorized volunteers from any and all claims, demands, costs or liabilities arising from or connected with all activities governed by this Agreement, due to the negligent acts, errors, omissions, or willful misconduct of SAWA. SAWA will reimburse OCWD for any expenditures, including reasonable attorneys' fees and expert witness fees, incurred by OCWD in defending against claims ultimately determined to be due to negligent acts, errors, omissions, or willful misconduct of SAWA in connection with this Agreement.

(b) OCWD Responsibilities. OCWD agrees to indemnify, defend, and hold harmless SAWA, its officers, officials, employees, agents, consultants, and authorized volunteers from any and all claims, demands, costs or liabilities arising from or connected with all activities governed by this Agreement, due to the negligent acts, errors, omissions, or willful misconduct of OCWD. OCWD will reimburse SAWA for any expenditures, including reasonable attorneys' fees and expert witness fees, incurred by SAWA in defending against claims ultimately determined to be due to negligent acts, errors, omissions, or willful misconduct of OCWD in connection with this Agreement.

4.5 No Representation or Warranty. Each party acknowledges that neither the other party, nor any of the other party's officers, employees, agents or representatives, has made any written or oral representation, promise or warranty, express or implied, regarding any matter that is the subject of this Agreement, other than as expressly set forth herein.

4.6 Assignment. SAWA may not transfer, assign, convey, hypothecate or encumber this Agreement or any interest herein, whether voluntarily or by operation of law, and whether for the benefit of creditors or otherwise, without the prior written express approval of OCWD, which OCWD may withhold in its sole and absolute discretion. In the event of any unapproved transfer, including but not limited to any bankruptcy proceeding, OCWD may, in its sole and absolute discretion, terminate this Agreement upon not less than fifteen (15) days' prior written notice to SAWA. The foregoing shall not be deemed to apply to any cooperative agreements that SAWA may enter into with a different legal entity conducting similar business.

4.7 No Obligation to Third Parties. The approval and execution of this Agreement shall not be deemed to confer any rights upon any person or entity other than OCWD and SAWA. There are no third party beneficiaries to this Agreement.

4.8 Conflict of Interest. No officer, official, employee, agent, representative or volunteer of OCWD or SAWA shall have any financial interest, direct or indirect, in this Agreement, or participate in any decision relating to this Agreement which affects his or her financial interest or any entity in which he or she is financially interested, in violation of any federal, state or local statute, ordinance or regulation.

4.9 Records and Review. SAWA shall keep and maintain all records, accounts and reports relating to this Agreement for a period of three (3) years following the expiration or earlier termination of this Agreement, and OCWD shall have access to such records at any time during normal business hours upon seventy-two (72) hours' notice to SAWA. At its cost, OCWD shall have the right to audit the books, records and accounts of SAWA no more than once annually and SAWA shall provide reasonable cooperation to OCWD in this regard. Such audit right by OCWD is not in lieu of SAWA's obligation to audit the SAWA Trust Fund, including the OCWD Account, pursuant to Paragraph 2.1 above.

4.10 Disputes. In the event of a dispute between the parties regarding the interpretation of this Agreement or the enforcement of its rights or the other party's obligations hereunder (a "Dispute"), the aggrieved party may initiate legal proceedings against the other party, but only following exhaustion of the informal dispute resolution process set forth in Paragraph 4.10.1, and non-binding mediation in accordance with Paragraph 4.10.2.

4.10.1 Either party may seek to resolve a Dispute by means of informal dispute resolution. A party shall initiate the informal dispute resolution process by transmitting written notice to the other party, setting forth the nature and extent of the Dispute, and requesting that the parties engage in informal dispute resolution. Within ten (10) working days from the date of receipt of the request for informal dispute resolution, staff members of both of the parties shall meet and confer in a good faith effort to resolve the Dispute by recognizing their mutual interests and attempting to reach a resolution of the Dispute that is just, equitable and satisfactory to both parties. The parties may by mutual agreement recess or continue the informal dispute resolution conference. In the event that the parties have not reached a mutually satisfactory resolution of the Dispute within ten (10) calendar days following the date of the initial informal dispute resolution conference (unless the parties have mutually agreed to extend the process beyond the 30 days), either party may initiate non-binding mediation.

4.10.2 Mediation shall be conducted under the auspices of the Judicial Arbitration and Mediation Services, Inc. ("JAMS"). A party may initiate mediation by transmitting a written notice to the other party ("Mediation Notice"), setting forth the nature and scope of the Dispute, requesting mediation, and proposing five (5) mediators from the Orange County office of JAMS as candidates to serve as the mediator for the Dispute ("Mediator"). Within ten (10) working days from the receipt of the Mediation Notice, the responding party shall respond in writing, selecting one of the proposed mediators as the Mediator. In the event that the parties are unable to select the Mediator, the question of the selection of the Mediator shall be submitted to the Presiding Judge of the Orange County Superior Court in accordance with Code of Civil Procedure Section 1281.6. The fees and expenses of the Mediator shall be shared equally by OCWD and SAWA. The mediation shall be conducted generally in accordance with the JAMS "Guide to the Mediation Process for Lawyers and their Clients," as published on the JAMS website as of the date of this Agreement.

4.10.3 In the event that the parties are unable to reach a mutually satisfactory resolution of the Dispute by means of non-binding mediation, either party may initiate and prosecute litigation in the Riverside County Superior Court to adjudicate the Dispute (the "Action"). The prevailing party in the Action, in addition to any other relief and recovery ordered by the court, shall be entitled to recover all statutory costs, plus reasonable attorneys' fees and expert witness costs.

5. Miscellaneous.

5.1 Term and Termination. This Agreement shall remain in effect for a period of ten (10) years, beginning on the Effective Date and expiring on the tenth (10^{th}) anniversary thereto, unless terminated earlier by mutual written agreement of the Parties. The Parties agree to meet and confer in person at least once every five (5) years during the term of this Agreement in order to evaluate the programs described herein and to determine whether the Agreement should be extended. Either Party may terminate this Agreement with or without cause upon ninety (90) days written notice to the other. From and after the date of such termination notice, SAWA shall not expend any further funds from the OCWD Account except (a) to pay contractors or reimburse OCWD for work performed prior to the date of such notice, or (b) in accordance with the prior written consent of OCWD. Upon termination, SAWA shall prepare a final accounting of the funds in the OCWD Account in the SAWA Trust Fund, and deliver to OCWD both a copy of the final accounting and the remaining balance of funds in the OCWD Account as of the date of termination. OCWD shall have the right, at its cost and within 120 days of the date of its receipt of such funds and final accounting, to review and audit the books and records of SAWA.

5.2 Notices. Any notice, payment or instrument required or permitted to be given or delivered by this Agreement may be given or delivered by personal delivery or by depositing the same in any United States mail depository, first class postage-prepaid, and addressed as follows:

If to OCWD:	Orange County Water District P.O. Box 8300 18700 Ward Street Fountain Valley, CA 92728 Attn: Natural Resources Director
If to SAWA:	Santa Ana Watershed Association P.O. Box 5407 Riverside, CA 92517 Attn: Executive Director

or such other person or address as either party may direct in writing to the other; provided, however, that such new or different person or address shall not become effective until acknowledged in writing by the party to whom directed or 7 days after transmission thereof by registered or certified mail, whichever first occurs. Except where service is by personal delivery or by registered or certified mail, return receipt requested, service of any instrument or writing shall be deemed completed forty-eight (48) hours after deposit in the United States mail depository.

5.3 Contract Administration. The Natural Resources Director of OCWD or his or her designee shall administer this Agreement on behalf of OCWD; and, except as expressly required otherwise by this Agreement, the OCWD Natural Resources Director or his or her designee shall have the authority to take all actions that OCWD is required or authorized to take under this Agreement. The Executive Director of SAWA or his or her designee shall administer this Agreement on behalf of SAWA.

5.4 Headings. The titles and headings of sections and paragraphs of this Agreement, as set forth here, have been inserted for the sake of convenience only, and are not to be taken, deemed or construed to be any part of the terms, covenants or conditions of this Agreement, or to control or modify any of the terms, covenants or conditions hereof.

5.5 Time of Essence. Time is of the essence of this Agreement.

5.6 Waiver. No delay or omission in the exercise of any right or remedy by a non-defaulting party on any default shall impair such right or remedy or be construed as a waiver. A party's consent to or approval of any act or omission by the other party requiring the party's consent or approval shall not be deemed to waive or render unnecessary the other party's consent to or approval of any subsequent act or omission. Any waiver by either party of any default must be in writing.

5.7 Entire Agreement. This Agreement represents the entire understanding of OCWD and SAWA to those matters contained herein. No prior oral or written understanding shall be of any force or effect with regard to those matters covered by this Agreement. This Agreement supersedes and cancels any and all previous negotiations, arrangements, agreements or understandings, if any, between the parties, and none shall be used to interpret this Agreement.

5.8 Construction and Amendment. This Agreement shall be construed, interpreted, governed and enforced in all respects according to the laws of the State of California and as if drafted by both OCWD and SAWA. No amendment, change or modification of this Agreement shall be valid unless in writing, stating that it amends, changes or modifies this Agreement, and is signed by authorized representatives of both OCWD and SAWA.

5.9 Cooperation. SAWA and OCWD shall each execute and deliver any and all additional papers, documents and other assurances, and do any and all acts and things reasonably necessary, in connection with the performance of their obligations hereunder and to carry out the intent of the parties under this Agreement.

5.10 Warranty of Authority. Each officer of OCWD and SAWA affixing his or her signature to this Agreement warrants and represents by such signature that he or she has the full legal authority to bind his or her respective party to all of the terms, conditions and provision of this Agreement, that his or her respective party has the full legal right, power, capacity and authority to enter into this Agreement and perform all of its provisions and obligations, and that no other approvals or consents are necessary in connection therewith.

5.11 Successors. Subject to Paragraph 5.6 above, this Agreement, and all of the terms and conditions herein, shall inure to the benefit of, and be binding upon, OCWD, SAWA, and their respective successors and assigns.

IN WITNESS WHEREOF, the Parties have executed this Agreement as of the Effective Date first written above.

"OCWD"

ORANGE COUNTY WATER DISTRICT

By: ____________________
President

By: ____________________
General Manager

APPROVED AS TO FORM:

By: ____________________
General Counsel, Orange County Water District

"SAWA"

Santa Ana Watershed Association

By: ______________ 8-8-2013
Board Chair

By: ______________ 8-8-2013
Executive Director

APPROVED AS TO FORM:

By: ______________
General Counsel, SAWA

EXHIBIT A

Copy of 2002 MOA

MEMORANDUM OF AGREEMENT

THE SANTA ANA RIVER WATERSHED TRUST FUND
FOR ARUNDO ERADICATION AND HABITAT ENHANCEMENT
IN-LIEU FEE MITIGATION PROGRAM

This agreement regarding establishment of an In-Lieu Fee Program, hereinafter, the Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement (Fund) is made and entered into on (Date), by and among the U.S. Army Corps of Engineers, Los Angeles District (Corps), the Santa Ana Watershed Association of Resources Conservation Districts (SAWA), and the Orange County Water District (OCWD).

I. PREAMBLE

A. Whereas, the Corps, SAWA, and OCWD (collectively, "the Parties") recognize the effect of invasive non-native vegetation on decreasing functions related to native species habitat, water quality, and hydrology of riparian ecosystems and the importance of invasive non-native vegetation eradication for restoring and enhancing native riparian functions and values within waters of the United States including wetlands (see Exhibit A);

B. Whereas, the parties have the ability and desire to work with public and private landowners to restore riparian areas in the Santa Ana River Watershed that are infested with invasive, non-native plant species, such as but not limited to *Arundo donax* (Arundo), *Ricinius communis* (castor bean), and *Tamarix* spp. (saltcedar or tamarisk);

C. Whereas, discharge of dredge or fill material into waters of the U.S. including wetlands is regulated under provisions of Section 404 of the Clean Water Act and administered through a permit program under the auspices of the Corps;

D. Whereas, the Corps recognizes the potential for direct, indirect, and cumulative impacts that may occur to waters of the U.S. as a result of activities authorized under Section 404 of the Clean Water Act; the Corps requires compensatory mitigation including restoration and enhancement to offset unavoidable impacts to the aquatic resources to ensure authorized activities comply with the Section 404(b)(1) Guidelines (40 CFR 230);

E. Whereas, the Corps recognizes the utility of eradicating Arundo and other invasive exotic vegetation to increase functions and values of riparian ecosystems to compensate for unavoidable impacts to waters of the U.S. as evidenced by the peer-reviewed scientific literature (see Exhibit B);

F. Whereas, the Corps recognizes SAWA as a non-governmental natural resource management organization committed to increasing natural resource values within the Santa Ana River

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Watershed in the context of an established program (see Exhibits C and D)

G. Whereas, OCWD has established the Santa Ana River Watershed Trust Fund to eradicate Arundo and restore native riparian habitat, which supports endangered and sensitive species (see Exhibit E);

H. Whereas, the parties in partnership have demonstrated the wherewithal to successfully eradicate Arundo, manage endangered species, and involve the public (Exhibits C, D, E, and F);

I. Whereas, this success and expertise is manifest and recognized in the recovery progress of the least Bell's vireo in the Prado Basin, near-eradication of Arundo on San Timoteo Creek resulting in an excess of approximately 200 acres of riparian habitat values, and widespread public recognition and support in part through congressional appropriations (Exhibits F, G, and H);

J. Whereas, experience in eradicating Arundo for the purpose of compensatory mitigation has been demonstrated by the OCWD (Exhibits E and F) and SAWA (Exhibit G and H);

K. Whereas, those monies deposited into the Fund by permittees at the direction of the Corps will be solely used to restore and enhance riparian resources by removal of the invasive, non-native plant species listed above;

L. Whereas, the parties will obtain approval of public and private landowners prior to conducting any work on their lands;

M. Whereas, the Corps retains full authority to approve or deny the use of those Fund monies generated through the permitting process, to approve proposed project sites, and to approve or modify plans.

N. Whereas, this agreement does not in any manner affect statutory authorities and responsibilities of the signatory parties.

O. Whereas, the following exhibits are incorporated as appendices to this agreement:

- Exhibit A. Literature Summarizing Impact of Exotic Vegetation on Riparian Functions
- Exhibit B. Literature Summarizing Value of Exotic Vegetation Removal in Mitigation
- Exhibit C. SAWA Work Summary, Contract, and Budget for FY 2001 and FY 2002
- Exhibit D. Los Angeles Times Article on SAWA
- Exhibit E. Agreement establishing the Santa Ana River Watershed Trust Fund
- Exhibit F. Cooperative Agreement between the OCWD and the U.S. Fish and Wildlife Service to Cooperatively Manage OCWD's Lands in Prado Basin
- Exhibit G. Map of the San Timoteo Arundo Removal Project
- Exhibit H. Map of Arundo Removed from the Santa Ana Watershed Program
- Exhibit I. Santa Ana River Watershed Program Annual Work Plan

II. <u>OCWD AGREES TO</u>:

A. Maintain the dedicated interest-bearing account known as the Santa Ana River Watershed Trust Fund for the purpose of receiving funds to be used for this *Arundo* eradication and habitat enhancement program. The OCWD will annually provide a statement showing the credits and debits within the account.

B. Use the funds generated to support the following tasks: removal or treatment of invasive weeds, endangered species management, obtaining conservation easements, mapping, and monitoring (see Exhibit I). The OCWD will annually evaluate costs and provide a detailed cost analysis to the Corps.

C. Provide expertise, oversight, and assistance in all aspects of the activities that will be associated with the implementation of this Agreement, including permit compliance and reporting.

D. Maintain records, documents, and other evidence pertaining to monies received and expenses incurred related to removal of invasive exotics, mapping, monitoring, reporting, and other costs. By April 30 of each year, SAWA will provide the Corps with a statement detailing monies received and expenses incurred.

III. <u>SAWA AGREES TO</u>:

A. Accept legal responsibility to ensure mitigation terms are fully satisfied.

B. Remove non-native vegetation such as but not limited to *Arundo donax, Ricinus communis,* and *Tamarix* spp., maintain the site free of invasive non-native vegetation in perpetuity if invasive non-native vegetation exits upstream of the site or for 10 years otherwise, and provide annual monitoring reports to the Corps for a minimum period of three (3) years from establishment of each parcel. Annual monitoring reports must be submitted until sites remain at 1% or less exotic cover for 24 consecutive months. If invasive exotic vegetation cover is still greater than 1% beyond three years, eradication activities shall be reinitiated and the monitoring period cycle shall begin again, until there is less than 1% exotic cover for 24 consecutive months.

C. Plant native seedlings, rooted cutting, and propagules in areas where exotics are removed in a manner simulating natural riparian growth where there is a specific, compelling, biological or hydrological need to hasten natural recovery, as needed, and in accordance with the Annual Work Plan (Exhibit I).

D. Obtain all appropriate environmental permits, clearances, or approvals necessary to perform the removal and restoration work contemplated by this agreement.

E. Facilitate access to the restored areas by the Corps staff for the purpose of compliance inspections.

F. Perform annual monitoring and re-treatment, as needed, of all restored areas.

G. Maintain accurate records for expenditure of funds and documentation of restored areas showing date the work began for each parcel and total number of acres restored, all of which will be included in the annual reports submitted to the Corps.

H. Perform maintenance activities as needed for each parcel by treating the re-infested areas as documented in the Annual Work Plan (Exhibit I). The program will be reevaluated at the end of year seven of a ten-year cycle by the Parties. At the end of each cycle, the program will be redesigned and/or renewed by the Parties and extended. If the program is not renewed, no new treatment sites will be initiated in years eight through ten. However, OCWD and SAWA shall not be relieved of their obligations under this agreement to restore and maintain the areas for which it has received funds through the first seven years.

I. Obtain conservation easements or rights of entry before work is to be performed on private lands. These easements will allow for the treatment protocol as described in Exhibits H and I.

IV. The Corps Agrees to:

A. Review each project requiring a Section 404 permit on a case-by-case basis and determine the suitability to use the Fund to fulfill its compensatory mitigation requirements.

B. Determine the mitigation ratio on a case-by-case basis for projects requiring a Section 404 permit prior to issuance of the permit, considering the aquatic functions and values lost from the permitted activity and the functions and values gained from the exotics removal and habitat enhancement program.

C. Perform annual compliance visits to assess the conditions of the restored areas, recommend corrective measures, if any, for a period of three (3) years from the date of initial restoration.

V. It Is Mutually Agreed:

A. This program will be limited to mitigation for unavoidable, minimal impacts to aquatic resources in the Santa Ana River Watershed, including the San Jacinto River Watershed (Exhibit H). This program will be available to any person or organization receiving an authorization under Section 404 of the Clean Water Act. Use of this mitigation program is subject to the approval of the Corps on a case-by-case basis.

B. Funds provided for compensatory mitigation shall begin to be used for eradication efforts within a year.

C. This program shall not be used to mitigate for impacts to unique aquatic resources such as vernal pools, tidal/estuarine wetlands, and/or seep wetlands.

D. This program shall be limited to mitigation for 1) permanent impacts to aquatic resources authorized by a nationwide or regional general permit (generally less than 0.5 acre), 2) permanent impacts to aquatic resources authorized by an individual permit after compensatory mitigation is first performed at a 1:1 ratio (i.e one acre of mitigation for each acre of impact) using enhancement, restoration, or creation, 3) for temporary impacts to aquatic resources, and 4) unauthorized impacts to wetlands and other waters of the U.S. in conjunction with a restoration order.

E. An acre of mitigation in this program consists of the work performed on an acre of land with 100% infestation of invasive, non-native plants. Work on an acre of land with less than 100% infestation will receive credit proportional to the percentage infestation of invasive, non-native plants.

F. Success of the restored areas shall be assessed using the following criteria:

Time from start of activities	Criteria
Year 1-2	The project area is treated for removal of non-native vegetation. Non-native vegetation on site consists of 30% of the total vegetation. Necessary grading, irrigation lines, as indicated in any project-specific mitigation plan has been conducted. Re-vegetation with native riparian vegetation has been initiated, if needed. Arundo re-sprouts are being actively treated for removal.
Year 3	Non-native vegetation consists of less that 10% of the total vegetation on site. Successful growth of native riparian vegetation including the herbaceous, shrub and tree species as listed in any site-specific mitigation plan are present.
Year 4-5	Area contains less that 1% exotic vegetation and showing a start of canopy development, with shrub and herbaceous under-story.

G. This agreement shall become effective on the date of signature by the Corps. Any party to this agreement may terminate their participation upon written notification to the other parties. The Parties may discontinue receiving funds to conduct restoration activities upon written notification to the Corps. However, the Parties shall not be relieved of their obligations under this agreement to restore and maintain the areas for which funds have been received without written approval of the Corps.

H. This agreement may be amended mutually upon agreement by all signatory parties.

Richard G. Thompson
Colonel, Corps of Engineers,
District Engineer
Los Angeles District
U.S. Army Corps of Engineers

Virginia Grebbien
General Manager, Orange County Water District

APPROVED AS TO FORM

By
General Counsel For
Orange County Water District

Shelli Lamb
Chairperson, Santa Ana Watershed Association

Tab 1

Exhibit A-1

Exhibit A-1

ECOLOGY AND MANAGEMENT OF *ARUNDO DONAX*, AND APPROACHES TO RIPARIAN HABITAT RESTORATION IN SOUTHERN CALIFORNIA

Gary P. Bell

The Nature Conservancy of New Mexico, 212 E. Marcy Street, Suite 200, Santa Fe, NM 87501, USA

Abstract

By far the greatest threat to the dwindling riparian resources of coastal southern California is the alien grass species known as *Arundo donax*. Over the last 25 years the riparian forests of coastal southern California have become infested with *A. donax* which has spread by flood-fragmentation and dispersal of vegetative propagules. *Arundo donax* dramatically alters the ecological/successional processes in riparian systems and ultimately moves most riparian habitats towards pure stands of this alien grass. By current estimates there are tens of thousands of acres of *A. donax* along the major coastal drainage systems of southern California, including the Santa Ana, Santa Margarita, Ventura, Santa Clara, San Diego, and San Luis Rey rivers. The removal of *A. donax* from these systems provides numerous downstream benefits in terms of native species habitat, wildfire protection, water quantity and water quality.

Introduction

Arundo L. is a genus of tall perennial reed-like grasses (Poaceae) with six species native to warmer parts of the Old World. *Arundo donax* L. (giant reed, bamboo reed, giant reed grass, arundo grass, donax cane, giant cane, river cane, bamboo cane, canne de Provence), is the largest member of the genus and is among the largest of the grasses, growing to a height of 8 m (Fig. 1). This species is believed to be native to freshwaters of eastern Asia (Polunin and Huxley 1987), but has been cultivated throughout Asia, southern Europe, north Africa, and the Middle East for thousands of years and has been planted widely in North and South America and Australia in the past century (Perdue 1958; Zohary 1962). It was intentionally introduced to California from the Mediterranean in the 1820's in Los Angeles area as an erosion-control agent in drainage canals, and was also used as thatching for roofs of sheds, barns, and other buildings (Hoshovsky 1987). Subsequent plantings have been made for the production of reeds for a variety of musical instruments including bassoons and bagpipes. Today it is an invasive pest throughout the warmer coastal freshwaters of the United States, from Maryland to northern California.

Arundo donax is a hydrophyte, growing along lakes, streams, drains and other wet sites. It uses prodigious amounts of water, as much as 2,000 L/meter of standing *A. donax*, to supply its incredible rate of growth (Perdue 1958; Iverson 1994). Under optimal conditions it can grow more than 5 cm per day (Perdue 1958). *Arundo donax*

Plant Invasions: Studies from North America and Europe, pp. 103–113
edited by J.H. Brock, M. Wade, P. Pyšek and D. Green

stands are among the most biologically productive of all communities. Under ideal growth conditions they can produce more than 20 tons per hectare above-ground dry mass (Perdue 1958).

Perhaps as much as 90% of the historic riparian habitat in the southern part of California has been lost to agriculture, urban development, flood control, and other human-caused impacts (Jones and Stokes 1987; Katibah 1984). The greatest threat to the remaining riparian corridors today is the invasion of exotic plant species, primarily *Arundo donax*. This alien grass readily invades riparian channels, especially in disturbed areas, is very competitive, difficult to control, and to the best of our knowledge does not provide either food or nesting habitat for native animals. *Arundo* competes with native species such as *Salix* (willows), *Baccharis salicifolia* (mulefat), and *Populus* (cottonwoods) which provide nesting habitat for the federally endangered bird, the least Bell's vireo (*Vireo bellii pusillus*), the federally threatened bird, the willow flycatcher (*Empidonax traillii eximus*) and other native species (Hendricks and Rieger 1989; Franzreb 1989; Zembal 1986, 1990).

Ecological value of native riparian systems

Like most riparian systems, the cottonwood/willow riparian forest is a dynamic community, dependent upon periodic flooding to cycle the community to earlier successional stages (Warner and Hendrix 1985). Periodic floods of large magnitude and migration of the river channel are essential to depositing fresh alluvium where seeds and vegetative propagules of *Baccharis*, *Salix*, and *Populus* can germinate and take root (Gregory et al. 1991; Richter and Richter 1992). Adequate moisture and an absence of subsequent heavy flooding is critical to the survival of the young trees through their first year. As these seedlings mature they increase channel roughness and alter flow during small flood events, increasing sediment deposition (Kondolf 1988; Richter and Richter 1992; Stromberg *et al.* 1993). Sediment deposition builds river terraces and, as they elevate, other plant species colonize resulting in further diversification in the floodplain community (Richter and Richter 1992).

When *Populus/Salix* riparian scrub, which may include such species as *Baccharis salicifolia*, *Vitis californica*, *Rubus ursinus*, and *Urtica dioica* ssp. *holosericea*, reaches four or five years of age, it begins to exhibit the structural diversity required for breeding by the bird, the least Bell's vireo (Franzreb 1989; Hendricks and Rieger 1989). Least Bell's vireo, along with the riparian birds, southwestern willow flycatcher, yellow-breasted chat (*Icteria virens*), yellow warbler (*Denroica petechia*), and many other species may continue to use this diverse community for another ten to twenty years. Gradually the canopy of the maturing *Salix* and *Populus* begins to shade out the diverse understory of vascular plants required by these birds. Older riparian gallery forests will continue to be used by western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), Cooper's hawk (*Accipiter cooperii*), warbling vireo (*Vireo gilvus*) and other species (Zembal 1990; Zembal *et al.* 1985), but as the stand ages the diversity of the flora and fauna within the forest declines. Annual flooding, channel migration, and occasional large flood events maintain this cycle of succession and therefore maintains a mosaic of diverse natural communities (Gregory *et al.* 1991).

Arundo donax as a competitor

Within its introduced range, *A. donax* is an aggressive competitor. *Arundo donax* flowers in late summer with a large, plume-like panicle. Fortunately for California land managers, the seeds produced by *A. donax* in this country are seldom, if ever, fertile. It is not known if this is because of clonal isolation or because of the physiological effects of climate as has been observed in the related *Phragmites communis* (common reed) (Haslam 1958; Rudescu *et al.* 1965). *Arundo donax* is well adapted to the high disturbance dynamics of riparian systems as it spreads vegetatively. Flood events break up clumps of *A. donax* and spread the pieces downstream. Fragmented stem nodes and rhizomes can take root and establish as new plant clones. Thus invasion, spread, and therefore management, of *A. donax* is essentially an intra-basin and downstream phenomenon.

Once established *A. donax* tends to form large, continuous, clonal root masses, sometimes covering several acres, usually at the expense of native riparian vegetation which cannot compete. Root masses, which can become more than a meter thick, stabilize stream banks and terraces (Zohary and Willis 1992), altering flow regimes. *Arundo donax* is also highly flammable throughout most of the year, and the plant appears highly adapted to extreme fire events (Scott 1994). While fire is a natural and beneficial process in many natural communities in southern California it is a largely un-natural and pervasive threat to riparian areas. Natural wild fires usually occur during rare lightening storm events in late fall, winter, and early spring. Under these conditions the moist green vegetation of riparian areas would normally act as a fire break. Human-caused wild fires, in contrast, often occur during the driest months of the year (July through October). Drier conditions in riparian zones at this time of year make them more vulnerable to fire damage. Because *A. donax* is extremely flammable, once established within a riparian area it redirects the history of a site by increasing the probability of the occurrence of wildfire, and increasing the intensity of wildfire once it does occur. If *A. donax* becomes abundant it can effectively change riparian forests from a flood-defined to a fire-defined natural community, as has occurred on the Santa Ana River in Riverside County, California. *Arundo donax* rhizomes respond quickly after fire, sending up new shoots and quickly outgrowing any native species which might have otherwise taken root in a burned site. Fire events thus tend to help push riparian stands in the direction of pure *A. donax*. This results in river corridors dominated by stands of giant reed with little biological diversity.

Arundo donax as habitat

All evidence indicates that *A. donax* provides neither food nor habitat for native species of wildlife. *Arundo donax* stems and leaves contain a wide array of noxious chemicals, including silica (Jackson and Nunez 1964), tri-terpines and sterols (Chandhuri and Ghosal 1970), cardiac glycosides, curare-mimicking indoles (Ghosal *et al.* 1972), hydroxamic acid (Zuñiga *et al.* 1983), and numerous other alkaloids which probably protect it from most native insects and other grazers (Miles *et al.* 1993; Zuñiga *et al.* 1983). Areas taken over by *A. donax* are therefore largely depauperate of wildlife. This also means that native flora and fauna do not offer any

Fig. 1. Arundo donax. Plant × 1/3; spikelet and floret × 3 (from Hitchcock and Chase 1950).

significant control mechanisms for *A. donax*. It is uncertain what the natural controlling mechanisms for this species are in the Old World, although infestations of corn borers (Eizaguirre *et al.* 1990), spider mites (El-Enany 1985) and aphids (Mescheloff and Rosen 1990) have been reported in the Mediterranean. In the United States a number of diseases have been reported on giant reed, including root rot, lesions, crown rust, and stem speckle (USDA 1960), but none seems to have seriously hindered the advance of this weed.

Recent studies by the Santa Ana Watershed Project Authority (Chadwick and Associates 1992) suggest that *A. donax* also lacks the canopy structure necessary to provide significant shading of bank-edge river habitats, resulting in warmer water than would be found with a native gallery forest of *Populus* or *Salix*. As a result, riverine areas dominated by *A. donax* tend to have warmer water temperatures, which results in lower oxygen concentrations and lower diversity of aquatic animals, including fishes (Dunne and Leopold 1978). In the Santa Ana River system this lack of streambank structure and shading has been implicated in the decline of native stream fishes including *Gila orcuttii* (arroyo chub), *Gasterosteus aculatus* (three-spined stickleback), *Rhinichthys osculus* (speckled dace), and *Catostomus santaanae* (Santa Ana sucker). This lack of stream-side canopy structure may also result in increased pH in the shallower sections of the river due to high algal photosynthetic activity. In turn, high pH facilitates the conversion of total ammonia to the toxic un-ionized ammonia form which further degrades water quality for aquatic species and for downstream users (Chadwick and Associates 1992).

Control methods

A suite of methods is needed to control *A. donax* depending upon the presence or absence of native plants, the size of the stand, the amount of biomass which must be dealt with, the terrain, and the season.

The key to effective treatment of established *A. donax* is killing of the root mass. This requires treatment of the plant with systemic herbicide at appropriate times of the year to ensure translocation to the roots. Only one herbicide is currently labeled for wetlands use by the EPA; Rodeo®, a tradename formulation of glyphosate, produced by Monsanto Corporation. Glyphosate is a broad-spectrum herbicide which can be used on *A. donax*, *Tamarix ramosissima* (salt cedar), and most other monocots and dicots. It has proven very effective against *A. donax* (Finn and Minnesang 1990; Jackson 1994; USDA Forest Service 1993). Other herbicides might also be used as labels and conditions allow. Monocot-specific chemicals, such as Fusilade-DX® (fluazapop-butyl) and Post® (Sethoxidan), might be particularly useful for treating *A. donax* in stands with a substantial component of native dicots; however, neither is currently labeled for wetlands use.

The most effective treatment on *A. donax* is the foliar application of a two-to-five percent (2–5%) solution of Rodeo applied post-flowering and pre-dormancy at a rate of 0.5 to 1 l/hectare. During this period of time, usually mid-August to early November, the plants are actively translocating nutrients to the rootmass in preparation for winter dormancy which results in effective translocation of herbicide to the roots. Recent preliminary comparison trials on the Santa Margarita River (Omori 1996) indicate that foliar application during the appropriate season results in almost 100%

control, compared with only 5–50% control using cut-stem treatment. Two to three weeks after foliar treatment the leaves and stalks brown and soften creating an additional advantage in dealing with the biomass: cut green stems might take root if left on damp soil and are very difficult to cut and chip. Treated stems have little or no potential for rooting and are brittle. They may be left intact on the ground or chipped *in situ* for mulch.

Cut-stem treatment requires more time and man-power than foliar spraying and requires careful timing. Cut stems must be treated with concentrated herbicide within one to two minutes in order to ensure tissue uptake (Monsanto 1989). This treatment is also most effective post-flowering. The chief advantage of the cut-stem treatment is that it requires less herbicide that can be more-or-less surgically applied to the stem. Because of its reduced efficacy, and due to the labor required, it is rarely cheaper than foliar spraying except on very small, isolated patches or individual plants.

A popular approach to dealing with *A. donax* has been to cut the stalks and remove the biomass, wait three to six weeks for the plants to grow to about one meter tall, then apply a foliar spray of herbicide solution. The chief advantage of this approach is that less herbicide must be applied to treat the fresh growth compared with tall, established plants, and that coverage is often better because of the shorter and uniform-height plants. However, cutting of the stems may result in the plants returning to growth-phase, drawing nutrients from the rootmass. As a result there is less translocation of herbicide to the roots and less root-kill. Therefore many follow-up treatments must be made which negates any initial savings in herbicide and greatly increases the manpower costs.

Pure stands (>80% canopy cover) of *A. donax* or *T. ramosissima* are most efficiently treated by aerial application of an herbicide concentrate, usually by helicopter. Helicopter application can treat at least 50 hectares per day. Special spray apparatus produces extremely fine droplets (400 microns) of concentrated herbicide which actually reduces herbicide use, minimizes over-spray, and results in greater kill.

In areas where helicopter access is impossible, where *A. donax* makes up the understory, where patches are too small to make aerial application financially efficient, or where weeds are mixed with native plants (<80% cover), herbicides must be applied by hand. Street-vehicles with 400 liter spray tanks are a good alternative where road access is available, but small "quad-runner" vehicles equipped with 60 liter sprayers are the preferred approach where the streambed is not so rocky as to prevent access. Twenty liter backpack sprayers are the final alternative where the vegetation is too dense, or the landscape too rugged for vehicles to be effective.

Methods for vegetation removal include use of prescribed fire, heavy machinery (e.g. bulldozers), handcutting by chainsaw or brushcutter, hydro-axe, chipper, biomass burning or removal by vehicle. Removal of the biomass should only be done where the weed cover is so dense as to prevent recovery by native vegetation after treatment, or where cut vegetation might create a debris-dam hazard during flood events. Prescribed fire, or burning piles of stacked biomass, is the most cost-effective way of removing biomass as long as it does not threaten native vegetation or other resources. Chipping is more costly in terms of equipment and labor, and cut, dried chips pose no threat for regeneration or for forming debris dams. Hauling of biomass by vehicle is extremely expensive and should only be done as a last resort. Most landfills will not accept *A. donax* and those that do will only accept it if cut into short lengths and bagged into plastic trash bags, making the labor costs far too great. The use of heavy machinery such the Hydro-ax® is extremely expensive. The machines are very slow – a Hydro-ax can only cut about 1-5 ha per day.

Riparian restoration and management

One of the prime incentives for riparian habitat restoration has been endangered species recovery, including the federal Endangered Species Act (ESA). The ESA has focused attention on declining species and sought to protect those species in greatest risk by provisions against take (Under the ESA the term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct). Focus of the legislation has been on individual protected species with little attention given to the dynamics of the natural systems of which these species are a part. There are important historical and legislative reasons for this approach. In the 1970's, when the ESA was drafted, ecologists and wildlife managers were highly focused on single species; system-oriented approaches were not widely applied. In addition, it is far easier to attach legal definition to something tangible, such as an individual animal, than it is to the more vague concept of ecological processes (Gregory *et al.* 1991).

The concept of habitat restoration developed in response to the "take" provisions of the ESA as a means of mitigating site-specific damage. While re-vegetation has been carried out in a wide variety of natural community types, its earliest successes and its greatest application has been in mitigation of losses of riparian forests. In southern California, riparian re-vegetation has been pursued as an ever-evolving artform in response to the perceived need for replacement of habitat for the federally and state endangered least Bell's vireo (*Vireo bellii pusillus*) and a suit of other endangered or candidate species including the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and the willow flycatcher (*Empidonax traillii*) (Anderson and Miller 1991; Baird and Rieger 1989; Parra-Sjizz 1989; RECON 1988).

It may be argued that the main reason why riparian re-vegetation has received so much attention is because it is so relatively easy to achieve. This ease is a result of the very dynamics of riparian systems – they are high-disturbance systems composed of flood-adapted and resilient species. *Salix, Populus, Baccharis,* and other riparian plant species establish easily by fragmentation in flood events in addition to seeding in flood-washed sediment beds. As a result riparian re-vegetation essentially requires only plant material (cuttings or rooted stock) and water (irrigation). However, such re-vegetation projects can be extremely expensive.

It is also important to recognize that re-vegetation does not necessarily equate with habitat restoration. While the matrix plant species of habitats are relatively easy to establish, the dynamics of native riparian communities are poorly understood. Establishing a *Salix/Populus* stand on a stream-side terrace will probably not provide the community diversity of a natural stand or the dynamic processes required to establish it. While some re-vegetation programs have been successful in terms of establishing a matrix of riparian habitat which is used by some native species, re-vegetating is the not necessarily the best way to create habitat.

The best way to address habitat loss in southern California riparian systems is through a comprehensive program of eradication of *A. donax*, *T. ramosissima*, and other invasive aliens, and relying on natural physical processes, especially flood dynamics, for the recovery of native natural communities and species. This approach might be just as easily argued for other high disturbance-adapted communities.

This strategy is based upon two of important factors. First, riparian habitats are flood-dynamic communities, dependent upon natural cycles of flood scouring and sediment deposition to create the proper conditions for community establishment (Gregory *et al.* 1991; Richter and Richter 1992; Stromberg *et al.* 1991). The Santa Ana, Santa Margarita, San Luis Rey, and many other southern California streams have all of the factors necessary for the recovery and maintenance of healthy riparian communities and riparian species. These watersheds retain flood regimes sufficient to move and sort sediment and extensive sources of seed and vegetative propagules for *Salix* and other native riparian plants. Second, the only real threats to the integrity of the system are (1) habitat fragmentation by development and (2) introduced exotic species which have altered the successional dynamics and stability of the natural communities. In other words, the native riparian communities of the Santa Ana and other major riparian corridors (and thus riparian-dependent species such as least Bell's vireo) are limited, not by the capacity of the community to regenerate, or the available area of riparian zones, but by the capacity of native species to compete with aggressive invasive exotic species, chiefly *A. donax*.

The majority of the limited resources available for riparian management on these rivers should therefore be directed at managing for the process of riparian systems: removing the key perturbation from the system, thereby allowing natural flood dynamics to operate and the natural communities to recover. Attempts to re-vegetate riparian species in floodplains that retain both native riparian species and flood regimes are redundant, and resources spent to this end are largely wasted. This is not to imply that riparian (and other habitat) re-vegetation efforts should not be applied; however, they should be applied judiciously and only in situations where specific management goals are achieved by carrying out a re-vegetation project (e.g. closing up an important corridor or re-establishing native species in a depauperate watershed). Relying on natural processes for the recovery of the riparian communities has the following major benefits:

a. Cost-effectiveness. Riparian forest restoration is extremely expensive, often on the order of tens of thousands of dollars per hectare. This necessarily limits the size, and therefore the biological value, of any funded restoration project. *Arundo donax* can be removed from most areas of a river for a fraction of the cost of revegetation, opening up areas for natural re-colonization by native riparian species.

b. Biological value. As indicated above, the high cost of re-vegetation limits the size of restoration projects. Additionally, artificially-produced riparian habitat lacks the high stem densities characteristic of naturally regenerating riparian habitat, making the actual biological value of re-vegetated sites questionable. Much higher value may be achieved by removing invasive exotics such as *A. donax* from the system. Areas opened up for recolonization which are subsequently flood-scoured and naturally seeded or "planted" with vegetative propagules spread by the flood are more likely to recover in high stem density habitat.

c. Natural vulnerability. Riparian systems are, by nature, dynamic. The natural flood process that produces the conditions for natural riparian establishment also puts artificially (and naturally) created habitat areas in flood jeopardy. This makes riparian revegetation a high-risk investment of limited resources. Several expensive revegetation projects on the Santa Margarita and Santa Ana Rivers were damaged or lost to flood scouring in January 1993. Some of these areas recovered with high stem-density *Salix* scrub when *A. donax* was controlled. Other sites, without such weed control efforts, succeeded to high density *A. donax* colonies.

Summary

By virtue of its growth characteristics, adaptations to disturbance, especially fire, its lack of natural predators and competitors in North America, and its unsuitability as food or habitat for native wildlife, *Arundo donax* has established itself as one of the primary threats to native riparian habitats in the western United States.

Control and management of *A. donax* within a watershed requires a coordinated, watershed-wide approach. *Arundo donax* should be removed from the watershed beginning in the upper tributaries to prevent reinfestation of treated downstream sites from upstream sources. Removal of *A. donax* requires treatment with systemic herbicides in order to kill the large root mass.

Past practices of riparian restoration have focused on re-vegetation of small sites without consideration of natural riparian processes. Resources should be spent on managing for the natural dynamic processes of these systems on a watershed-wide scale. In coastal southern California the primary perturbation to the natural riparian succession process is invasion by *A. donax*, and its removal from river systems will have a far greater beneficial effect on most riparian species than planting of riparian vegetation.

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Exhibit A-2

Exhibit A-2

Ecological Monographs, 65(3), 1995, pp. 347–370

MECHANISMS ASSOCIATED WITH DECLINE OF WOODY SPECIES IN RIPARIAN ECOSYSTEMS OF THE SOUTHWESTERN U.S.[1]

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Abstract. Throughout western North America, riparian ecosystem function has been transformed by anthropogenic influences on riverine environments. Modified flood frequency, duration, or intensity; depressed floodplain water tables; and increased alluvium salinity have contributed to change in riparian forest communities formerly dominated by *Populus fremontii* and *Salix gooddingii*. The invasion of the naturalized arborescent shrub, *Tamarix ramosissima*, potentially alters competitive hierarchies and disturbance regimes in these riparian ecosystems. We evaluated the structure and function of two southwestern riparian communities that differed in the degree of streamflow perturbation to which they had been subjected: the highly regulated lower Colorado River and the less tightly regulated Bill Williams River. Ordination analyses provided evidence that these riparian communities are structured along gradients relating to moisture, salinity, disturbance from fire, and community maturity, with Colorado River sites being more xeric and saline than those on the Bill Williams River.

Foliar elemental analyses revealed high sodium concentrations in *Tamarix* (Na:K ratio = 1.87) and in the native shrub *Tessaria sericea* (Na:K = 1.56). Evaluation of tissue water relations parameters showed that *Tamarix* had lower osmotic potentials than sympatric woody taxa, helping to confirm that *Tamarix* is halophytic and probably capable of greater osmotic adjustment than native species. Carbon isotopic discrimination (Δ) provided evidence for higher water use efficiency in *Tamarix* than in *Populus*, *Salix*, and *Tessaria*. *Tamarix* Δ averaged over 1‰ less than that of the other riparian taxa. Experimental removal of *Tamarix* from stands where *Salix* was codominant resulted in growth augmentation, less negative water potentials, and higher leaf conductance in *Salix*, all providing evidence of interspecific competition. The persistence of *Salix*, but not *Populus*, on the Colorado River appears to be due to greater water- and salinity stress tolerance in *Salix* than in *Populus*. A preponderance of senescent *Populus* along the Colorado River is an indication that this formerly dominant species is effectively approaching local extinction in parts of this ecosystem.

Key words: Bill Williams River; carbon isotope ratios; Colorado River; experimental vegetation removal; morphology; ordination; plant water relations; Populus fremontii; Salix gooddingii; Tamarix ramosissima; Tessaria sericea; *water use efficiency.*

INTRODUCTION

In spite of their arid surroundings, the native trees dominating low elevation alluvial plant associations of the southwestern United States have their closest phylogenetic relationships with taxa from montane and mesic forest communities in North America. However, this is not an indication that the biotic and abiotic processes acting to structure forest communities in these disparate regions are uniform. Southwestern riparian communities owe their existence to mesic microenvironments along the floodplains of perennial watercourses. Functional attributes such as disturbance, regeneration, and competition operate differently in southwestern riparian ecosystems than in other North American temperate deciduous forest systems. The influences of xerophytic or halophytic taxa are also important in setting southwestern riparian forest and scrub communities apart.

Flooding is a form of disturbance to which many of the taxa occurring in riparian communities appear well adapted. Decreased frequency or intensity of flooding as a result of damming, water diversion, and flow regulation has major effects on riparian ecosystems.

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Downstream effects of impoundment include altered river discharge, decreased suspended sediment, channel incision, and floodplain narrowing (Williams and Wolman 1984). Accompanying such changes in the alluvial environment are shifts in riparian plant community composition. Water management practices have been implicated in reducing *Populus* recruitment in riparian forests and the over-representation of senescent individuals in these populations (Rood and Heinze-Milne 1989, Howe and Knopf 1991). Perturbation of floodplain hydrology resulting in the depression of floodplain water tables may also result in water stress in riparian trees and shrubs, given the phreatophytic habit of the taxa dominating floodplain communities (Busch et al. 1992). Such stress may accelerate plant senescence or reduce the ability of woody species to resist a variety of damaging agents (Runeckles 1982, Franklin et al. 1987).

The invasion of exotic vegetation in riverine ecosystems is a cosmopolitan phenomenon (Loope et al. 1988, McIntyre et al. 1988, Griffin et al. 1989, Thebaud and DeBussche 1991). Rapid invasion by naturalized *Tamarix ramosissima* in floodplain ecosystems of the southwestern United States has profoundly altered riparian community composition (Crins 1989). The invasion of *Tamarix* has also fundamentally altered riparian ecosystem properties. *Tamarix* is capable of desiccating watercourses (Vitousek 1990) and appears to induce novel riparian ecosystem disturbance regimes, including those associated with fire (Busch and Smith 1993). Given that the invasion of *Tamarix* often involves the displacement of native *Salix gooddingii* and *Populus fremontii* (Ohmart and Anderson 1982, Vitousek 1990, Stromberg et al. 1991), it appears that anthropogenic hydrological perturbation may also affect competitive interrelationships among woody riparian taxa.

While research on riparian communities has clarified germination and establishment with respect to abiotic factors for a variety of riparian species, those factors contributing to long-term survival or community change remain largely unidentified. An understanding of riparian community dynamics based only upon information collected during germination and initial establishment is insufficient because survival through these early stages is infrequent in natural forest populations (Peet and Christensen 1987). In addition, ecophysiological differences in juvenile and adult woody plants may lead to differential mortality between age classes (Donovan and Ehleringer 1991). Consequently, geomorphic and hydrologic instability in riparian ecosystems often makes the sites that are most favorable for germination among the most unlikely for survivorship through subsequent age classes (Asplund and Gooch 1988, Stromberg et al. 1991). Although the physicochemical and biotic interactions occurring after establishment are of considerable importance to riparian community structure, such interactions have not been addressed in past studies of riparian community ecology or controlled experimentation with seeds or seedlings.

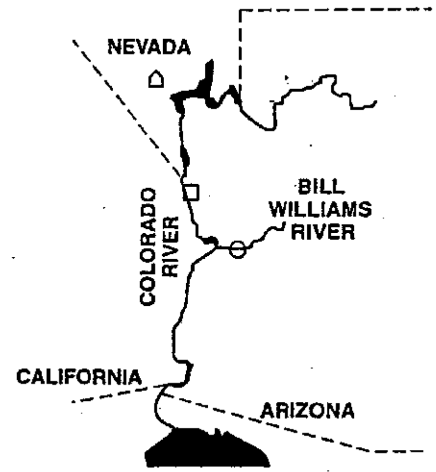

FIG. 1. Study areas on the Bill Williams (○) and Colorado (□) Rivers, Arizona, and at Las Vegas Wash, Nevada (⌂).

Perspectives based on isolated components of the terrestrial–aquatic interface have only limited value to the understanding of riparian ecosystems (Gregory et al. 1991). Thus, hydrologic, geomorphic, and edaphic gradients are of key importance in riparian community organization. Because of the increasing rarity of pristine riparian ecosystems in the southwestern United States, it is vital that experimental approaches contrast unperturbed riparian sites showing evidence of community vigor with those showing indications of incipient or chronic environmental stress. Interactions of dominant woody riparian taxa of the lower Colorado River system were evaluated under two primary hypotheses: (1) that hydrologic variation has significant effects on riparian plant community structure and function; and (2) that varying salinity in floodplain environments also affects these attributes. We used data on site physical characteristics and plant moisture and salinity relations, together with multivariate community analyses, to evaluate how environmental influences and ecophysiological responses of the dominant woody taxa govern riparian community structure. We also hypothesized that the invasion of *Tamarix* has led to the alteration of competitive hierarchies in riparian communities of the southwestern United States. Experimental manipulation of plant populations was used to examine this phenomenon at sites subject to chronic hydrological perturbation, where plant interactions were likely to be intense due to potential limitation in the groundwater moisture source.

STUDY AREA

Research was conducted in two areas of west-central Arizona near the lower Colorado River (Fig. 1, Plate 1). The first of these was in the Colorado River flood-

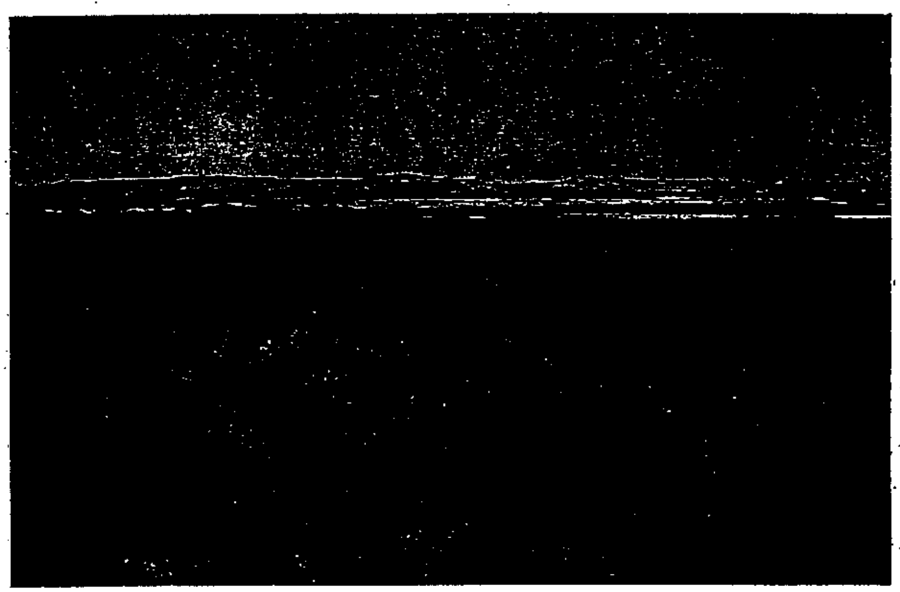

PLATE 1. Study areas. Top: riparian gallery forest of *Salix gooddingii* and *Populus fremontii* lining the active Bill Williams River channel. Bottom: riparian scrub habitat dominated by *Tamarix ramosissima* and *Tessaria sericea* covering the lower Colorado River floodplain.

plain (34°50′ N, 114°35′ W, elevation 150 m). The second was in the Bill Williams River floodplain east of Lake Havasu (34°15′ N, 114°0′ W, elevation 150 m). Throughout the general study area, January temperatures average 10°–13°C, while average July temperatures are >32° (Hecht and Reeves 1981). Precipitation averages 13 cm annually (Sellers and Hill 1974). Hyperthermic Aridosols are the characteristic soils of the lower elevations of western Arizona; study site soils are from the Torrifluvents Association, the well-drained, sandy, recently mixed alluvium of floodplains in southwestern Arizona (Hendricks 1985). The surrounding upland vegetation was representative of the Lower Colorado subdivision of the Sonoran Desertscrub formation (Turner and Brown 1982).

The Colorado and Bill Williams Rivers possess fundamental differences relating principally to their physiographic characteristics. With its headwaters in the Rocky Mountains ≈2700 km to the northeast and 4000 m higher than its lower reach, the Colorado River is one of the major rivers of the southwestern United States, draining a 630 000 km^2 basin. Historically, this lower perennial river transported large quantities of sediment which were deposited laterally in episodic floods, creating a broad, deep floodplain alluvium where the river was not constrained in canyons. At such sites, deciduous woody taxa formed closed canopy riparian gallery forests. The construction of several large dams on the river during the middle of the twentieth century allowed regulation of river discharge to meet flood control, agricultural, and electrical power generation requirements. Channel aggradation and degradation have been altered by the presence of impoundments and by dredging and bank stabilization programs. Sites in the Colorado River floodplain that were selected for this research were 54 km downstream from Davis Dam, one of the major impoundment points. Amplitude and frequency of river discharge in this reach were profoundly affected by dam operation.

The Bill Williams River is a tributary to the Colorado River and drains a more localized (12 300 km^2) basin. There is nearly continuous riparian forest and scrub vegetation along the lower 23 km of the Bill Williams River floodplain. Above this reach, the river is restricted to a narrow canyon extending another 30 km upstream to where it is impounded at Alamo Dam. Although subjected to some of the same sorts of hydrologic perturbation that affect the Colorado, flows in the Bill Williams River are more variable and less predictable, based on long-term averages. Unlike the Colorado River, the Bill Williams River channel is not confined by anthropogenic channelization or natural channel incision, so its floodplain is subject to periodic flooding.

Szaro (1989) characterized the forest vegetation native to the Colorado River riparian zone as the *Populus fremontii–Salix gooddingii* association. The *Tamarix pentandra* (*nom. illeg.*) community type (Szaro 1989) is abundantly distributed along the Colorado River and its tributaries, and is a riparian scrub formation dominated by the woody taxa *Tamarix ramosissima*, *Tessaria sericea*, *Prosopis glandulosa*, *Prosopis pubescens*, and *Atriplex lentiformis*. Central to the goals of this study was an examination of the interrelationships of *Tamarix*, *Tessaria*, *Populus*, and *Salix*. Because much of the Colorado River floodplain is now dominated by monotypic *Tamarix*, study site selection on the two rivers was limited to stands with remnant *Populus* or *Salix*. Areas delineated as *Populus–Salix* habitats (Younker and Anderson 1986, Ohmart et al. 1988) generally have *Populus* or *Salix* present, although often at low densities relative to *Tamarix* or *Tessaria*.

Two types of sites on the Bill Williams River were selected for ecophysiological data collection, both types having *Tamarix*, *Salix*, and *Populus* in a riparian forest assemblage. Hydrogeologic characteristics were the basis for the distinction between Bill Williams River areas. In upstream portions of the study reach, the stream and alluvial aquifer maintain a hydraulic connection, but downstream the lack of such a connection leads to much more extensive seepage into the alluvium (Rivers West 1990). Thus, our "upstream" sites (n = 3) were in an effluent stream reach where stand evapotranspiration and water table declines did not substantially deplete stream discharge. An initial demographic assessment of these sites depicted apparent vigor among the native taxa due to the presence of seedlings (evidence of recent germination) and a low proportion of mature tree senescence or mortality. Although floristically similar to upstream sites, "downstream" sites on the Bill Williams River (n = 3) were located where streamflow was intermittent. Trees on these sites had experienced crown dieback and mortality. All study sites were within 300 m of the active Bill Williams River channel.

Populus has become localized and rare in the lower Colorado River floodplain. Although the sites chosen to represent this area in comparisons with Bill Williams River sites were classified within the *Populus–Salix* association (Younker and Anderson 1986), *Salix* and *Tamarix* dominated these sites; *Tessaria* was locally abundant as an understory shrub. Disturbance-associated increases in *Tessaria* riparian coverage (Busch 1995) led to its inclusion in the study design for the Colorado River in the place of *Populus*. Colorado River "control" sites (n = 4) had nearly complete canopy cover by tall *Tamarix–Salix* thicket vegetation. Based on their shoot architecture, the spread of *Salix* and *Tamarix* in these areas appeared to be largely clonal. Crown dieback was evident in most of the *Salix* thickets. Colorado River sites were <400 m from the river's channel. "Experimental" sites (n = 4) on the Colorado River were plots where vegetation removal was conducted.

Methods

Hydrology and soil moisture

All sites were within 7 km of U.S. Geological Survey (USGS) river gauges. Hydrographic data were obtained electronically from the USGS Arizona data base for the years 1949–1990 on the Colorado River, and 1940–1990 on the Bill Williams River. Median flows and ranges in flow were determined on a monthly basis using daily discharge data for the years of field study (1989–1990). Comparisons of study period discharge with historical hydrographs were made using monthly flow averages over the periods for which data were available from this data base.

Observation wells were installed to measure groundwater depth in the unconfined alluvial aquifers at all study sites. Depths from the soil surface to the water table were measured to characterize this potential moisture source. Four groundwater observation wells were placed on the upstream and downstream sites adjacent to the Bill Williams River. Three wells were located near the complex of control and experimental sites in the Colorado River floodplain.

Time-domain reflectometry (TDR) has been used to measure dielectric properties of many materials, and can be used to accurately measure volumetric moisture percentage (Θ) in surface soils (Topp and Davis 1985). At each study site, arrays (n = 3 or 4) of four stainless steel TDR probes were implanted vertically in the alluvium. Two 90-cm probes served as electromagnetic wave guides, with single 60- and 30-cm probes paired with a 90-cm probe to estimate Θ over each 30 cm depth interval. Vertical probe orientation resulted in an integrated Θ measurement over the upper 90 cm of the soil profile (Θ_i), and measurements for the 0–30, 30–60, and 60–90 cm depth intervals (Θ_d).

Soil and water analyses

Soil samples were collected by soil auger at randomly selected points at each of the study sites for nutrient and salinity analyses. Sampling depth intervals corresponded to those used in TDR soil moisture measurements (i.e., 0–30, 30–60, and 60–90 cm; $n \geq 8$ for each depth on each site). Groundwater samples were obtained by hand pumping water from study site wells once every two months. To avoid taking water standing in wells, three well volumes were withdrawn prior to taking a 500 ml aliquot for analysis. Water samples were grouped by river system for comparisons of aquifer water characteristics.

With only minor modifications, soil extract and water analyses followed identical protocols. Sample electrical conductivity (EC) and pH were determined using an electrical conductivity probe and pH meter, respectively. Total dissolved solids (TDS) determinations were made on water samples by evaporating the water and then weighing the residual evaporate. Water and soil extract sample carbonate (CO_3) and bicarbonate (HCO_3) concentrations were determined by colorimetric titration with a 0.1 or 0.04 mol/L sulfuric acid solution. Chloride (Cl) concentrations were ascertained by titration with 0.1 mol/L silver nitrate. Sample sulfate (SO_4) concentrations were determined by titration with 0.00521 mol/L barium perchlorate. An atomic absorption spectrophotometer (Perkin–Elmer 2380, Norwalk, Connecticut) was utilized in assays of sample extract potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) concentrations. Nitrate (NO_3) concentrations were determined using ultraviolet spectrophotometry on soil extracts. Extract fluoride (F) concentrations were ascertained using a fluoride electrode in combination with a pH meter. A spectrophotometer was used to evaluate boron (B), phosphate (PO_4), and ammonium (NH_4) concentrations of sample extracts (Wolf 1971, Greenberg et al. 1981). Saturation percentages (Sat.%) for the soil sample extracts were determined by overnight drying of the soil paste. Sodium absorption ratios (SAR), an expression of the activity of Na ions in exchange reactions with soils (Hillel 1980), were calculated for water samples.

Plant measurements

On a seasonal basis, terminal segments of *Populus* and *Salix* branches were removed for morphological analysis. This analysis was limited to these taxa, where proleptic growth produced bud scale scars making annual growth increments identifiable. Stem segments were randomly taken from sunlit branches at the mid-canopy level from each of the study sites. On each branch sample, stem elongation was measured as the distance from the most terminal bud scale scar to the branch apex. Annual leaf production was quantified by counting the leaves with petiole insertions on these terminal segments, and by measuring the leaf area of individual leaves from annual growth increments with a leaf area meter (Decagon Delta-T, Pullman, Washington). Leaves were then rinsed, oven-dried at 65°C for 72 h, and weighed. Specific leaf area (SLA) was calculated as leaf area per unit dry leaf tissue mass.

Oven-dried leaf tissue was used in interspecific foliar element comparisons. These analyses were extended to *Tamarix* and *Tessaria* leaf tissue which were sampled and prepared in a similar manner. Dried leaf tissues were ground using a Wiley mill to produce homogeneous samples. Leaf tissue samples taken from 5–10 individuals were bulked so that each species–study site combination was represented in the foliar analyses (n = 18) for each of the taxa investigated. Tissue samples were subjected to a nitrate digest and analyzed for dry weight concentrations of P, K, Ca, Mg, Na, Zn, Fe, Mn, Cu, and B using a Jarrell-Ash Atomcomp 975 inductively-coupled plasma atomic emission spectrometer (Franklin, Massachusetts). Total N was determined using a micro-Kjeldahl procedure.

Plant water relations

At each study site, three individuals of each species were selected for intensive monitoring. At Bill Williams River sites, *Tamarix*, *Salix*, and *Populus* were sampled. For the Colorado River, *Tessaria* replaced *Populus* in the study design. Water relations data were collected on a monthly basis, from April through October (full leaf expansion to senescence), over a 2-yr period. Data on leaf stomatal conductance (g), transpiration (E), leaf temperature (T_L), and photosynthetic photon flux (PPF) were collected by making repeated measurements at two-hour intervals on fully-expanded, mid-canopy leaves of each individual using a steady-state porometer (Licor LI-1600 with a LI-190S-1 quantum sensor, Lincoln, Nebraska). Data collection was confined to clear days, but leaves were not always sunlit due to mutual shading. A cylindrical chamber (Licor LI-1600–07) was used to measure g and E from both leaf surfaces of these amphistomatous species. Area-specific porometry results for all species were calculated using a single leaf surface derived from leaf area meter measurements.

Plant water potential (ψ) determinations were made twice daily with a pressure chamber (PMS Model 1000, Corvallis, Oregon) on two to four 5–10 cm terminal branch segments that were clipped from the mid-canopy level of study site individuals. Water potentials were determined before dawn and near midday (1100–1300) at times corresponding to maximum and minimum daily ψ, respectively, as determined by diurnal ψ trials.

Water potential components were estimated for *Populus, Salix, Tessaria,* and *Tamarix* using pressure–volume analyses (Turner 1988). Analyses were performed seasonally (April, July, and October) on rehydrated cuttings from riparian stands near Las Vegas Wash, Nevada (36°5′ N, 114°50′ W, elevation 600 m; Fig. 1), a tributary of the Colorado River. This site was chosen because of its ecological similarity to our field sites and its proximity to a laboratory with facilities for tissue water relations quantification. Evidence of rehydration-induced shifts in pressure–volume parameters in trees from xeric sites has led to the recommendation of short (i.e., 1–3 h) rehydration periods for mesophytic trees (Dreyer et al. 1990, Kubiske and Abrams 1991). After rehydration for 1.5–2.5 h, terminal branch segments ≈10 cm in length were detached and rapidly weighed, followed by pressurization in the pressure chamber. For each branch segment (n = 10 for each species in each season), this process was repeated 7–11 times, or until xylem sap no longer exuded from the cut surface under pressure. Following this procedure, segments were dried at 65° for 72 h prior to dry mass determination. Sample water volumes were then calculated as the segment tissue mass less the oven-dry mass. Tissue water relations parameters were developed from pressure–volume plots of the reciprocals of chamber balancing pressure ($1/P$) versus relative water content (R) for each sample. A computer-assisted analytical technique (Schulte and Hinckley 1985) was employed to estimate relative water content at zero turgor (R^0), osmotic potential at full turgor (ψ_π^{100}), osmotic potential at the turgor loss point (ψ_π^0), and bulk modulus of elasticity (ϵ^0).

Carbon isotope fractionation occurring via CO_2 assimilation was used to evaluate potential differences in water use efficiency (WUE) among the four taxa investigated. The ratio of carbon isotopes in leaf tissue samples (R_{sam}) relative to that of the PeeDee Belemnite standard (R_{std}) was used to express carbon isotope compositions on a parts per thousand (‰) basis:

$$\delta^{13}C = [(R_{sam} - R_{std})/R_{std}]10^3$$

Carbon isotopic ratios were determined on oven-dried leaf tissues that were prepared as for the leaf elemental analyses. Samples (n = 20 for *Salix* and *Tamarix*, n = 12 for *Populus*, and n = 4 for *Tessaria*) were taken across all study sites where these taxa occurred. Isotopic analyses involved combustion of a 2–3 mg subsample of the dried leaf tissue for 6 h at 850° to produce CO_2 in sealed evacuated Vicor tubes containing cupric oxide and silver foil. Following cryogenic purification of the CO_2 produced, sample $\delta^{13}C$ values were determined on a Finnigan MAT delta E isotope ratioing mass spectrometer (San Jose, California). Carbon isotopic analyses were conducted at the University of Utah Stable Isotope Ratio Facility for Environmental Research, where instrument error associated with each observation has been estimated at 0.01‰, and error between repeated analyses at ≤0.14‰ (Ehleringer 1990). Assuming a $\delta^{13}C$ for atmospheric CO_2 of −8.0‰, carbon isotopic discrimination values (Δ) for leaf tissues with $\delta^{13}C$ measured as δ_p were calculated using:

$$\Delta = (-8.0 - \delta_p)/(10^3 + \delta_p)$$

Farquhar et al. (1989*a*, *b*) have shown that Δ is related to the ambient and intercellular partial pressures of CO_2; ratios of these partial pressures are related to WUE and thereby also to Δ.

Tamarix *removal experiment*

To evaluate possible competitive interactions between a native riparian dominant and exotic *Tamarix*, plant community manipulations were conducted in the vicinity of the Colorado River control site. During the period of winter dormancy, *Salix* was left standing while surrounding vegetation was mechanically removed at four sites interspersed among the four control sites. Clearing was accomplished by bulldozer, and involved complete aboveground removal of *Tamarix* from around the base of *Salix* clones. Given the low precipitation of the study area, it is unlikely that the cleared areas benefitted from additional surface soil moisture as the result of *Tamarix* removal. Surface disruption or incomplete removal of downed vegetation may have added nutrients or elevated salinities in the cleared areas, although attempts were made to minimize and document such effects.

Experimental and control *Salix* were irregularly distributed and >50 m apart. The plant removal areas were roughly circular, extending ≈20 m from the base of the remaining *Salix* individuals. This radial distance was approximately three times the height and seven times the crown diameter of the remaining *Salix*. The lack of resprouting *Tamarix* during the data collection period obviated the need for reclearing efforts and provided an indication that experimental *Salix* were freed from both belowground and aboveground interspecific influences. Data on soil moisture, soil chemistry, plant morphology, and plant water relations were collected. In this manner, data from *Salix* on these experimental sites were available for comparison to *Salix* data from the interspersed Colorado River control sites, as well as to data from Bill Williams River study areas.

Community structure

Data for an analysis of plant community structure were collected from 97 circular plots (of area 200 m²) selected from a wide range of microhabitats throughout the Colorado River (n = 63) and Bill Williams River (n = 34) floodplains. Studies of the variability in species richness relative to the number of plots sampled in southwestern riparian vegetation (Szaro and King

1990) indicate that these sample sizes were statistically adequate. Plots were restricted to vegetation stands classified within the *Populus–Salix* association (Younker and Anderson 1986); thus vegetation quantification was restricted to floodplain sites with evidence of recent dominance by one or both of these taxa. Estimation of perennial plant cover followed the Daubenmire (1959) method for classifying vegetation canopy coverage in six classes. A demographic aspect was introduced into this classification by subcategorizing *Populus* and *Salix* by size. Preliminary analyses of *Salix* at our study areas indicated that the frequency distribution of diameter at breast height (DBH) for reproducing individuals did not differ significantly from normal (Kolmogorov–Smirnov test, $P > 0.99$, $n = 39$), and that the lower quartile of this distribution fell at 10 cm DBH. Comparable results for reproductive *Populus* led to the adoption of a DBH criterion of $\leq$10 cm for defining a "juvenile" size class in these taxa. Trees of greater DBH were assigned to an "adult" class, unless standing dead branches contributed >20% of the canopy volume, in which case trees were classified in a "senescent" age class (Gatsuk et al. 1980). Demographic classification was based on primary stems, without accounting for the clonal nature of various riparian species.

Relative cover and relative frequency percentages were calculated for those taxa demonstrating $\geq$5% relative cover over the general study area. Detrended correspondence analysis (DCA; Hill 1979) was employed to produce ordinations of all stands and perennial species. Study areas were highlighted in stand ordinations to assess the assumption that these sites adequately depicted microsite structural variation within their respective ecosystems. Axes of variation in ordination studies frequently reflect regeneration characteristics of plant communities (Grubb 1977). Thus, in addition to correlation with physical or physiological parameters, association with disturbance or re-establishment features was also investigated.

Data analysis

Statistical significance was assumed at the five percent level of probability ($P \leq 0.05$). Because the various soil elemental concentrations deviated highly and were expressed using different units, standard scores for these variables were calculated to aid in study site and subsurface depth comparisons. Standard scores (C) for a given soil constituent were calculated as the average deviation of each site–depth combination from the overall mean:

$$C = (\bar{X}_i - \bar{X}_g)/s_g$$

where $\bar{X}_i$ represents the mean from each unique site–depth combination, $\bar{X}_g$ is the mean for each constituent from all sites and depths, and s_g is the standard deviation associated with $\bar{X}_g$.

Where normality, independence, and randomness were reasonable assumptions for sample data and sampling regimes, procedures to test the equality of treatment means were carried out using parametric statistical techniques. Generally, this involved analysis of variance (ANOVA) followed by multiple range analysis using the Student Newman–Keuls (SNK) test in cases where ANOVA results indicated significant differences of $\geq$ 2 means. A posteriori residual and normal probability plots were used to assess the adequacy of ANOVA model assumptions and, where used, departures from these assumptions were minor.

Where the above assumptions were not valid, nonparametric statistics (Conover 1980) were employed in hypothesis testing. For groundwater constituents, the Mann–Whitney test was used to compare distribution functions for the two river systems. The Kruskal–Wallis test was employed to examine the null hypothesis that study area soil parameters were identical. Stand positions relative to DCA axes were treated as ordinal data. Spearmann rank correlation coefficients (ρ) were used to clarify possible associations between study site positions along ordination axes and gradients of physical or physiological factors at these sites.

Sequential sampling of the same experimental material violates the independence assumption associated with the univariate ANOVA test. This was unavoidable for analyses of soil moisture and plant water relations where a considerable investment of effort was required to establish study sites, install soil probes, etc. For comparisons of ecophysiological responses collected on a sequential basis, repeated measures analysis of variance (ANOVAR) or "profile analysis," has been advocated (Moser et al. 1990, Potvin et al. 1990). Using the SPSS-X profile analysis procedure (SPSS 1988), ANOVAR was employed in site comparisons of Θ_d, g, E, and predawn and midday ψ. Monthly and hourly data collections were treated as the repeated factors. Mauchly's criterion was used to evaluate the assumption of compound symmetry of the variance–covariance matrix of these data sets.

Results

Hydrogeology

Colorado River discharge was approximately three orders of magnitude greater than that of the Bill Williams River (Fig. 2). Over the course of the study, highly regulated Colorado River flows were nearly identical to the long-term average (1949–1988) in terms of monthly discharge and its fluctuations. Daily and annual variation in discharge was high in the Colorado River. As a result of upstream dam releases, the range in daily flows was as much as 63% of the monthly median. The range in monthly discharge was 144% of the annual average flow for 1989. Throughout the study, Bill Williams River discharge was much more stable on an absolute basis than that of the Colorado River. The range of daily variability was <32% of the

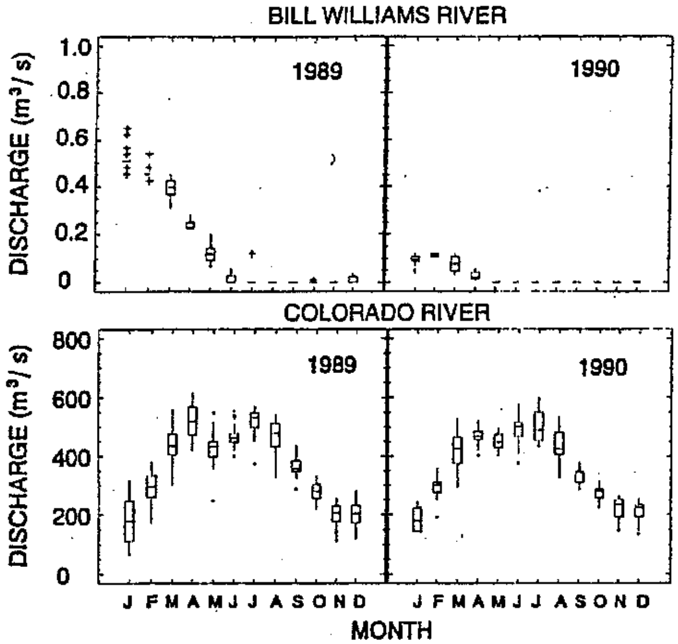

FIG. 2. Hydrographs for the Colorado and Bill Williams Rivers in 1989 and 1990, derived from the U.S. Geological Survey Arizona stream gauge database. Boxes depict second and third quartiles (i.e., the bounds of the middle 50%) of daily discharge for each month, with medians indicated by the lines inside each box. Line extensions indicate range of daily discharges for each month that are ≤1.5 interquartile ranges from the second and third quartiles. Outlying points are plotted individually with flows >3 interquartile ranges below the second, or above the third, quartiles indicated with a "+" mark. Note contrasting ordinate scales for the two rivers.

monthly median, with monthly variation for 1989 only 19% of the annual average discharge. Monthly flow variation appeared to be attributable to localized precipitation and runoff events on the Bill Williams River.

Declining water tables during the 1990 growing season (Fig. 3) coincided with surface flow attenuation in the Bill Williams River (Fig. 2), but were also coincident with the midsummer peak in potential evapotranspiration. Variation among groundwater observation points was less for Bill Williams River floodplain sites than it was for the Colorado River study areas. Mean monthly water table depth ranged from 3 to 4.5 m for the Colorado River study sites and from 1.5 to 3 m for Bill Williams River sites. The annual progression in water table depth for the Colorado River floodplain appeared to follow the Colorado River hydrograph closely. Volumetric soil moisture (Θ_d) varied significantly ($F = 7.98$; $P < 0.02$; 2,7 df) among the four study areas (Fig. 4). Bill Williams River upstream sites had the greatest ($\bar{X} \pm$ SE = 12.2 ± 2.2%) annual mean soil moisture integrated over the upper 90 cm of the floodplain alluvium (Θ_i). As expected for locations where the principal source of soil moisture replenishment is the alluvial aquifer, Θ_d increased with subsurface depth at Bill Williams River upstream sites. The lack of change in Θ_d with depth at Bill Williams River downstream sites suggests that groundwater and moisture in surface soils were not closely connected. Soil moisture in the upper 90 cm (Θ_i) averaged 7.4 ± 1.6% for these sites. Likewise, the Colorado River areas exhibited no clear trend in Θ_d with subsurface depth. Both areas were characterized by substantially lower mean Θ_i (5.0 ± 0.5% and 4.6 ± 0.4% for control and experimental areas, respectively) relative to Bill Williams River floodplain areas.

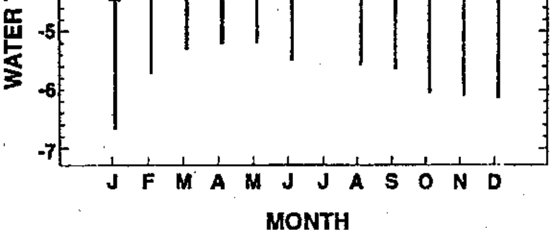

FIG. 3. Alluvial water table depth in study region floodplains during 1990. Means are presented for the Colorado (filled squares; $n = 3$ wells) and Bill Williams (open circles; $n = 4$ wells) Rivers. Spatial variability among groundwater wells is represented by vertical bars extending ± 1 SD from the means.

Alluvium, water, and tissue analyses

There were few differences among study areas with regard to the texture of floodplain soils (D. E. Busch, *unpublished hydrometer data*). Results of soil elemental analyses indicate a tendency for cation and anion concentrations to be statistically indistinguishable be-

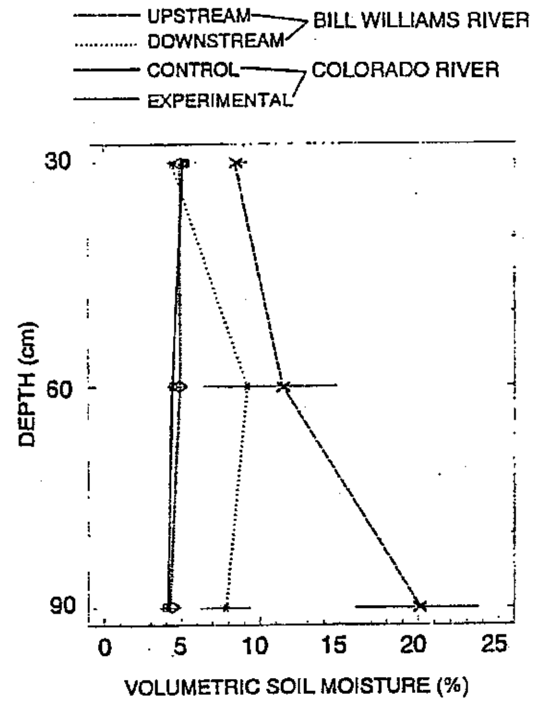

FIG. 4. Volumetric soil moisture (θ_d) at Bill Williams River and Colorado River floodplain study areas. Lines are plotted through means for $\theta_d \pm 1$ SE, ($n = 12$) at each of three subsurface depths in the alluvium.

tween study areas within each river system, but with significant differences between the river systems (Table 1). This was demonstrated by EC and by concentrations of Na, K, Mg, Cl, and SO_4, all of which were substantially higher in soils of the Colorado River sites. Factors for which downstream Bill Williams River sites had the highest concentrations, or did not differ significantly from the two Colorado River areas, included Sat.%, B, F, CO_3, NH_4, and PO_4. Bill Williams River downstream soil pH was significantly greater than that at both Colorado River study areas. These areas, in turn, had higher pH than did the Bill Williams River upstream sites. Significant among-area differences were not detected for Ca, HCO_3, or NO_3.

Standard scores for soils in the 0–30 cm depth interval tended to deviate positively from overall factor means (Fig. 5). This pattern was pronounced for the two Colorado River study areas. Few differences were distinguishable between experimental and control areas from the Colorado River, although the experimental sites had the greatest positive deviation from mean factor values in the upper 30 cm. With the exception of Ca and HCO_3 in the upper 30 cm and NO_3 at the 60–90 cm level, Bill Williams River upstream sites had negative standard scores, indicating lower concentrations of soil cations and anions. The Bill Williams River areas tended to be similar for most parameters, but downstream sites had high positive deviations from overall means for pH, Sat.%, B, NO_3, NH_4, and PO_4.

Groundwater concentrations of Ca, Mg, and SO_4 tended to follow the general pattern indicated for study area soils. Colorado River samples tended to have significantly greater values for these constituents than did groundwater from the Bill Williams River floodplain (Table 2). This presumably contributed to the significantly higher value for EC and TDS in Colorado River groundwater as well. The mean concentrations of several ions (Na, K, and Cl) were higher in Bill Williams groundwater than in samples from the Colorado River study areas. Higher Na, but lower Mg and Ca concen-

TABLE 1. Analysis of soil extracts for Colorado River and Bill Williams River study sites. Data represent means ± 1 SE, $n = 24$. Entries not sharing common letter superscripts denote between-site statistical difference at $P \leq 0.05$ in Kruskal-Wallis and multiple range tests.

	Study site			
	Bill Williams River		Colorado River	
Factor	Upstream	Downstream	Control	Experimental
pH	7.4 ± 0.7[a]	8.0 ± 0.1[b]	7.8 ± 0.1[c]	7.8 ± 0.1[c]
Sat.%* (%)	30.5 ± 0.1[a]	34.3 ± 0.9[b]	34.2 ± 0.7[b]	33.7 ± 0.9[b]
EC† (dS/m)	1.6 ± 1.6[a]	5.1 ± 1.7[a]	11.7 ± 1.2[b]	12.8 ± 1.6[b]
B (mg/L)	0.3 ± 0.2[a]	1.2 ± 0.2[b]	1.4 ± 0.2[b]	1.4 ± 0.2[b]
Na (mg/L)	131.1 ± 388.7[a]	825.7 ± 420.9[a]	2440.3 ± 308.2[b]	2601.3 ± 411.7[b]
K (mg/L)	11.7 ± 17.9[a]	42.9 ± 19.1[a]	105.3 ± 14.0[b]	92.0 ± 19.0[c]
Ca (mg/L)	175.2 ± 45.8[a]	252.0 ± 49.4[a]	278.8 ± 36.2[a]	398.0 ± 48.6[a]
Mg (mg/L)	36.4 ± 37.9[a]	85.2 ± 40.9[a]	217.2 ± 30.0[b]	310.8 ± 40.1[b]
F (mg/L)	1.8 ± 0.2[a]	3.5 ± 0.2[b]	2.4 ± 0.2[a]	2.4 ± 0.2[a]
CO_3 (mg/L)	0.0 ± 0.0[a]	5.7 ± 0.7[b]	0.1 ± 0.1[a]	1.8 ± 0.9[a]
HCO_3 (mg/L)	152.5 ± 19.9[a]	201.3 ± 21.5[a]	207.4 ± 15.8[a]	225.7 ± 21.1[a]
Cl (mg/L)	156.2 ± 394.1[a]	990.5 ± 422.5[a]	2154.9 ± 312.4[b]	2548.9 ± 418.9[b]
SO_4 (mg/L)	518.4 ± 537.6[a]	1200.0 ± 580.8[a]	3595.2 ± 422.4[b]	4022.4 ± 566.4[b]
NO_3 (mg/L)	6.8 ± 5.2[a]	16.8 ± 5.6[a]	4.5 ± 4.1[a]	6.8 ± 5.5[a]
NH_4 (mg/L)	0.6 ± 0.6[a]	4.0 ± 0.7[b]	5.2 ± 0.5[b]	3.7 ± 0.7[b]
PO_4 (mg/L)	0.0 ± 0.1[a]	0.6 ± 0.1[b]	0.2 ± 0.1[a]	0.1 ± 0.1[a]

* Saturation percentage.
† Electrical conductivity.

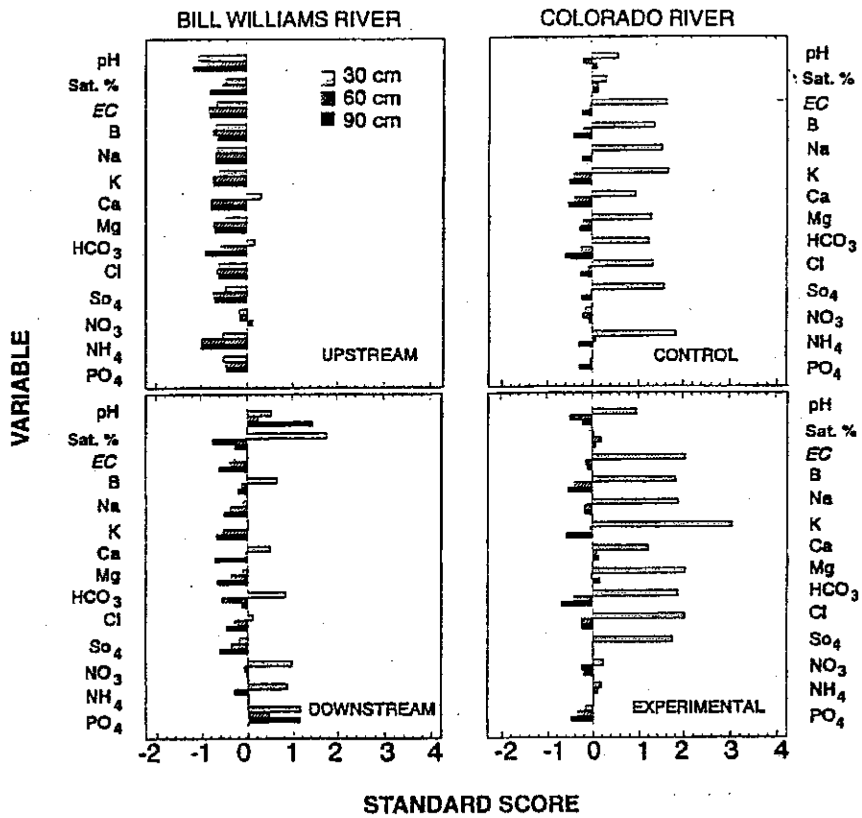

FIG. 5. Standard scores for soil extract analysis variables. Each parameter value was subtracted from the grand mean for that parameter, at all sites and depths. The resultant difference was divided by the standard deviation associated with the grand mean to calculate a standard score in standard deviation units.

trations, resulted in higher mean SAR values in Bill Williams groundwater relative to that of the Colorado River. There were higher mean HCO_3 levels in Bill Williams River study area samples than in Colorado River groundwater, but no significant difference in groundwater pH between the two river systems.

TABLE 2. Groundwater analysis results for samples from wells near the Bill Williams (n = 16) and Colorado (n = 11) Rivers. Data represent mean ± 1 SE for each factor.

Factor	Well location: Bill Williams River	Colorado River
pH	7.70 ± 0.02	7.73 ± 0.02
Na (mg/L)*	113.39 ± 0.46	98.90 ± 1.61
K (mg/L)***	7.80 ± 0.13	5.07 ± 0.20
Ca (mg/L)***	66.56 ± 3.01	91.40 ± 2.68
Mg (mg/L)***	20.40 ± 0.64	27.24 ± 0.72
SO_4 (mg/L)***	95.52 ± 0.96	252.00 ± 2.40
HCO_3 (mg/L)***	310.49 ± 12.71	218.99 ± 9.29
Cl (mg/L)***	106.20 ± 1.07	81.07 ± 1.42
SAR***	3.15 ± 0.03	2.32 ± 0.03
EC (dS/m)*	1.00 ± 0.01	1.08 ± 0.01
TDS (mg/L)***	606.6 ± 2.4	731.6 ± 6.6

Asterisks indicate significant differences between means using the Mann-Whitney test at $P \leq 0.05$ (*) or $P \leq 0.001$ (***).

Foliar analyses revealed that *Tamarix* tended to concentrate cations in leaf tissue (Table 3). Calcium, Mg, Na, and Fe were all found at significantly higher levels in *Tamarix* than in leaf samples from the other three taxa. *Salix* and *Populus* had higher mean leaf tissue concentrations of P, K, and Zn relative to *Tamarix* and *Tessaria*. Strikingly high Mn concentrations in *Salix* and the relatively high leaf tissue Ca in *Populus* were exceptions to the tendency of *Salix* and *Populus* to have similar concentrations of the same elements. Like *Tamarix*, *Tessaria* had high levels of Na and Fe. There were also elevated levels of Cu and B in *Tessaria* leaf tissue. Concentrations of B were greater in *Salix* and *Populus* than in *Tamarix*. There were no significant interspecific differences in leaf N.

Growth and morphology

Annual stem elongation, leaf area, and specific leaf area (SLA) were all significantly greater for *Salix* from Bill Williams River upstream sites than they were at control sites on the Colorado River (Table 4). The number of leaves produced annually showed little variation among any of the study sites in *Salix*. Morphological measurements indicated distinct differences between

TABLE 3. Leaf element concentrations (mean ± 1 SE, n = 18) for woody taxa sampled at Bill Williams River and Colorado River study areas. Concentrations are presented on a leaf tissue dry weight basis. Entries not sharing letter superscripts along rows indicate significant interspecific differences indicated by ANOVA and Student Newman–Keuls multiple range analysis ($P \leq 0.05$).

Element	*Tamarix*	*Salix*	*Populus*	*Tessaria*
		Concentration		
N (mg/g)	20.4 ± 1.0^{a}	21.3 ± 1.0^{a}	20.3 ± 1.2^{a}	16.6 ± 2.2^{a}
P (mg/g)	1.2 ± 0.1^{a}	1.7 ± 0.1^{ab}	1.9 ± 0.1^{b}	1.6 ± 0.2^{ab}
K (mg/g)	9.7 ± 0.6^{a}	15.0 ± 0.6^{b}	18.5 ± 0.8^{c}	7.2 ± 1.4^{d}
Ca (mg/g)	25.9 ± 1.1^{a}	9.9 ± 1.0^{b}	23.0 ± 1.2^{a}	10.9 ± 2.4^{b}
Mg (mg/g)	11.2 ± 0.3^{a}	3.7 ± 0.3^{b}	5.6 ± 0.3^{c}	6.1 ± 0.6^{c}
Na (mg/g)	18.1 ± 0.7^{a}	0.7 ± 0.7^{b}	1.1 ± 0.8^{b}	11.2 ± 1.5^{c}
Zn (μg/g)	40.0 ± 13.5^{a}	160.5 ± 13.1^{b}	248.8 ± 15.8^{c}	70.1 ± 30.6^{a}
Fe (μg/g)	183.5 ± 11.5^{a}	117.7 ± 11.3^{b}	63.4 ± 13.5^{c}	280.4 ± 26.3^{d}
Mn (μg/g)	55.5 ± 58.8^{a}	1059.0 ± 57.4^{b}	8.2 ± 68.8^{a}	153.7 ± 133.8^{a}
Cu (μg/g)	4.7 ± 0.6^{a}	6.2 ± 0.6^{a}	6.8 ± 0.7^{a}	19.5 ± 1.4^{b}
B (μg/g)	45.7 ± 8.5^{a}	75.6 ± 8.3^{ab}	93.4 ± 9.9^{b}	114.7 ± 19.3^{b}

upstream and downstream site *Populus*, but not *Salix*, along the Bill Williams River. *Salix* SLA was greater at the downstream Bill Williams River sites compared to the upstream sites. Stem elongation was 62% greater and leaf area was 88% greater in Colorado River experimental *Salix* than at control sites. Although there was no significant difference in *Salix* SLA between experimental and control sites on the Colorado River, annual growth increments had 60% greater leaf area on the experimental plots.

Plant water relations

Tamarix stomatal conductance (g) was similar among areas, although Bill Williams River downstream sites tended to have slightly lower midday g than at Bill Williams River upstream or Colorado River control sites (Fig. 6). *Tamarix* from Colorado River control sites exhibited markedly higher transpiration (E) than on either of the sites on the Bill Williams River. Overall, *Salix* showed a graded response (F = 4.70; $P <$ 0.05; df = 2,7) with g lowest at Bill Williams River downstream sites, and the Bill Williams River upstream, Colorado River control, and Colorado River experimental sites successively higher. *Salix* E at the Colorado River study areas was greater than at Bill Williams River areas. Differences in E were less distinct between sites within the river systems. *Populus* from the Bill Williams River exhibited g and E responses similar to those for *Salix* from the Bill Williams River.

Predawn and midday water potential (ψ) in *Tamarix* (Fig. 7) differed significantly between areas (F = 36.9; $P <$ 0.001; df = 2,7). Both predawn and midday ψ were higher for *Tamarix* at the Bill Williams River upstream sites than for either the Bill Williams River downstream or the Colorado River control sites. Midsummer declines in ψ were greatest for the Bill Williams River downstream areas. Significant (F = 20.0; $P <$ 0.01; df = 2,7) differences were exhibited in midday ψ for *Salix*, where late growing season differences

TABLE 4. Morphological measurements for *Populus fremontii* and *Salix gooddingii* from study sites on the Colorado and Bill Williams Rivers. Data are the stem elongation of the 1990 growth increment and the leaf number, leaf area, and specific leaf area of the branch segment making up this increment. Values presented are means ± 1 SE (n = 30) for each measurement factor, with unshared letter superscripts indicating significant ($P \leq$ 0.05) between-site differences within rows using ANOVA and Student Newman–Keuls tests.

	Study site			
	Bill Williams River		Colorado River	
Species	Upstream	Downstream	Control	Experimental
		Stem elongation (cm)		
Salix	24.4 ± 1.9^{a}	24.2 ± 2.0^{a}	12.4 ± 1.5^{b}	20.1 ± 2.2^{a}
Populus	173.0 ± 15.6^{a}	70.1 ± 15.3^{b}	...	...
		Leaf number (n)		
Salix	19.0 ± 1.1^{a}	17.3 ± 1.1^{a}	16.2 ± 0.8^{a}	19.0 ± 1.3^{a}
Populus	12.8 ± 0.7^{a}	8.0 ± 0.7^{b}	...	...
		Leaf area (cm^2)		
Salix	122.3 ± 12.3^{a}	101.5 ± 12.4^{ab}	40.0 ± 9.2^{c}	75.0 ± 13.6^{b}
Populus	189.8 ± 11.9^{a}	57.0 ± 11.9^{b}	...	...
		SLA (cm^2/g)		
Salix	126.6 ± 3.6^{a}	136.8 ± 3.7^{b}	111.6 ± 2.7^{c}	112.2 ± 4.1^{c}
Populus	137.5 ± 5.4^{a}	118.6 ± 5.4^{b}	...	...

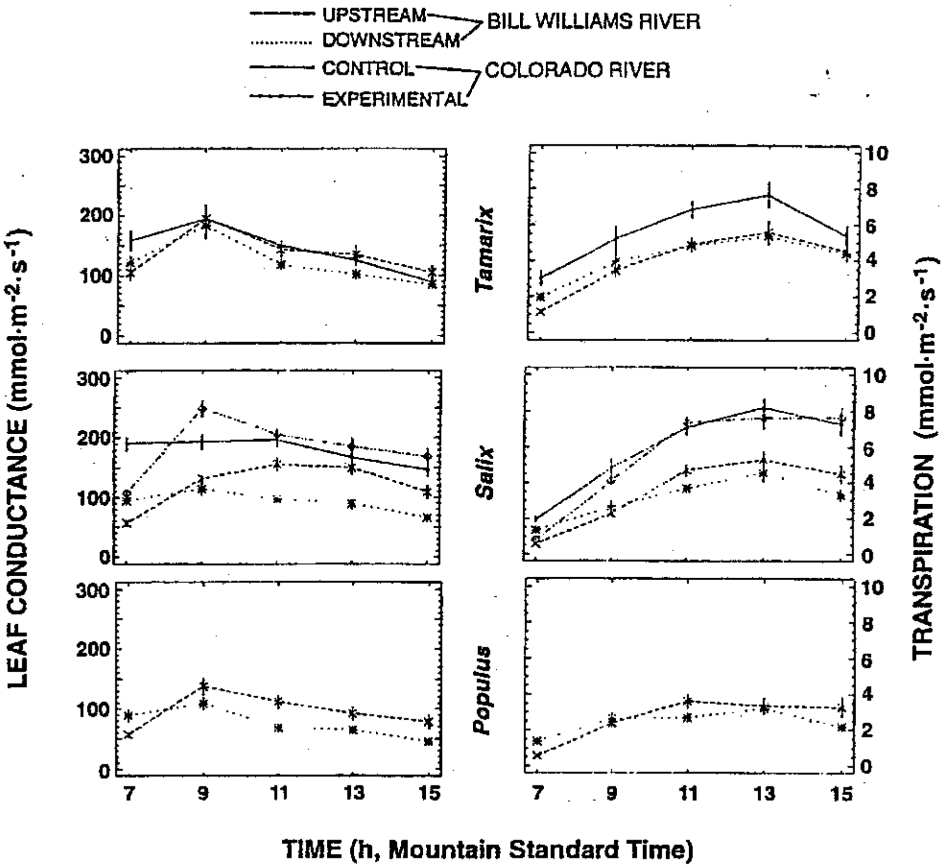

FIG. 6. Stomatal conductance (g) and transpiration (E) for dominant woody taxa of the Colorado River and Bill Williams River floodplains. Due to the lack of strong seasonal variation in g and E, composite diurnal curves from the 1989 and 1990 study periods are presented for these parameters. Points represent composite means, vertical lines represent 1 SE (n = 36).

as great as 0.5 MPa were observed between the Colorado River control sites and the upstream sites on the Bill Williams River. Water potentials in Bill Williams River *Populus* were greater for upstream sites relative to downstream sites (F = 18.63; $P < 0.05$; df = 1,4). This difference became more pronounced as the growing season progressed.

Despite the close taxonomic relationship of *Populus* and *Salix*, estimates of *Salix* tissue water relations parameters were often closer to those of *Tessaria* or *Tamarix* than to *Populus* (Table 5). Relative water content at zero turgor (R^0) was similar in *Tamarix* and *Salix* and was significantly lower than that for *Populus*. *Tessaria* had the lowest R^0 of any species. Osmotic potential at the turgor loss point (ψ_π^0) was most negative in *Tamarix*, intermediate in *Tessaria* and *Salix*, and highest in *Populus*. Although there was a similar relationship for osmotic potential at full turgor (ψ_π^{100}), *Salix* and *Populus* ψ_π^{100} values were significantly higher than those of *Tamarix* and *Tessaria*. There were no significant differences among *Tamarix*, *Salix*, and *Populus* in bulk modulus (ϵ^{100}), but lower ϵ^{100} in *Tessaria* relative to the other taxa provided an indication of greater tissue elasticity in this species.

Tamarix leaf tissue carbon isotope discrimination (Δ) was significantly (F = 6.98; $P < 0.005$; 3,47 df) lower than that of the other taxa examined (Fig. 8), providing an indication of higher water use efficiency (WUE) in this species. Two-way ANOVA indicated that photosynthetic photon flux (PPF) at the mid-canopy level did not differ significantly between Colorado and Bill Williams River sites. Interspecific differences in PPF between *Salix* and *Tamarix* were also insignificant. *Salix* PPF was significantly (t = 4.61; $P < 0.01$; n = 660) greater on experimentally cleared sites ($\bar{X} \pm 1$ SE = 491.2 ± 27.8 μmol m^{-2} s^{-1}) than at control sites on the Colorado River (306.8 ± 25.8 μmol m^{-2} s^{-1}). Leaf temperatures (T_L) did not differ significantly between the two ecosystems, but there were significant (F = 4.85; $P < 0.05$; 1, 938 df) differences in T_L between *Salix* (27.80 ± 0.4 °C) and *Tamarix* (29.00 ± 0.4 °). *Salix* T_L did not vary significantly between experimental and control sites on the Colorado River.

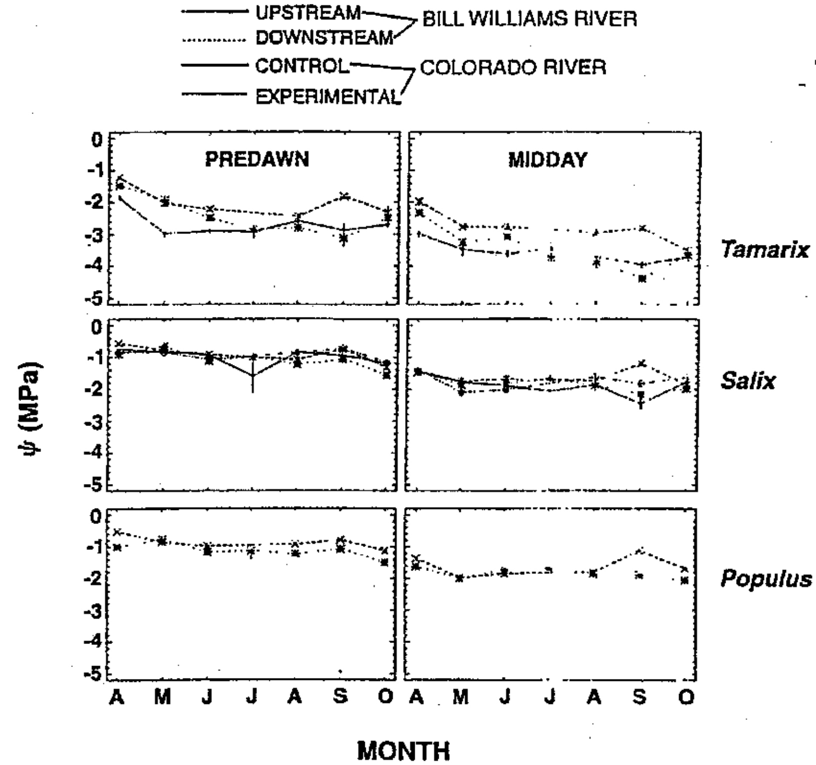

FIG. 7. Predawn and midday water potentials (ψ) at Bill Williams River and Colorado River study sites. Means ± 1 SE (n = 6) are presented using data compiled for months when leaves were fully expanded but not senescent during 1989 and 1990.

Vegetation community structure

Colorado River riparian vegetation plots were characterized by high relative cover and relative frequency of *Tessaria, Tamarix* and *Salix* (Fig. 9). *Prosopis pubescens, Baccharis glutinosa,* and *Populus* were represented in the riparian community, but at lower abundance values. *Populus* was represented largely by senescent individuals in the Colorado River ecosystem. The largest proportion of *Salix* was also senescent, but adult and juvenile segments were clearly identifiable for the Colorado River. Based on relative cover, *Tamarix* and *Salix* dominated the Bill Williams River riparian community. *Populus* and *Salix* both had greater importance in the Bill Williams River floodplain than that of the Colorado River. Juvenile and adult population segments were also much better represented for *Populus* on the Bill Williams River than on the Colorado River. While juvenile and adult population segments were also identified in the *Salix* age structure for the Bill Williams River, the proportion of senescent individuals in this population was greater than that of the Colorado River.

Detrended correspondence analysis (DCA) results for riparian vegetation from throughout the Bill Williams and Colorado River floodplains are presented in Figs. 10–12. The three axes derived from this ordination had eigenvalues of 0.41, 0.23, and 0.17, and accounted for ≈81% of the variation in the community

TABLE 5. Results of pressure–volume analyses for riparian woody taxa. Data represent means ± 1 SE. Entries are followed by an indication of significant ($P \leq 0.05$) difference in average values (entries not sharing letter superscripts) as shown by ANOVA and Student Newman–Keuls multiple comparison tests.

	Species			
Variable*	*Tamarix* (n = 23)	*Salix* (n = 26)	*Populus* (n = 31)	*Tessaria* (n = 29)
R^0	0.79 ± 0.01^a	0.78 ± 0.01^a	0.83 ± 0.01^b	0.87 ± 0.01^c
ψ_π^0 (MPa)	−2.93 ± 0.09^a	−2.54 ± 0.09^b	−2.29 ± 0.08^c	−2.59 ± 0.08^b
ψ_π^{100} (MPa)	−2.40 ± 0.08^a	−1.94 ± 0.08^b	−1.77 ± 0.07^b	−2.26 ± 0.07^a
ϵ^{100} (MPa)	15.80 ± 1.47^a	17.38 ± 1.38^a	17.31 ± 1.26^a	11.48 ± 1.30^b

* R^0 = relative water content at the turgor loss point; ψ_π^0 = osmotic potential at zero turgor; ψ_π^{100} = osmotic potential at full turgor; and ϵ^{100} = bulk modulus of elasticity at full turgor.

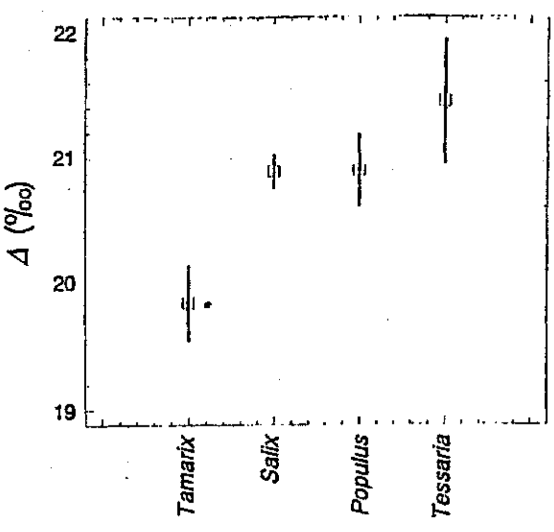

FIG. 8. Carbon isotope ratios (Δ) of leaf tissue from four dominant woody taxa of the Colorado River and Bill Williams River riparian zones. Asterisked mean denotes a significant ($P < 0.05$) difference from other means presented. Error bars represent ± 1 SE.

analysis data set. There was a tendency for salt- or water stress-tolerant taxa to have lower values, and for hydrophytes and mesophytes to have higher values along DCA axis 1 (Fig. 10). Examples of taxa that fit this pattern include *Prosopis pubescens* and *Tessaria* (values <100), and *Typha latifolia,* and juvenile *Salix* and *Populus* (values >200). Evidence for a community maturity gradient was indicated along DCA axis 1 where senescent *Salix* and *Populus* tended to have lower weights than juvenile classes for these taxa. However, this trend is more clearly indicated by DCA axis 2 where higher loadings were characteristic of senescent *Populus* and *Salix* relative to juvenile age classes. Ruderal (*Suaeda torreyana* and *Tessaria*) and late successional (*Prosopis* spp.) taxa also occurred near opposite extremes of DCA axis 2.

Stands from the Bill Williams River were segregated from Colorado River vegetation plots relative to DCA axis 1 (Fig. 11). Exceptions to this included stands from areas of the Colorado River floodplain that have shallow water tables and clustered on the ordination with Bill Williams River stands. Evidence for community organization along moisture gradients is reinforced by the significant correlation of DCA axis 1 with depth to the water table, Θ_i, and ψ (Table 6). This axis may depict community organization along salinity and nu-

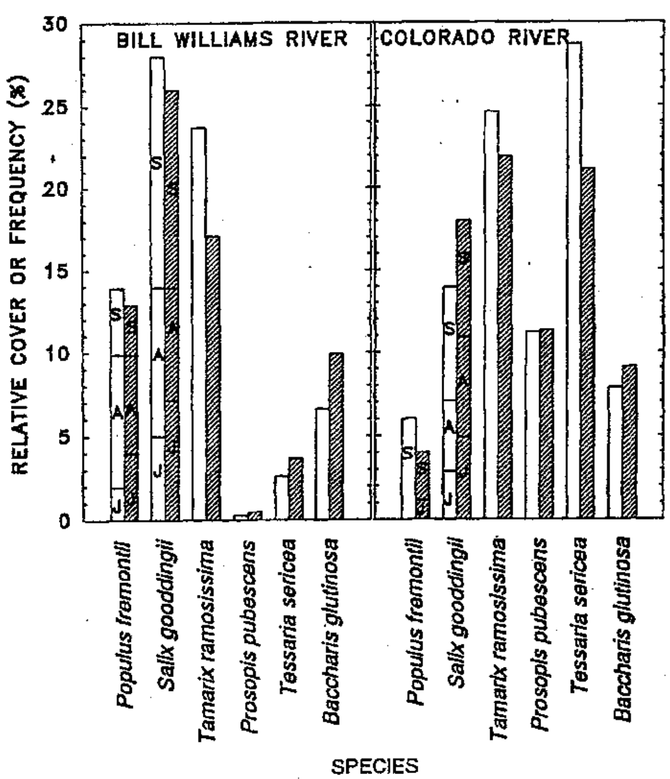

FIG. 9. Histograms depicting relative cover (open bars) and relative frequency (stippled bars) percentages for each perennial species that exceeded 5% relative cover in the Bill Williams River and Colorado River floodplains, when considered jointly. *Populus* and *Salix* are partitioned into juvenile (J), adult (A), and senescent (S) age classes.

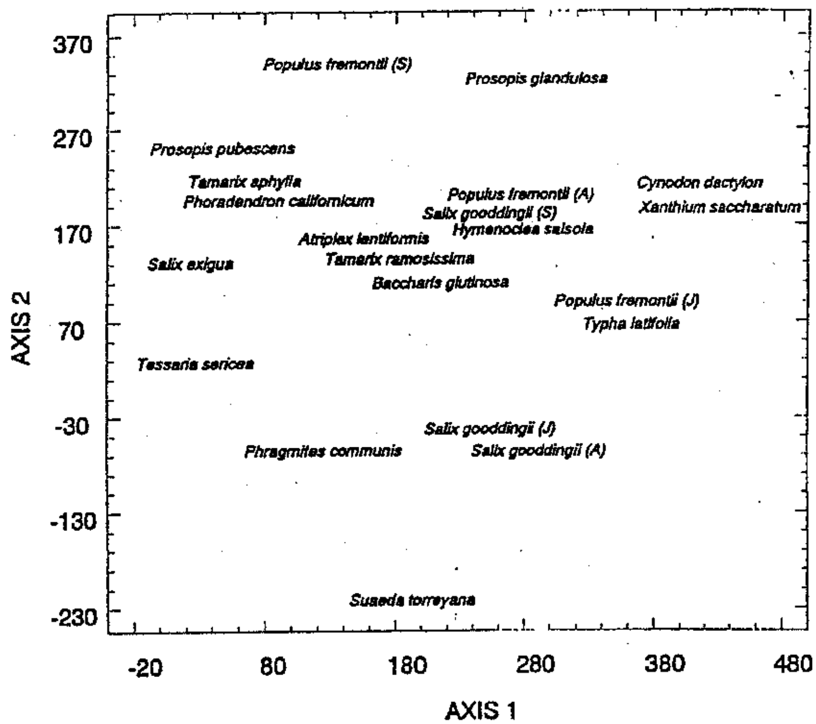

FIG. 10. Ordination of perennial plant taxa on Colorado River and Bill Williams River vegetation plots against the first two detrended correspondence analysis (DCA) axes. Demographic classes for *Salix gooddingii* and *Populus fremontii* are coded *J* for juvenile, *A* for adult, and *S* for senescent.

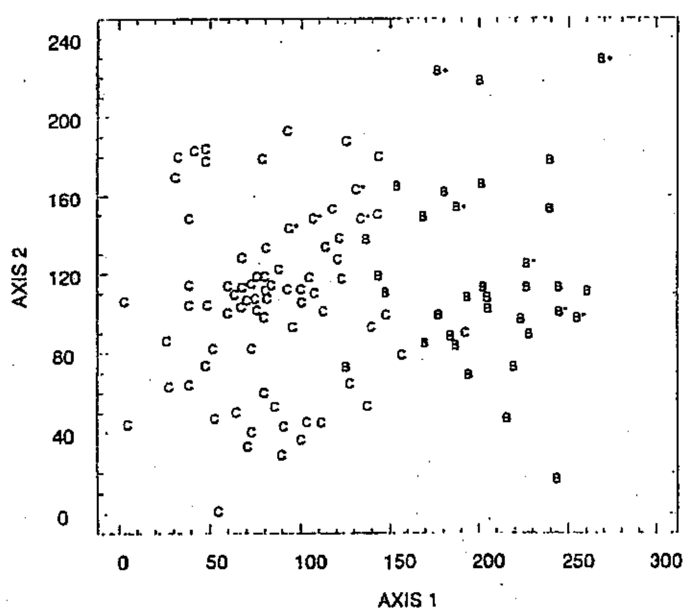

FIG. 11. Ordination of 97 Bill Williams River and Colorado River riparian stands against the first two DCA axes. Stands denoted as B were from the Bill Williams River and those with a C are from the Colorado River. Asterisks (*) indicate the Colorado River control and Bill Williams River upstream sites, while pluses (+) represent the Bill Williams River downstream sites.

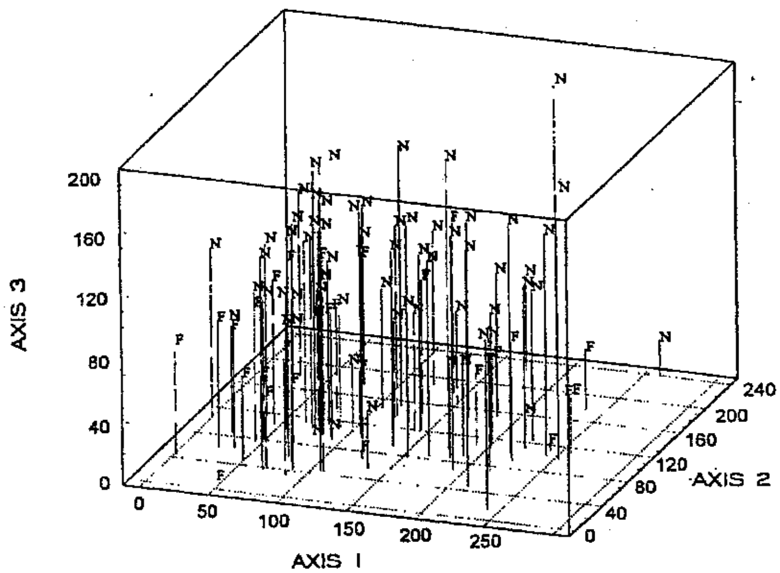

FIG. 12. Ordination of Colorado River and Bill Williams River stands against three DCA axes derived from a community analysis of these ecosystems. Plots showing evidence of recent fire are denoted F, while those showing no evidence of burning are marked N.

trient gradients as well, based on correlations with electrical conductivity (EC), total dissolved solids (TDS), and NO_3. DCA axis 2 was correlated with soil NO_3, a finding consistent with our species ordination, indicating that this axis depicts community maturity. The addition of DCA axis 3 (Fig. 12) shows how disturbance is also important in riparian community organization. Stands that showed evidence of recent burning tended to have lower values along DCA axis 3 than stands not exhibiting signs of such disturbance. The negative correlations of soil PO_4 and PPF with this axis provide additional evidence that fire is an important form of disturbance in this ecosystem (Table 6).

TABLE 6. Correlation of three detrended correspondence (DCA) axes, derived from community analysis of the Bill Williams and Colorado Rivers, with physical and physiological variables from sites in these ecosystems.

Factor†	DCA Axis 1	DCA Axis 2	DCA Axis 3
	Correlation		
Water table depth	−0.64*	−0.01	−0.35
θ_i	0.85***	0.40	−0.07
EC	−0.50*	−0.26	0.56*
TDS	−0.80***	−0.41	0.36
NO_3	0.59*	0.68*	−0.37
PO_4	−0.32	0.07	−0.66*
ψ_{max}	0.46*	0.42	−0.32
ψ_{min}	0.67*	0.42	−0.15
PPF	−0.43	−0.38	−0.58*

Spearman rank correlation coefficients (ρ) with probability of statistical significance indicated by * ($P \leq 0.05$) or *** ($P \leq 0.001$).

† Volumetric soil moisture (θ_i), soil extract electrical conductivity (EC), nitrate (NO_3), and phosphate (PO_4), total dissolved solids in water samples (TDS), plant predawn (ψ_{max}) and midday (ψ_{min}) water potential, and photosynthetic photon flux (PPF).

DISCUSSION

Hydrogeology

There were clear hydrological differences between the two river systems, but within each system site differences were less well defined. The Colorado River possesses nearly all of the physical effects characteristic of impounded riparian ecosystems, including increased channel incision and confinement, and augmented daily flow variation (Williams and Wolman 1984). The Colorado River differs from the unregulated discharge pattern prior to river impoundment in that peak flows occur in midsummer rather than the spring, and because flows rarely overtop the riverbanks, thus eliminating flooding in this ecosystem. In contrast, the Bill Williams River exhibits a more natural flow pattern for the region (Stromberg et al. 1991) with peak runoff in the spring and flooding occurring over much of the floodplain in wet years.

The midsummer peak in groundwater elevation at Colorado River floodplain sites resembles the pattern for surface flows and demonstrates the linkage of the river and the alluvial aquifer. Diel variation in groundwater depth tracked diel discharge fluctuations, indicating that surface flows and water table depth were closely coupled. High groundwater levels during the summer months also are contrary to the pre-development pattern, in which increased evapotranspiration and reduced runoff would have tended to depress water tables at this time. Although Bill Williams River surface flow curtailment was reported in both study years, it was more likely to affect downstream sites than upstream sites where flows diminished but were detectable throughout the study period. Mean water table depths at Bill Williams River study sites were always shallower ($\leq$2.8 m) than those for the Colorado River.

Low values for moisture content in the surface soils of Colorado River study sites were the result of depressed floodplain water tables, lack of moisture replenishment by flooding, low precipitation, and high potential evapotranspiration. Although the latter two factors also typify the Bill Williams River ecosystem, floodplain soils had higher moisture content than those of the Colorado River due to shallower water tables and periodic flooding. Lower soil moisture and deeper water tables at the downstream sites were similar to the Colorado River sites, in that surface soils were severed from groundwater moisture sources.

Nutrients and salinity

Where water table incursion into the unsaturated zone was infrequent, leaching of soil nutrients was also reduced. This contributed to elevated values for Na, K, Mg, Cl, SO_4, and NH_4 ions in the alluvium of Colorado River study sites, and also contributed to high electrical conductivities (EC) and saturation percentages (Sat.%) in Colorado River soil extracts. Colorado River floodplain study areas can be characterized as high in salinity and marginally low in nutrient status relative to those on the Bill Williams River. Soil element concentrations in the upper 30 cm contributed most strongly to this pattern. This demonstrates that elements are not dispersed uniformly through the soil profile by aqueous transport due to the infrequency of precipitation and the rarity of flooding or groundwater incursion into the unsaturated zone in the Colorado River ecosystem. In contrast, periodic flooding and groundwater incursion into surface soils tend to decrease salinity in the Bill Williams River floodplain soils.

Total dissolved solids (TDS) and EC values in Colorado River groundwater were high and were positively correlated with soil concentrations, indicating that this is the more saline ecosystem. Soil EC at Colorado River sites exceeded salinities equivalent to those shown to reduce growth in *Populus* and *Salix* seedlings (Jackson et al. 1990), while *Tamarix* and *Tessaria* appear to be within their salinity tolerance limits at all sites. Soil EC also approached stressful levels for *Populus* and *Salix* at downstream Bill Williams River sites, while salinities at upstream sites were relatively low. Based on EC and TDS measurements, groundwater salinities were beneath salinity stress thresholds (Jackson et al. 1990) for all four taxa in both river systems.

Variation in leaf nutrient levels in natural vegetation is often less than in soil samples because rapid growth on fertile sites tends to dilute the tissue nutrient pool, whereas nutrient concentration in plant tissues may occur on infertile sites (Chapin 1980). In this study, differences in leaf element concentrations followed a halophyte–glycophyte dichotomy. Specifically, *Tamarix* and *Tessaria* leaf tissue Na:K ratios (1.87 and 1.56, respectively) deviated strongly from those of glycophytic *Populus* and *Salix* (Na:K $<$0.1 in both). While glycophytes generally rely on ion exclusion at the root endodermis, *Tamarix* is thought to survive in saline soils by maintaining high uptake of ions in conjunction with salt extrusion, cellular compartmentation, and utilization for osmoregulation (Greenway and Munns 1980). *Tamarix* possesses glands that produce a salty exudate, but this plant also may use inorganic ions for turgor maintenance at low water potentials (Berry 1970). The ions detected in high concentrations in *Tamarix* leaf tissue were also found at high concentrations in both the soil and groundwater. There is thus evidence for a lack of selectivity in *Tamarix* ion uptake, concentration, and excretion, as has been shown in *Tamarix* solution culture experiments (Berry 1970, Kleinkopf and Wallace 1974). Furthermore, the observation that high root zone concentrations of Na lead to decreased K uptake in *Tamarix* (Kleinkopf and Wallace 1974) appears to be substantiated here for *Tamarix* as well as *Tessaria*. An alternate strategy is suggested for *Populus* and *Salix*. These glycophytes showed evidence of Na exclusion combined with concentration of K in leaf tissues.

Tissue level water relations

Water relations characteristics estimated in pressure–volume analyses provide evidence for adaptations favoring the competitive status of *Tamarix* and *Tessaria*, and for the persistence of *Salix* in perturbed ecosystems. Studies of temperate deciduous hardwoods indicate that acclimation to water deficits are made through adjustments in osmotic potential (ψ_π) rather than changes in cell wall elasticity (Tyree et al. 1978, Dawson 1990, Dreyer et al. 1990, Ranney et al. 1990). However, osmotic adjustment may result in potentially maladaptive solute concentrations through water loss or membrane damage (Morgan 1984). Trees capable of accumulating solutes have been shown to maintain turgor and high leaf conductance (g) as tissue water potential (ψ) declines, while others maintain turgor only through stomatal closure (Osonubi and Davies 1978).

Interspecific differences in bulk modulus (ϵ) may be important in riparian plant responses to water or osmotic stress. Low ϵ values (high elasticity) allow the maintenance of turgor as tissue water content varies and may be of physiological or ecological advantage where there are short-term fluctuations in soil moisture; high ϵ ensures that changes in water content and cell solute concentration are relatively small as ψ changes (Zimmermann 1978). High ϵ is thought to offer advantages in maintaining water uptake in xeric environments or microsites, but the utility of low ϵ in maintaining turgor is more apparent than are claims that increases in ϵ enhance water uptake (Monson and Smith 1982, Abrams 1988, Abrams et al. 1990, Schulte 1992).

Low bulk modulus at saturation (ϵ^{100}), taken in conjunction with high relative water content at the turgor loss point (R^0), reflect leaf succulence in *Tessaria*. Tissue elasticity could thus contribute to turgor maintenance under desiccating conditions in this species.

The variability in *Tamarix* water potential (ψ) among field sites indicates that the choice of a representative location for tissue water relations determinations was difficult. This potential problem was minimized by collecting *Tamarix* at a variety of locations. Also, field ψ was consistently lower in *Tamarix* than in the other taxa, indicating that the differences observed in pressure–volume analyses were valid. *Tamarix* osmotic potentials at saturation (ψ_π^{100}) were lower than those in *Populus* and *Salix* and at the point of turgor loss, osmotic potentials (ψ_π^0) in *Tamarix* were lower than all three other species. This would prove advantageous to *Tamarix* where water uptake and transport depend on low plant ψ due to elevated soil salinity or water table depression. High tissue solute levels in this species are presumably involved with the adaptations of this species to generate low ψ_π.

Measurements of ψ_π^{100} and ψ_π^0 in *Populus* and *Salix* were within ranges of values reported from *Populus* and *Salix* species growing in mesic climates (Tyree et al. 1978, Tschaplinski and Blake 1989, Dawson 1990, Gebre and Kuhns 1991). However, interspecific differences in tissue water relations between *Salix* and *Populus* demonstrate the potential for ecological heterogeneity between these taxonomically related, sympatric taxa. Lower osmotic potentials (ψ_π^0) in *Salix* may favor its persistence over *Populus* under conditions of high salinity or moisture stress in southwestern riparian ecosystems. As in *Tamarix* and *Tessaria*, the ability of *Salix* to maintain turgor at lower values of ψ would allow it to operate under conditions of reduced moisture availability.

Whole plant water relations

Predawn and midday ψ levels were significantly lower in *Tamarix* from the Colorado River than in plants at Bill Williams River upstream sites. Comparably low ψ was previously reported for Colorado River *Tamarix* (Gay and Sammis 1977), but ψ appears to be maintained at a higher level in *Tamarix* from more mesic environments (Wilkinson 1972, Anderson 1982). Bill Williams River downstream *Tamarix* showed a seasonal decline in ψ from levels approximately equivalent to those of the upstream sites to levels approximating those at the Colorado River control sites. However, low ψ levels in *Tamarix* were not accompanied by pronounced reductions in stomatal conductance or transpiration, indicating that they were not stressful for this species. *Tamarix* thus shows similarities to plants that maintain turgor and stomatal function through osmotic adjustment or tissue elasticity under conditions of reduced moisture availability (Osonubi and Davies 1978, Abrams 1988).

Tamarix, Populus, and *Salix* all demonstrated midmorning peaks in stomatal conductance (g), with afternoon declines varying among species. Transpiration (E) increased throughout the day in these taxa, tending to reach maximal values in the early afternoon in conjunction with maximum leaf-to-air vapor pressure deficit (VPD). Gay and Sammis (1977) and Anderson (1982) demonstrated similar diurnal responses in *Tamarix g*, but these responses were associated with more immediate declines in E. Transpiration in *Tamarix* is thought to follow the evaporative demand of the ambient air (Hagemeyer and Waisel 1989). Higher VPDs are likely for the Colorado River floodplain due to reduced soil moisture and tree canopy cover. Such differences would explain higher *Tamarix E* on the Colorado despite the similarity in g between river systems. Neither radiation flux (PPF) nor leaf temperature (T_L) varied significantly between ecosystems so that higher VPD along the Colorado River is likely to cause these differences.

Tamarix has been described as possessing inherently low water use efficiency (Anderson 1982), a characterization that has also been applied to aridland phreatophytes in general (Smith and Nobel 1986). It is thus of note that water use efficiency (WUE) in *Tamarix* is the highest of the woody riparian taxa investigated, based on our interspecific comparison of carbon isotope discrimination (Δ). Carbon isotopic ratios can vary temporally and spatially as a function of topography or position within the tree canopy (Garten and Taylor 1992). By obtaining leaf samples from trees and shrubs that were sympatric and often possessed overlapping canopies, and by consistently sampling at approximately the same time and canopy height, microenvironmental contributions to Δ were minimized. Unambiguous ranking of species WUE using foliar Δ-value differences of $<1.0‰$ requires that T_L not differ by >2.5 °C between species (Ehleringer et al. 1992). Although there was little overall T_L difference between ecosystems, *Tamarix* T_L was ≈ 1.2 ° greater than that in *Salix*. The 1.0–1.6‰ differences in Δ between *Tamarix* and the other taxa evaluated thus provide a measure of reliability to indications that WUE is significantly greater in *Tamarix*.

Fractionation of carbon isotopes in halophytes under elevated salinities may occur through diffusional processes or carboxylation in the leaf (Farquhar et al. 1982). Concurrent measurements of photosynthesis and E have shown that increasing environmental salinity causes higher WUE due to reduced E (McCree and Richardson 1987, Plaut et al. 1990). Halophytes that are well supplied with moisture may salinize soils, thereby reducing water uptake and transpiration (Passioura et al. 1992). In addition to their role in osmotic regulation, *Tamarix* salt glands may also provide a mechanism for carbon concentration via a process of carbonate secretion and CO_2 release (Waisel 1991*a*). High WUE in *Tamarix* thus appears to have a functional basis that is related to its halophytic life history. An hypothesized dichotomy between halophytes without solute-excreting mechanisms that could reduce salt uptake by decreasing E and increasing WUE and those with salt glands, which would tend to have lower WUE (Guy et al. 1989), does not appear to be supported. This is because *Tamarix* WUE was greater (based on significantly lower Δ) than that in *Tessaria*, which is not known to excrete salts.

Senescing leaves from hardwood trees have been shown to maintain turgor by decreasing stomatal conductance (Gee and Federer 1972). A similar mechanism could occur in riparian plants that are senescent due to moisture or salinity stress. Regulation of leaf conductance has been documented in *Populus* clones as a moisture stress avoidance mechanism (Pallardy and Kozlowski 1981, Tschaplinski and Blake 1989) and in *Salix* species adapted to xeric extremes of soil moisture gradients (Dawson 1990). Diurnal patterns of g in *Salix* from both ecosystems, and in *Populus* from Bill Williams River sites, support the concept of stomatal regulation as a mechanism for maintaining ψ in riparian trees. In both taxa, lower g was characteristic of drier downstream sites relative to upstream sites on the Bill Williams River.

Populus and *Salix* exhibited Δ values that suggest that WUE is low in these riparian taxa relative to the desert perennials found in surrounding upland habitats (Ehleringer 1989). Carbon isotope discrimination in *Salix gooddingii* in this study approximated that reported for *S. exigua* from a semi-arid habitat (Donovan and Ehleringer 1991). Individuals that conserve water may be at a competitive disadvantage to those that do not possess high WUE (Davies and Zhang 1991). This may apply well in pristine riparian forest ecosystems where taxa with low WUE but high growth rates may be superior competitors for limiting space or light. Where water has become less available due to hydrologic perturbations, elevated plant WUE may become important. Consequently, species with higher WUE (*Tamarix*) are likely to have advantages when moisture supply is less abundant or varies substantially.

Morphological responses

Variation in shoot morphology is closely related to successional status or growth conditions in deciduous trees (Marks 1975). Such variation is likely to be integrated with other moisture and salinity responses to determine plant productivity, competitive status, and riparian community structure. There were distinct differences in morphology between *Populus* individuals growing on upstream and downstream sites in the Bill Williams River floodplain. This was not the case in *Salix*, although *Salix* morphology did differ significantly between the two river systems. For the 1990 growth increment, leaf number per shoot was consistent among sites in *Salix*, as is typical for plants exhibiting determinate extension growth (Marks 1975). For this species, adjustments to water deficits appeared to occur through reductions in the area of new leaves produced or via reduced stem elongation.

Stem elongation, leaf number, and leaf area were all greater at upstream relative to downstream sites in *Populus* on the Bill Williams River. *Populus* spp. have been described as indeterminate in their extension growth, with early senescence contributing to decreased leaf production (Marks 1975, Waisel 1991*b*). The reduction in leaf number at downstream Bill Williams River sites is considered a typical desiccation response. Premature leaf abscission may also have contributed to reduced leaf number at these sites. Thus, adjustments in leaf area appear to be among the mechanisms mediating responses to water or salinity stress in *Populus*.

Trends in specific leaf area (SLA) can be viewed in terms of the adaptive value that xeromorphy brings to trees exposed to water or salinity stress. Leaves with lower SLA tend to be smaller in surface area, thicker in cross section, have lower maximum leaf conductances, and fewer but larger stomata; they are, thus, better suited for xeric habitats (Hinckley et al. 1989, Abrams et al. 1990). Lower SLA in *Populus* from the Bill Williams River downstream site indicates a trend toward xeromorphy due to drying soils or increased salinity. Stomatal conductance was also lower during peak diurnal time periods for downstream site *Populus*. A similar morphological relationship exists in comparisons of *Salix* between the Colorado and Bill Williams Rivers, but g was higher in Colorado River trees with reduced SLA. The tendency of *Salix* at the Bill Williams River downstream site to have greater SLA but lower g in comparison to upstream site individuals indicates that this species may rely more on stomatal regulation than morphological adaptations in short-term stress responses. Tissue level adaptations in *Salix* allowing osmotic adjustment during periods of desiccation could also delay the onset of morphological responses as witnessed in Bill Williams River *Populus*. Such adaptations may also allow *Salix* persistence with reduced leaf area and annual growth on the Colorado River, where such stress is chronic. An absence of osmotic regulatory capabilities may contribute to morphological declines that would lead to reduced productivity in *Populus* at the Bill Williams River downstream area, and to its near-extirpation from the Colorado River.

Competitive relationships

There was little evidence for altered soil moisture availability following *Tamarix* removal on the Colorado River. Experimental and control sites were interspersed too closely to permit measurement of change in water table depth or river discharge, and no differences in moisture content of surface soils were observed. Clearing of woody vegetation over spatial scales that were both more intensive locally, and more extensive regionally, indicate that aquifer and stream baseflow responses are difficult to detect and may develop at nearly imperceptible rates (Weeks et al. 1987, Allison et al. 1990). Thus, measurable aquifer or stream recharge was not expected from the relatively small-scale clearing described here. The lack of a soil moisture response indicates either that increased water uptake in the remaining *Salix* prevented groundwater enhancement of surface soil moisture, or that bare surface evaporation rates depleted soil moisture at a rate comparable to evapotranspiration occurring prior to vegetation removal. Because desiccated surface soils, depressed water tables, and phreatophytic water uptake made substantial increases in surface evaporation unlikely, augmentation of *Salix* moisture supply is suggested.

Plant competitive abilities have been linked to rates of water extraction (Caldwell 1988, Eissenstat and Caldwell 1988). Based on values of Δ, *Tamarix* WUE surpasses that of *Salix*, indicating that *Salix* may possess an advantage in water acquisition where free water is readily available. Removal of neighboring vegetation increased ψ in desert shrubs (Fonteyn and Mahall 1978), but where water availability and leaf areas are high, ψ may decline due to higher transpiration rates (Pothier and Margolis 1990). There is also evidence that ψ may remain stable in plants with access to groundwater sources following the removal of neighbors (Manning and Barbour 1988). Because uptake is largely phreatophytic in *Salix* and *Tamarix* (Busch et al. 1992), we hypothesized that water status changes would not occur in *Salix* following the removal of neighboring *Tamarix*. However, the results showed distinguishable increases in midday ψ (up to 0.5 MPa) in *Salix* on cleared sites. Increased ψ coincided with higher leaf conductance, indicating that reduced water stress was associated with enhanced gas exchange in experimental *Salix*.

The removal of the shading effects of neighboring *Tamarix* led to the exposure of experimental site *Salix* to ≈60% greater PPF at the mid-canopy level. Stomatal responses to increased radiation flux may thus be implicated in the higher g characteristic of *Salix* following the removal of *Tamarix*. This suggests that competition for light may also be a factor acting to structure southwestern riparian communities, particularly where *Salix* and *Tamarix* thickets overlap. Experimental clearing of *Tamarix* from around established *Salix* thickets on the Colorado River resulted in a positive growth response in *Salix* shoots. Although tree architecture appears to have evolved in response to competition for light, water may act as a "cost" limiting tree height (King 1990). The shorter, thicket morphology typical of Colorado River *Salix* differs from the taller, arborescent form on the Bill Williams River. Such morphological variation is a probable result of decreased water availability, and may intensify competition with *Tamarix* for light in dense riparian stands.

Community structure

Low community abundance of *Populus* shows that this formerly dominant tree is in danger of local extirpation in the Colorado River floodplain. Canonical discriminant analysis of southwestern riparian community types indicated a trend toward *Salix* dominance on low-elevation sites, and codominance of this species with *Populus* at middle elevations (Szaro 1989). However, we have shown that hydrologic and salinity factors also contribute to *Populus* and *Salix* growth. The tendency for hydrological perturbations to become more prevalent in riparian ecosystems at the lower end of southwestern elevational gradients makes it probable that elevation is confounded with other physical or physiological factors driving such patterns.

Analysis of the age structures of *Salix* and *Populus* populations revealed large senescent segments on both the Colorado and Bill Williams Rivers. Despite this, an abundance of juvenile and adult *Salix* along both rivers demonstrates that ramet sprouting and establishment occur frequently. The same holds true for *Populus* on the Bill Williams River. The presence of juvenile cohorts in these populations cannot be taken as evidence for establishment of new individuals, because genets were not differentiated in our community analyses. As proposed by Neilson (1986), clonal growth appears to uncouple riparian plants from environmental stress that affects sensitive stages of their life cycles and presents limitations to dispersal and colonization.

Novel, monospecific community types may be formed as a consequence of human perturbation deflecting natural processes in environmental mosaics (Whittaker and Levin 1977). Our results indicate that *Tessaria* and *Tamarix* are functionally suited to exploit the environmental conditions present in riparian areas subject to perturbation. The community importance of these shrub species appears to have increased as native trees (*Populus* and *Salix*) have declined. *Tamarix* and *Tessaria* now dominate the Colorado River floodplain, with *Tamarix* extending its importance to the Bill Williams River riparian community. Because the Bill Williams River and Colorado River riparian zones were contiguous, it is doubtful that the recent (≈40-yr) isolation imposed by river impoundment explains the differences in community structure between the two river systems. Thus, the environments available for colonization by shrubby taxa are presumably less extensive on the Bill Williams River than on the Colorado River.

Ordination analyses often reveal combinations of attributes which suggest causes for vegetation patterns not initially obvious from the geographic distribution of stands (James and McCulloch 1990). While our analysis revealed distinct patterns of salinity response in riparian species, it was more difficult to differentiate the Bill Williams River from the Colorado River floodplains in terms of salinity. Rank correlation analysis revealed that the first DCA axis was negatively associated with gradients in plant moisture stress and salinity, and positively associated with moisture availability and soil NO_3. This makes it evident that riparian species in the vicinity of the lower Colorado River do aggregate into communities along lines of moisture availability and salinity.

In addition to measurable features of the physical environment, ordination axes can also clarify population regeneration characteristics (Grubb 1977). The second DCA axis was significantly correlated with soil NO_3 levels. This is consistent with reported accumulation of organic matter as riparian stands age (Johnson et al. 1976). It also supports our interpretation of riparian community organization along the lines of maturity, as suggested by species (and *Salix* and *Populus* age class) loadings on DCA axis 2. The third DCA axis, which was negatively correlated with PPF and PO_4, also appeared to be associated with the occurrence of fire. Ecophysiological studies with mesophytic and riparian forest communities have demonstrated that increased PPF and increased soil nutrient concentrations are characteristic of post-fire environments (Reich et al. 1990, Busch and Smith 1993). Given evidence for increased abundance of halophytic shrubs following riparian zone fires (Busch 1995), episodic burning appears to be an important factor influencing community structure in the riparian ecosystems evaluated.

Successful invaders are often characterized by broad niches with respect to resource use (Bazzaz 1986). Similarly, a "general-purpose genotype" has been proposed for *Tamarix* (Brotherson and Von Winkel 1986). The osmotic and dehydration tolerances demonstrated here provide evidence for adaptations supporting *Tamarix* survival in desiccated or salinized riparian environments. Such tolerance does not preclude its survival or vigor in more mesic or less saline habitats, however. Accordingly, *Tamarix* was located near the center of the perennial species ordination, suggesting that this species may combine stress tolerance with adaptations promoting rapid growth in less stressful environments. Halophytic adaptations and apparent low WUE were characteristic of *Tessaria* and may help to explain its extreme position relative to the first ordination axis. Such adaptations are likely to facilitate the apparent expansion of these species in Colorado River riparian habitats where hydrological perturbation has been intense. Juvenile and adult *Populus* occupied positions in species ordination space indicative of a mesophytic niche. Relative to *Populus*, juvenile and adult *Salix* were displaced slightly toward the halophytic/xerophytic pole of DCA axis 1. Osmotic adjustment, which appears to allow more vigorous water- or salinity stress responses in this species relative to *Populus*, may thus be an important adaptation permitting the persistence of *Salix* in perturbed riparian environments.

Conclusions

The objective of this study was to provide a functional interpretation of the transition from *Populus–Salix* forest to domination by *Tamarix* or *Tessaria* scrub in southwestern riparian ecosystems. A comparison of adjacent alluvial ecosystems that were relatively pristine (Bill Williams River) and highly perturbed (lower Colorado River) was fundamental to this approach. Contrasts between Colorado River control sites and interspersed experimental sites, at which surrounding *Tamarix* was cleared from the bases of *Salix* thickets, helped elucidate potential competitive mechanisms acting to structure these communities. Comparisons were also made within the Bill Williams River ecosystem between upstream sites, which supported healthy age structures and vigorous growth of the dominant native riparian taxa, and downstream sites, which exhibited morphological and demographic indications of decline. The physical differences between these sites were subtle, thus challenging us to discriminate more finely among potential causes for incipient physiological stress.

Tissue water relations characteristics and leaf elemental analyses confirmed that *Tamarix* is likely to be tolerant of a relatively high degree of salinity or water stress. Based on carbon isotopic ratios, *Tamarix* also has significantly greater water use efficiency than the other riparian taxa examined. These adaptations are likely to be beneficial where salinities are elevated or water tables depressed, conditions characteristic of perturbed riparian environments. On the Colorado River, halophytic adaptations allowed *Tamarix* to operate at lower water potentials with higher leaf conductances relative to the other species and ecosystems examined. While high water use efficiency is not universally regarded as providing a competitive advantage, it may be beneficial in desiccated riparian habitats. Such characteristics are thought to confer advantages to *Tamarix* in its role as an invader in riparian ecosystems. It appears that *Tessaria* combines halophytic adaptations with leaf succulence and low water use efficiency, traits that appear to contribute to increases in the abundance of this shrub following disturbance in riparian ecosystems.

Growth and water relations responses to experimental clearing suggested a close interaction between neighboring *Salix* and *Tamarix* on the Colorado River. Higher stomatal conductance in experimental *Salix* relative to controls may have been attributable to enhanced radiation flux following *Tamarix* removal. However, increased water potentials and consideration of the water cost of height maintenance in trees indicates that competition for moisture is probable as well. Ecophysiological variation thus helps explain community dynamics along competitive hierarchies that may have intensified due to hydrological perturbation in riparian ecosystems.

The ecological roles for *Populus* and *Salix* in riparian ecosystems were previously assumed to be relatively uniform. However, it appears that there is a physiological basis for individualistic responses to riparian ecosystem perturbation between these taxa. *Salix* tended to exhibit tissue water relations values that were intermediate between those of *Tamarix*, a salt-tolerant facultative phreatophyte, and *Populus*, a mesophytic obligate phreatophyte. Because these taxa may operate near the limits of their water and salinity stress response capabilities in low elevation southwestern riparian habitats, this distinction helps explain the persistence of *Salix*, and not *Populus*, in hydrologically perturbed environments such as the Colorado River floodplain. Such adaptations may also have been responsible for the lack of obvious morphological adjustments in *Salix* to short-term desiccation stress on the Bill Williams River, while morphological and water relations responses of *Populus* were indicative of a low tolerance to moisture or salinity stress.

Moisture was clearly a variable to which riparian plant populations responded. Distinct differences were evident in surface- and groundwater hydrology in the two ecosystems, and species water-relations characteristics tended to vary according to such differences. The Colorado River ecosystem offered the more saline and moisture-deficient environment, but downstream attenuation of Bill Williams River flows induced stress related to soil moisture declines and elevated salinity. Ordination analyses revealed that the riparian communities of the Colorado and Bill Williams Rivers are structured along moisture and salinity gradients. With the prevalence of desiccated floodplain environments, *Tamarix* and *Tessaria* have increased in importance in riparian plant communities while *Salix* and *Populus* have declined, the latter more precipitously than the former. Distinct adaptations for dealing with salinity and water stress among these taxa are apparently responsible for the shifts in riparian community structure which accompany ecosystem change. These shifts include fundamental transformations in vegetation physiognomy, from gallery forest to riparian scrub or thicket habitats, that have accompanied hydrological perturbation in southwestern river systems.

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Exhibit B

Exhibit B

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PROFILE
Wetland Mitigation Banking: A Framework for Crediting and Debiting

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ABSTRACT / Wetland mitigation banking as a resource management tool has gained popular support for its potential to provide an ecologically effective and economically efficient means to fulfill compensatory mitigation requirements for impacts to aquatic resources. Although this management tool has been actively applied within the past 10 years (C. Short, 1988, Mitigation banking, in *Biological Report* 88(41): 1–103), assessment of credits and determination of a compensation ratio that reflects existing and/or potential functional condition in a mitigation bank has been a formidable task. This study presents a framework for a systematic approach for determination of credits and debits and subsequently the compensation ratio. A model for riparian systems is developed based on this framework that evaluates credits and debits for spatial and structural diversity, contiguity of habitats, invasive vegetation, hydrology, topographic complexity, characteristics of flood-prone areas, and biogeochemical processes. The goal of developing this crediting and debiting framework is to provide an alternative to the current methods of determining credits and debits in a mitigation bank and assigning mitigation ratios, such as best professional judgement or use of preset ratios. The purpose of this crediting and debiting framework is to develop a method that (1) can be tailored to evaluate ecological condition based on the target resources of a specific mitigation bank, (2) is flexible enough to be used for evaluation of existing or potential ecologic condition at a mitigation bank, (3) is a structured and systematic way to apply data and professional judgment to the decision-making process, (4) has an ecologically defensible basis, (5) has ease of use such that the level of expertise and time required to employ the method is not a deterrent to its application, and (6) provides a semiquantitative measure of the condition of aquatic resources that can be translated to a mitigation ratio.

Urbanization, land development, agriculture, resource extraction, and infrastructure development are often accompanied by impacts to aquatic resources through either direct fill or secondary and cumulative impacts. Discharge of dredged or fill material affecting aquatic resources, such as lakes, rivers, streams, oceans, or wetlands usually falls under the jurisdiction of Section 404 of the Clean Water Act and is regulated by the U.S. Army Corps of Engineers (Corps) regulatory program. Corps' regulations, guidelines, and Memorandum of Agreement (MOA) allow for compensatory mitigation to be performed to offset the unavoidable impacts associated with permitted activities. The 1990 MOA between the Corps and the U.S. Environmental Protection Agency (US EPA) regarding mitigation expresses a clear preference for on-site, in-kind replacement of wetland functions and values. Consequently, compensatory mitigation is often done at or near the project site and consists of either creation of new habitat, restoration or enhancement of degraded habitat, or, in some cases, preservation of intact habitat.

KEY WORDS: Wetlands; Mitigation banking; Credits; Debits; Section 404

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Within the last 10 years wetland mitigation banking has gained popular support as a resource management tool with the potential to provide an ecologically effective and economically efficient alternative to traditional site specific mitigation as a means to fulfill compensatory mitigation requirements (IWR 1992). Mitigation banking is founded on the premise that large, contiguous wetland parcels can have a greater chance of being biologically and hydrologically viable and can accrue more ecologic functions than small, isolated compensatory mitigation sites (Short 1988, Environmental Law Institute 1993). Wetland mitigation banks strive to establish large, contiguous wetland areas that can be used to mitigate for a number of independent impacts. This allows eligible permittees to purchase compensatory mitigation functions or credits from another entity that has already produced and banked them, thereby eliminating the need to produce compensatory mitigation areas on site. Mitigation banking can have the added advantage of establishing successful wetland functions in advance of the actual loss of functions associated with a permitted activity (IWR 1992).

Despite the recent rise in popularity and regulatory support for mitigation banks, assessment of credits in a mitigation bank and determination of compensation ratios that reflect existing and/or potential ecologic conditions in a mitigation bank continues to be one of the most problematic yet most essential aspects of mitigation banking (Environmental Law Institute 1993, IWR 1994). The November 1995 Joint Federal Guidance for the Establishment and Use of Mitigation Banks requires that mitigation banks include systems for determining the number of credits needed to compensate the impacts of a given project (i.e., defining the currency of the bank and setting mitigation ratios) (Federal Register 1995). The crediting and debiting methodology is a two-step process where the existing or potential condition of a mitigation bank (credits) and at the impact site (debits) are assessed and translated into a currency such as acreage or habitat units (IWR 1992, Environmental Law Institute 1993). The second step consists of a determination of the number of credits needed to compensate for losses from a project (debits) or the compensation ratio.

Numerous assessment methods have been proposed for the determination of credits and debits in wetland mitigation banks. The majority of wetland mitigation banks to date, however, use best professional judgment or simple indices, such as acreage, to determine the compensation ratio (Tabatabai 1994). The main advantage of simple indices is their lack of complexity and ease of use. These indices can be calculated quickly by project proponents and regulatory staff, often with little or no field work and little expenditure of resources. The disadvantage of simple indices is they ignore the complexities of wetland ecosystems and may not be representative of aquatic resource functions impacted and the existing or potential functions that exist in a mitigation bank (IWR 1994). Using best professional judgment to determine the acreage to compensate for loss of aquatic resources not only is problematic in terms of scientific indefensibility but also poses problems of inconsistency, uncertainty, and irreproducibility. Great caution must be exercised when using best professional judgment or simple indices to protect against wetland losses.

As an alternative to simple indices or best professional judgment, credits and debits can be computed using functional evaluation methods. Numerous techniques developed over the last 20 years attempt to use field indicators as measures of habitat function. These techniques include:

- Biotic indices, such as species density and the Shannon-Weaver index of species diversity. These biotic indices can be multiplied by acreage to yield diversity units.
- Assessments based on species composition or habitat suitability for specific indicator species, such as the Habitat Evaluation Procedure (US FWS 1980), Habitat Evaluation System (Pearsall and others 1986), Biological Evaluation Standardized Technique (Barnett and others 1991), and Index of Biotic Integrity (Karr 1991).
- Surveys of habitat characteristics, such as the Wetland Evaluation Technique (Adamus 1983), Wetland Replacement Evaluation Procedure (Bartoldus and others 1992), and Wetland Evaluation Methodology (WEM) (US ACOE 1988).
- Landscape level assessments using Geographic Information Systems (GIS) and other coarse resolution measures of function in a regional perspective, such as US EPA's Synoptic Approach to Impact Assessment (US EPA 1992).

The most recent and one of the most promising functional assessment techniques is the Hydrogeomorphic Method (HGM) (Smith and others 1995), developed by the U.S. Army Corps of Engineers Waterways Experiment Station (WES). This method uses variables measured in the field to compute functional indices for biotic, hydrologic, and biogeochemical functions. These indices are scaled against locally representative reference sites to account for regional variations in wetland ecosystems. However, development of regional models and reference standards requires considerable time, resources, and technical expertise; to date, few regional reference sets have been developed.

Each evaluation method has strengths and weaknesses, which have been previously discussed by several authors (Margules and Usher 1981, Westman 1985, Lonard and Clairain 1985, Jain and others 1993, Stein 1995). However, because mitigation banks are typically used to compensate for impacts resulting from multiple small projects, methods such as those listed above become cumbersome in terms of personnel resources and inefficient in terms of assessing functions impacted at each site eligible to use the mitigation bank. In addition, regulatory agencies may not have the expertise or resources to apply the functional assessment methods properly; therefore, the designated method may not be used accurately. In his review of functional assessment methods, Smith (1993) concluded that "no single method reviewed meets the requirements of a quick screening technique to determine a broad spectrum of wetland values and functions." It is unlikely that any single method could fully satisfy both the quick screening and the comprehensiveness criteria. However, it is our goal to develop a crediting and debiting framework for wetland mitigation banks that will address some of the limitations posed by other crediting strategies while providing a balance between ease of use and defensible measure of ecologic condition. To achieve this goal, a crediting and debiting framework should meet the following criteria: (1) can be tailored to evaluate ecologic condition based on the target resources of a specific mitigation bank, (2) is flexible enough to be used for evaluation of existing or potential ecologic condition at a mitigation bank, (3) is a structured and systematic way to apply data and professional judgment to the decision-making process, (4) has an ecologically defensible basis, (5) has ease of use such that the level of expertise and time required to employ the method are not deterrents to its application, and (6) provides a semiquantitative measure of the condition of aquatic resources that can be translated to a mitigation ratio.

In this paper we present a crediting and debiting framework for wetland mitigation banks that meets the above criteria. The principles of the framework are applied to develop a model for southern California riparian systems. Use of the riparian model is illustrated for Santa Ana River Mitigation Bank (SARMB), located in Riverside County, CA.

Crediting and Debiting Framework

The crediting and debiting framework is based on assessing changes in structural characteristics at the impact site and the mitigation site. Change is assessed by evaluating conditions before and after alterations to the site. Structural characteristics are used as indicators of ecologic condition of the specific class of aquatic resource.

Credits are determined based on the difference between structural characteristics of the post-restoration condition and pre-restoration (baseline) condition at the bank site. Similarly, debits are assessed by determining the difference between pre-project and post-project structural characteristics at the impact site. Each structural characteristic, or criterion, is evaluated on a linear interval scale and assigned a rating that reflects the relative value of that criterion at a given site. Credits are the sum of net gain of values for all criteria at the bank and debits are the sum of net loss of values for all criteria at the impact site. The mitigation ratio is the ratio of debits over the credits. When the mitigation credits must be calculated (or estimated) before the bank is functionally mature, the mitigation ratio can be based on the maximum expected gain at the bank (i.e., the enhancement potential) (Table 1). We will demonstrate the framework using the structural characteristics developed below for the southern California riparian model.

Table 1. Crediting and debiting framework. Application of the crediting and debiting framework involves three main steps: evaluation of credits, evaluation of debits, and determination of the mitigation ratio

Step 1. Evaluation of credits
Credits = Post-project Rating (or Enhancement Potential Rating) − Pre-project Value (Existing Value)
Step 2. Evaluation of debits
Debits = Pre-project Rating of the Impact Site − Post-project Rating of the Impact Site
Step 3. Determination of the mitigation ratio
Mitigation Ratio = Debits/Credits (or Projected Available Credits)

The framework is a systematic approach designed to balance directly measuring hydrologic and physical characteristics of aquatic resources against ease of use. The intent is not to provide an absolute tool for evaluating functional condition, rather to provide an ecologically based framework to organize best professional judgment and apply it in a systematic manner. The framework is intended to apply to the mitigation bank and the typically small impact sites that normally use a mitigation bank. Assumptions associated with this type of crediting and debiting methodology include equal weights assigned to each criteria and a linear increase in values associated with each interval.

This crediting and debiting framework may be applied to various types of ecosystems. Evaluation criteria will vary based on the type of the system being evaluated and should account for the hydrologic, biologic, biogeochemical, and landscape characteristics of the target aquatic system. Below we provide a sample crediting and debiting system developed for southern California riparian wetlands.

Southern California Riparian Model

Riparian systems in the western United States are typically narrow, linear strips of vegetation along rivers, streams, or lakes and are dependent on perennial or ephemeral surface or subsurface water (Knopf and others 1988, US DOI 1994). Dry climates and porous soils found in arid regions cause streamside soil moisture to decrease more rapidly with distance from the streambank than in humid regions, resulting in narrower riparian zones (Reichenbacher 1984). However, flooding duration, intensity, and timing are the ultimate determinants of riparian succession. Flooding waters bring nutrient-rich sediments to the flood plain, export organic and inorganic material from the flood plain, scour mature woodlands, and help spread propagules laterally into the flood plain (Strahan 1984, Warner and Hendrix 1985, Dickert and Tuttle 1985, Gosselink and others 1990a). Riparian systems form dynamic mosaics of active channels, terraces, flood plains, and alluvial fans. The composition and distribution of these systems is a product of fluvial processes, which erode material from some areas and deposit it in others during flood events, facilitating channel migration (Gregory and others 1991). This combination of degradation and aggradation results in the formation of bars and terraces with different drainage patterns and elevations. These elevational differences result in the extensive vegetative diversity of riparian systems (Strahan 1984). The viability of terraces and flood plains depends on their proximity to groundwater levels, surface emergent aquifers, or hyporheic zones (porous substrate allowing water to flow immediately beneath the surface of streambeds) (Stanford and Ward 1993). Therefore, in the arid west, the width and distribution of the riparian zone is ultimately determined by the vertical gradient between the benchland and the streambed (Szaro 1990).

Although their areal extent is proportionately less than in other parts of the country, western riparian systems have a proportionately greater significance for some functions because of the arid climates in which they occur (US DOI 1994). In the arid southwestern United States, riparian areas serve as linear or single-point habitat islands on which a multitude of native wildlife species are totally dependent for survival (Warner and Hendrix 1985). The US DOI (1994) estimated that although less than 1% of the western portion of the United States is covered by riparian vegetation, between 51% and 82% of all species in the southwestern United States depend on riparian areas for survival.

Evaluation Criteria for Southern California Riparian Systems

Based on the crediting and debiting framework, we developed a model for southern California's riparian systems using the following evaluation criteria: (1) spatial diversity and coverage of habitats; (2) structural diversity of habitats; (3) contiguity of habitats; (4) percent of invasive vegetation; (5) hydrology; (6) topographic complexity; (7) characteristics of flood-prone area; and (8) biogeochemical processing. These criteria reflect the fact that assessment of riverine systems requires examination of the entire riparian zone and consideration of the interaction between geology, hydrology, and organic and inorganic inputs to the system. In recognition of the fact that functional capacity differs between low-order and high-order streams, for some criteria we have provided different indicators for first- and second-order streams versus higher order streams. Because first- and second-order streams do not typically support the same complexity of habitat as higher order systems, they will typically score lower on the habitat criteria. For the purposes of this method, trees are defined as perennial woody dicots greater than 7.5 cm diameter at breast height (DBH). Saplings are defined as perennial woody dicots less than 7.5 cm DBH.

The first two evaluation criteria address structure, composition, and diversity of the site. Scoring of the first criterion, coverage and spatial diversity of habitats, should consider the site as a whole and evaluates both diversity of habitat types (i.e., interspersion) and species diversity within each patch. Scoring of the structural diversity of habitats criterion should focus only on the structure within the riparian patches on the site (as opposed to the site as a whole). Although this criterion partially captures species diversity, it is to a lesser extent than the spatial diversity criterion. The first two criteria should be scored based on the vegetative composition of the site regardless of whether the vegetation is native or non-native. Effects of non-native species on habitat integrity are addressed by a separate criterion. Evaluation of structure regardless of the geographic origin of the species accounts for the fact that increased biomass (regardless of species type) contributes to a site's ability to retain water and retain nutrients and compounds, thereby increasing some hydrologic and biogeochemical functions. This attribute is also directly accounted for by the biogeochemical processes criterion, which is scored based on abundance of biomass, regardless of whether or not it is native.

Coverage and Spatial Diversity of Habitats

Riparian habitats are typically patchy with an interspersion of different habitat types (Faber and Holland 1988). This interspersion allows the activities of animals in dry sites to be more closely coupled to those in wet sites. A mosaic of habitat types provides a richer, more continuous food source for mobile fauna than that of a homogeneous habitat. For example, Doyle (1990) found a strong correlation between the extent of herbaceous and deciduous shrub cover in riparian habitats and the abundance and diversity of small mammals. Habitat mosaics also allow animals to fulfill several life functions at a single site (e.g., foraging, escape, reproduction) (Warner and Hendrix 1985, Gosselink and others 1990b). Alpha diversity (diversity within a site) has been correlated to the ability of a patch to support a complex food chain and allow interior species with specific habitat requirements to thrive in the face of competition from generalists (Klopatek 1984, Harris 1988). Assessment of changes to the spatial diversity of a project site provides information about impacts to a site's capability to support a variety of different faunal species.

The ratings for the coverage and spatial diversity criterion are assigned based on the following scale:

0 = Site permanently converted to land use not able to support native riparian vegetation, such as housing, agriculture, or concrete channel.

0.2 = No existing riparian vegetation (e.g., covered with annual grasses and scrub, bare ground). However, site has the potential for revegetation without extensive structural modification.

0.4 = Patches of monotypic riparian vegetation covering up to 50% of the site, interspersed among herbaceous species or bare ground.

0.6 = Patches of diverse riparian vegetation (e.g., at least three different genera of riparian vegetation present) covering up to 30% of the site, interspersed among grasses, invasive plants, or bare ground; and/or greater than 50% of the site covered with monotypic patch(es) of riparian vegetation, interspersed among herbaceous species or bare ground.

0.8 = Diverse riparian vegetation covering between 30% and 75% of the site, e.g., strips or islands of riparian habitat interspersed in open space.

1.0 = Diverse riparian vegetation (e.g., at least three different genera of riparian vegetation present) covering between 75% and 100% of the site, interspersed in open space or herbaceous plant communities.

Structural Diversity of Habitats

The stratification of vegetation into layers, including shrubs, understory, and canopy, provides a variety of different habitats. This allows a diversity of organisms representing different trophic levels to coexist in a single site, thereby supporting a more complex and resilient food chain (Warner and Hendrix 1985). For example, diverse ground cover provides habitat for many insects which form the base of the food chain and provide important ecosystem functions, such as pollination. This allows higher-trophic-level organisms to utilize understory and canopy habitat that may be present (Erman 1984). Structural diversity within a site has been correlated with faunal diversity, especially for birds (Gosselink and others 1990b). The presence of a floristic structure consisting of three strata indicates that appropriate soil, moisture, and topographic conditions exist to support a "healthy" riparian system (Warner 1984). Structural diversity of the vegetated portions of the project site is used as a surrogate for general habitat suitability for an assortment of common species.

Because riparian habitats are typically patchy (Faber and Holland 1988), the ratings for this criterion are based on only the vegetated portions of each site:

0 = Site permanently converted to land use that will not be able to support native riparian vegetation, such as housing, agriculture, or concrete channel.

0.2 = No existing riparian vegetation (e.g., covered with upland grasses and scrub, bare ground). However, site has the potential for revegetation without extensive structural modification.

0.4 = Vegetated areas of the site contain sparse, scattered, patchy, or remnant riparian vegetation that is immature and/or lacks structural (vertical) diversity.

0.6 = The patches of riparian vegetation on the site contain riparian trees and/or saplings (i.e., perennial dicots), but contain no or poorly developed shrub understory.

0.8 = The patches of riparian vegetation on the site contain riparian trees and saplings, plus a well-developed native shrub understory.

1.0 = The patches of riparian vegetation on the site are structurally diverse. They contain riparian trees, saplings, and seedlings, as well as developed native shrub understory and herbaceous layer.

Contiguity of Habitats

Fragmentation and habitat loss are dominant causes of the decrease in biotic diversity (Harris 1988). The ecological value of disjunct habitat patches can be enhanced if they are connected by strips of protected habitat; these corridors facilitate movement between patches (Diamond 1975, Noss 1987). For animals with a home range exceeding the size of an individual habitat patch, corridors provide a means of moving from one habitat patch to another. Without a system of travel corridors allowing these animals passage from one refuge to another, they will probably not occur in future landscapes (Harris 1988). Even if partially disturbed, riparian corridors are vital to the successful migration of neotropical birds and other organisms (Croonquist and Brooks 1991). In addition, habitat connectivity helps small populations (such as endangered species) maintain demographic and genetic integrity in the face of the isolation caused by habitat fragmentation (Frankel and Soule 1981). Changes to linear contiguity affect not only corridors but also contribute to overall habitat fragmentation and decreases in patch size. This can be detrimental for resident as well as migrant species (Harris 1988).

The ecological value of riparian habitats also depends on their integration as units within the surrounding landscape (Gosselink and others 1990b). Many organisms have complex life histories in which different stages require distinct habitats within a regional landscape in order to meet their life requirements (Harris 1988). Therefore, continuity between riparian and upland habitats increases utilization by fauna and provides safe passage between riparian oasis and adjacent uplands (Gosselink and others 1990c). Furthermore, the greater the edge area between riparian habitat and developed areas, the greater the potential negative impact from adjacent upland land use (Warner and Hendrix 1985). Additionally, many riparian plants require adjacent uplands as a flood plain for establishment of their propagules during flooding events (Scott and others 1993). These flood plains also provide refuge for fauna during flooding (Gosselink and others 1990c).

The continuity criterion includes two components. Linear continuity refers to riparian habitat upstream and/or downstream of the site. Lateral continuity addresses the quality of upland habitat and reflects the connection of the site to the surrounding nonriparian habitat. The ratings for the contiguity criterion are assigned based on the following scale:

First and second order streams.

0 = No linear contiguity or transitional upland habitat; completely surrounded by or isolated within an urban setting or converted to an urban/suburban land use.

0.2 = No linear contiguity upstream or downstream, but isolated within upland open space habitat.

0.4 = Contiguous with comparable habitat on one end of the site (upstream or downstream), but surrounded with urban/suburban or other nonopen space lands adjacent (lateral to) to the site on at least one side.

0.6 = Contiguous with comparable habitat on one end of the site (upstream or downstream) and surrounded by transitional upland habitat which is at least 35 m wide.

0.8 = Contiguous with comparable habitat on both ends of the site (upstream and downstream), but surrounded with urban/suburban or other nonopen space lands adjacent (lateral to) to the site on at least one side.

1.0 = Contiguous with comparable habitat on both ends of the site (upstream and downstream) and surrounded by transitional upland habitat on both sides which is at least 35 m wide.

Higher order streams.

0 = No linear contiguity or transitional upland habitat; completely surrounded by or isolated within an urban setting or converted to an urban/suburban land use.

0.2 = No linear contiguity upstream or downstream, but isolated within upland open space habitat.

0.4 = Contiguous with comparable habitat on one end of the site (upstream or downstream), but surrounded with urban/suburban or other nonopen space lands adjacent (lateral to) to the site on at least one side.

0.6 = Contiguous with comparable habitat on one end of the site (upstream or downstream) and surrounded by transitional upland habitat which is at least twice the width of the riparian zone.

0.8 = Contiguous with comparable habitat on both ends of the site (upstream and downstream), but surrounded with urban/suburban or other nonopen space lands adjacent (lateral to) to the site on at least one side.

1.0 = Contiguous with comparable habitat on both ends of the site (upstream and downstream) and surrounded by transitional upland habitat on both sides which is at least twice the width of the riparian zone.

Percent of Invasive Vegetation

Invasive species often thrive in mesic environments and readily establish following disruption of riparian systems. Many invasive species have few, if any, native pests or diseases and thus grow rapidly. Once established, their proliferation excludes reestablishment of native species following subsequent disturbances, such as floods or fires (Warner and Hendrix 1985). Some invasive vegetation, such as *Arundo donax* and *Tamarix* spp. provide little to no habitat value for wildlife species (Hanes 1981, Bell 1993). Moreover, *A. donax* and *Tamarix* spp. pose a greater problem for flood control than native vegetation due to the morphological characteristics of the long stalks (*Arundo*) and deep taproots (*Tamarix*), which obstruct flood control channels more than native riparian vegetation. Overall, the replacement of native riparian habitat with *A. donax, Tamarix* spp., and other invasive vegetation displaces native fauna, reduces flood conveyance, increases evapotranspirative losses, increases water temperature, and creates fire hazards (Bell 1993). For example, eradication of *A. donax* from the Santa Ana River could reduce annual evapotranspirative water losses by an estimated 4.6×10^7 m^3, resulting in an estimated savings of $12 million annually (Iverson 1993). However, it has been suggested that the increased biomass associated with invasive weed infestation may increase retention times and, therefore, the ability of a site to sequester elements or compounds. The contribution of increased biomass to biogeochemical processes is accounted for in the structural diversity and spatial diversity criteria.

The ratings for the percent of invasive vegetation criterion are assigned based on the following scale:

0 = Site is covered by pure stands of invasive vegetation or lacks any riparian vegetation.
0.2 = Site is covered by 70–99% invasive vegetation.
0.4 = Site is covered by 40–69% invasive vegetation.
0.6 = Site is covered by 10–39% invasive vegetation.
0.8 = Site is covered by 5–9% invasive vegetation.
1.0 = Site is covered by less than 5% invasive vegetation.

Hydrology

Hydrology is the most important factor determining the establishment and maintenance of specific wetland functions (Mitsch and Gosselink 1993). Reviews of past mitigation sites reveal that improper hydrology is the most significant problem with many unsuccessful sites (Mitsch and Wilson 1996, Sudol 1996). Riparian systems rely on appropriate and natural hydrology for long-term self-sustainability and viability. This criterion addresses the source of water supporting the wetlands and the exposure of the site to riparian processes, such as scour and overbank flow. The geomorphic structure of the site is addressed by the topographic complexity and flood-prone area criteria. The ratings for the hydrology criterion are assigned based on the following scale:

0 = No regular supply of water to the site. Site not associated with any water source, surface drainage, impoundment, or groundwater discharge.
0.2 = Water supply to the site is solely from artificial irrigation (e.g., sprinklers, drip irrigation). No natural surface drainage, natural impoundment, groundwater discharge, or other natural hydrologic regime.
0.5 = Site is sustained by natural source of water but is not associated with a stream, river, or other concentrated flow conduit. For example, the site is sustained by groundwater or urban runoff. There is no evidence of riparian processes, such as overbank flow or scour or deposition.
0.7 = Site is within or adjacent to an impoundment on a natural water course which is subject to fluctuations in flow or hydroperiod.
1.0 = Site is within or adjacent to a stream, river, or other concentrated flow conduit that provides the primary source of water to the site. The site contains evidence of riparian processes, such as overbank flow or scour or deposition, or is within the flood-prone area (the channel plus the area defined by a horizontal projection at a height of twice the bankfull thalweg; Rosgen 1994).

Micro- and Macrotopographic Complexity

In riparian systems, fluvial processes that erode material from some areas and deposit it in others during flood events form dynamic mosaics of active channels, terraces, flood plains, and alluvial fans with different drainage patterns and elevations (Gregory and others 1991). These elevational differences result in the extensive vegetative diversity of riparian systems (Strahan 1984). Riparian flora depends on connectivity between active channels and flood plains for seed dispersal and germination and on base flow resulting from percolation into flood plain soils for survival during the dry season (Warner and Hendrix 1985, Harris and Gosselink 1990, Faber 1993). The ratings for the topographic complexity criterion are assigned based on the following scale:

First- and second-order streams.

0 = All flows, including flood flows, are contained in a concrete-lined channel, culvert, etc.
0.2 = Flood-prone area is characterized by a homogenous, flat earthen surface with little to no micro- and macrotopographic features.
0.6 = Flood-prone area contains micro- and/or macrotopographic features such as pits, ponds, hummocks, bars, rills, large boulders, but is predominantly homogeneous or flat surface.
1.0 = Flood-prone area is characterized by micro- and

macrotopographic complexity, such as pits, ponds, hummocks, rills, large boulders, etc.

Higher order streams.

0 = All flows, including flood flows, are contained in a concrete-lined channel, culvert, etc.
0.2 = Flood-prone area is characterized by a homogenous, flat earthen surface with little to no micro- and macrotopographic features.
0.5 = Flood-prone area contains micro- and/or macrotopographic features such as meanders, bars, braiding, secondary channels, backwaters, terraces, pits, ponds, hummocks, but is predominantly homogeneous or flat surface.
0.8 = Flood plain is predominantly heterogeneous, and is characterized by microtopographic features such as pits, ponds, hummocks, bars. However, there are no macrotopographic features, such as braiding, secondary channels, backwaters.
1.0 = Flood-prone area is characterized by micro- and macrotopographic complexity, such as meanders, bars, braiding, secondary channels, backwaters, terraces, pits, ponds, hummocks, etc.

Characteristics of Flood-Prone Area

Riparian systems are defined by the geomorphic structure and fluvial characteristics of the valleys in which they exist (Gregory and others 1991). Development of river flood plains and restriction of channel migrations alters the hydrologic regime of riparian systems and severs the critical link between the aquatic habitat and adjacent upland habitat. Alteration of the flood plain reduces overbank flooding, resulting in less seed dispersal and a reduced ability of riparian vegetation to establish (Harris and Gosselink 1990). Kraemer (1984) reported that loss of riparian flood plain along the Sacramento River led to decreased sediment deposition and energy dissipation, resulting in increased flows and less stable streambeds and banks. Once the flood plain is developed, storms result in more overland flow due to impervious surface, but less percolation (Faber 1993). Furthermore, disconnecting rivers from their flood plains reduces their ability to attenuate flood peaks, limits natural sediment deposition and water quality enhancement, and disrupts downstream successional processes and scour cycles (Warner and Hendrix 1985, Harris and Gosselink 1990, Scott and others 1990). Although specific effects vary, in general channel "improvements" cause downstream flood hydrographs to have higher peaks and also cause peaks to occur earlier (DeVries 1980).

The flood-prone area is defined as the bankfull channel plus the area defined by a horizontal projection at a height of twice the bankfull thalweg (Rosgen 1994). This criterion is based on flood-prone area instead of the flood plain because the former represents the area regularly exposed to overbank flow. Although the margins of the flood plain contribute greatly to the ecological function of the riparian system, these areas are often not subject to Corps jurisdiction (in semi-arid systems) and are therefore not the focus of mitigation efforts. The ratings for characteristics of the flood-prone area criterion are assigned based on the following scale.

First- and second-order streams.

0 = All flows, including flood flows, are contained in a concrete-lined channel, culvert, etc.
0.2 = Channel has an earthen bottom; however, it is structurally confined (e.g., riprap or concrete sideslopes) such that the flood-prone area is within the confined channel and flow would only overtop the channel during extreme events (i.e., greater than a 50-year-flood event).
0.4 = Channel has an earthen bottom and earthen sideslopes; however, it is incised or confined such that the channel would only overtop during extreme flow events (i.e., greater than a 50-year-flood event).
0.7 = Channel has an earthen bottom and earthen sideslopes and is mildly incised or confined such that the flood-prone area would be subject to periodic overbank flow (i.e., during a 10-year-flood event).
1.0 = Site is a natural channel with little to no evidence of incision or confinement.

Higher order streams.

0 = All flows, including flood flows, are contained in a concrete-lined channel, culvert, etc.
0.2 = Channel has an earthen bottom; however, it is structurally confined (e.g., riprap or concrete sideslopes) such that the flood-prone area is wholly contained within the channel and there is no opportunity for overbank flow, except in extreme events.
0.3 = Channel has an earthen bottom and earthen sideslopes; however, it is incised or confined such that the flood-prone area is wholly contained within the channel and there is no opportunity for overbank flow, except in extreme events.

0.6 = Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events (i.e., during a 2- to 10-year-flood event). However, the flood-prone area is confined by levees, berms, dikes, or other obstructions or barriers such that the area available for overbank flow is less than twice the width of the channel at bankful conditions.

0.8 = Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events (i.e., during a 2- to 10-year-flood event). The flood-prone area is confined by levees, berms, dikes, or other obstructions or barriers; however, the area available for overbank flow is equal to or greater than twice the width of the channel at bankfull conditions.

1.0 = Site is part of an unconfined natural floodplain at least twice the width of the channel at bankfull conditions and there is evidence of overbank flow.

Biogeochemical Processes

The location of riparian areas along streams along with the relatively low topography, natural ponding, and ground surface roughness of riparian zones allows them to act as sinks for sediment and nutrient runoff from adjacent uplands and as sources for conversion of detritus to consumable organic matter (Childers and Gosselink 1990, Scott and others 1990). Rising water overtops streambanks, slowing the flow velocity, allowing water and suspended material to access the adjacent flood plain and riparian zones (Gosselink and others 1990a, Scott and others 1990). Microbial action in the root zone removes toxics, nitrogen, and other nutrients from the runoff; thereby improving water quality and helping to reduce the impacts of nonpoint source pollution (Schaefer and Brown 1992). Peterjohn and Correll (1984) reported that each ha (2.47 acres) of riparian forest removed 4.1 mg of particulates, 11 kg of particulate organic nitrogen, 0.83 kg of ammonium-nitrogen, 2.7 kg of nitrate-nitrogen, and 3,0 kg of total particulate phosphorus per year. Gregory and others (1991) reported that up to 65% of the nitrogen and phosphorus can be removed from agricultural runoff by riparian vegetation. Heterotrophic microorganisms that thrive in riparian areas are also responsible for converting detritus from leaf litter and other dead organic matter into consumable organic matter. This organic material forms the base for the riparian food chain and can be released downstream as dissolved organic matter (Gregory and others 1991, Schaefer and Brown 1992). Knight and Bottoroff (1984) reported that up to 1000 g/m^2/year of detritus are produced by aquatic macrophytes in riparian zones, and this provides a food chain base for these ecosystems, promoting their biodiversity.

Biogeochemical processes depend on water flow through the site, availability of surfaces to slow water and provide a platform for microbial activity and chemical reactions and as sources of organic carbon. Water flow and availability of flood plain surfaces are addressed by the criteria discussed above. The ratings for surface roughness and sources of organic carbon are assigned based on the following scales:

First- and second-order streams.

0 = channel is contained in a concrete-lined channel, culvert, etc., with little to no vegetation or detritus.

0.2 = Site can support grasses, forbs, or other herbaceous vegetation, or there is debris, leaf litter, or detritus present in the channel.

0.4 = Channel supports at least 5% relative cover of herbaceous or other vegetation and there is at least 10% relative cover of debris, leaf litter, or detritus in the channel.

0.6 = Site contains between 5% and 20% relative cover of any type of vegetation and between 10% and 25% relative cover with debris, leaf litter, or detritus.

0.8 = Site contains greater than 20% relative cover of any type of vegetation or between 25% and 60% relative cover with debris, leaf litter, or detritus.

1.0 = Site contains greater than 20% relative cover of any type of vegetation and greater than 60% relative cover with debris, leaf litter, or detritus.

Higher order streams.

0 = channel is contained in a concrete-lined channel, culvert, etc., with little to no vegetation or detritus.

0.2 = Site can support grasses, forbs, or other herbaceous vegetation, and there is woody debris, leaf litter, or detritus present in the channel.

0.4 = Channel supports at least 25% relative cover of grasses, forbs, herbaceous, or riparian vegetation, and there is at least 10% relative cover of woody debris, leaf litter, or detritus in the channel.

0.6 = Site contains between 25% and 50% relative cover of any strata of riparian vegetation and between 10% and 40% relative cover with woody debris, leaf litter, or detritus.

0.8 = Site contains between 50% and 75% relative cover of any strata of riparian vegetation and between 40% and 60% relative cover with woody debris, leaf litter, or detritus.

1.0 = Site contains greater than 75% relative cover of any strata of riparian vegetation and greater than 60% relative cover with woody debris, leaf litter, or detritus.

Calculation of Credits and Debits

Credits and debits are calculated based on the number of condition units per ha (CU) gained at the mitigation bank and lost at the impact site. The number of CU per ha is calculated by adding the scores for most of the evaluation criteria. We chose to multiply the scores for the three habitat criteria by the score for the percent of invasive vegetation criterion because infestation with invasive vegetation tends to depress all habitat function in riparian systems. Using the score for percent invasive vegetation as a multiplier precludes the need to specify native versus invasive vegetation under the other habitat criteria. The effect of increased biomass associated with invasive plants on hydrologic and biogeochemical processes is accounted for in the biogeochemical processes criterion. Hydrology is widely recognized as the driving force behind wetland and riparian systems. Therefore, the condition units formula weights the hydrologic regime criterion at three times the importance of other criteria. This reflects the fact that appropriate hydrology is fundamental to overall riparian function, and it devalues sites with artificial or inappropriate hydrology. We recognize there may be some overlap between criteria, for example, the density of vegetation at a site contributes to the rating under both the coverage and spatial diversity and the biogeochemistry criteria; however, we believe this is appropriate because certain characteristics of a site contribute to multiple functions (e.g., habitat and biogeochemical functions). The number of condition units/ha is calculated using the following formula:

$$CU = [(ST + SP + CNT)\, I] + FPA + TC + BR + 3H$$

where ST = Habitat – Structural Diversity; SP = Habitat – Coverage and Spatial Diversity; CNT = Habitat – Contiguity; I = Percent of Invasive Vegetation; FPA = Characteristics of the Flood-prone Area; TC = Topographic Complexity; BR = Biogeochemistry – vegetation roughness and organic carbon; H = Hydrology.

When performing functional assessments for their own sake, for the purposes of impact evaluation or for design or evaluation of mitigation sites, functions should not be combined into overall indices. The practice of combining functions can result in certain functions being masked, thereby underestimating the overall importance of a wetland to watershed ecology and decreasing the resolution of the functional assessment. However, the intent of this method is not to evaluate wetland functions but to provide a tool to calculate mitigation ratios based on the ecologic condition of impact and restoration sites. To accomplish this goal in the context of a mitigation bank, we must generate a single number or index.

Application of the Riparian Model

The Santa Ana River Mitigation Bank (SARMB) provided the earliest application of the southern California's riparian crediting and debiting model. The Santa Ana River, with a watershed of area of 6345 km^2 (2450 $miles^2$), is the largest river system is southern California (Hanes 1981). The riparian habitat along the Santa Ana River is southern riparian scrub consisting of *Salix, Populus,* and *Baccharis* species. Of the 5667 ha (14,000 acres) of riparian habitat along the Santa Ana River, approximately 2000 ha (5000 acres) are infested with an invasive species commonly known as the giant reed, *A. donax* (Bell 1993). Replacement of the native riparian vegetation with *A. donax* has not only led to loss of suitable habitat for many wildlife species, including the federally listed endangered least Bell's vireo, *Vireo bellii pusillus,* but has also caused problems with water quality and water conservation (Bell 1993, Iverson 1993).

The Santa Ana River mitigation bank is located in the northern portion of Riverside County in the City of Riverside (Figure 1). The goal of the SARMB is to restore a degraded riparian system by reestablishing the native riparian ecological diversity and other riparian functions, such as flood flow alteration, groundwater recharge, improvement of water quality (temperature and organic matter), reduction of fire hazard, and increased recreational use. Credits were established by removal of invasive vegetation and selective planting to encourage natural recruitment of native riparian vegetation.

The size of the initial mitigation bank area was approximately 22.7 ha (56 acres). Since the initial bank establishment, additional areas have been incorporated in the bank, however, the information provided here only reflect the original 22.7 ha. The potential credits were determined using aerial photographs and field surveys. Review of aerial photographs and field surveys revealed three characteristic regions with varying degrees of invasive vegetation infestation within the bank area (Figure 2, Table 2). To determine the available credits, each region of the mitigation bank was rated

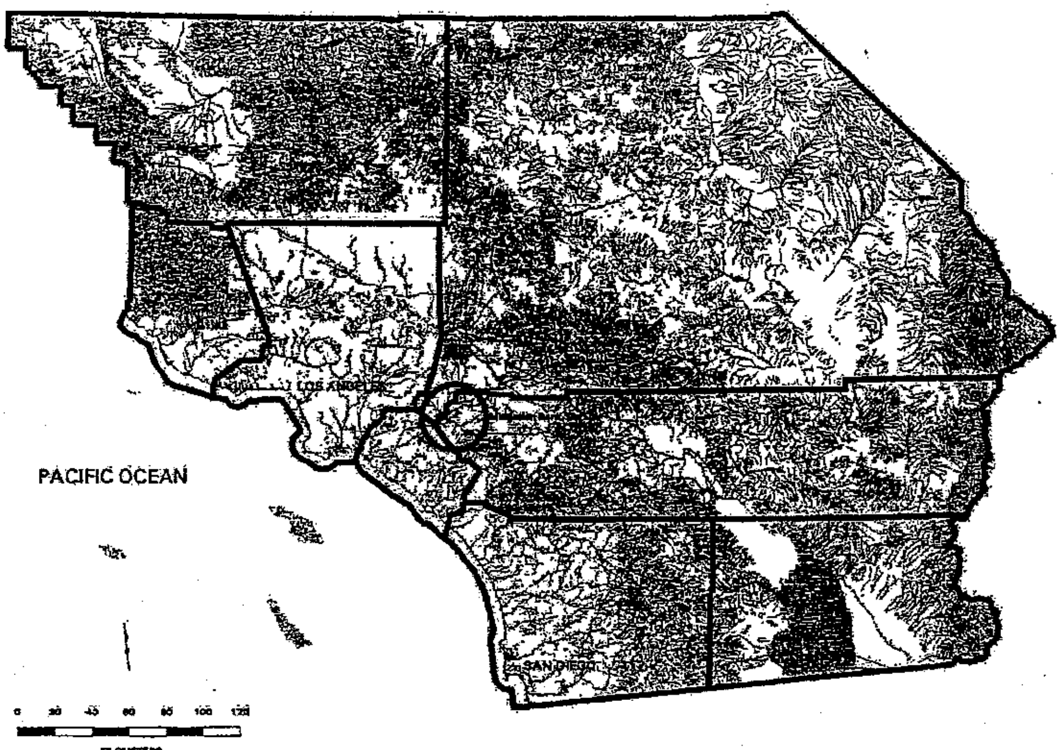

Figure 1. Location of the Santa Ana River mitigation bank. The area circled shows the location on the Santa Ana River where the mitigation bank is located. Thick lines are county boundaries, fine lines are streams.

separately based on homogeneity of the region or subunit. Post-bank scores were assigned based on the maximum possible score a similar uninfested resource in that region could achieve. The cumulative difference between the baseline rating and the predicted post-bank rating is the total available credits in the mitigation bank.

Region A, which is approximately 12.4 ha (30 acres) (62% of the total area), consists of 100% *Arundo* infestation with no native riparian vegetation and is adjacent to a riparian zone with two species of woody riparian plants and poorly developed understory on one half of the site and a structurally and spatially diverse riparian zone on the remaining half. Because of the high degree of *Arundo* infestation, there is low topographic complexity and diversity of detritus in Region A. Region B is approximately 7.6 ha (26 acres) (38% of the total area), and consists of mixed native riparian vegetation with shrub and herbaceous understory interspersed with 20–40% *Arundo*. Region B is connected to structurally and spatially diverse riparian zone on one half and 100% *Arundo*-infested zone on the remaining half. The topographic complexity and density of detritus is relatively greater in Region B than in Region A due to the presence of secondary channels and a native riparian vegetation. Region C is not part of the mitigation bank, however, it will be preserved and will function as a buffer between the bank and adjacent land uses. Region C consists of relatively mature riparian species (10–20 years), with a well-developed canopy, diverse understory, and less than 5% *Arundo* present. All three regions possess natural hydrology and are within a flood-prone area greater than twice the width of the active channel at bankful conditions. The scores for pre- and post-bank conditions are shown in Table 3.

The restoration effort began in 1993, when the local community underwent significant threat of fires fueled by *Arundo*. *Arundo* (reaching height of up to 8 m) is a tall grass native to eastern Asia, introduced to southern California in early 1800s for purpose of erosion control. Due to its high rate of growth (5 cm/day), it outcompetes the native riparian vegetation and soon becomes the dominant species in the riparian zone (Bell 1997). The rhizome, which typically reaches depths of 1 m, quickly stabilizes the stream bank and forms terraces severing the riparian zone from fluvial processes typi-

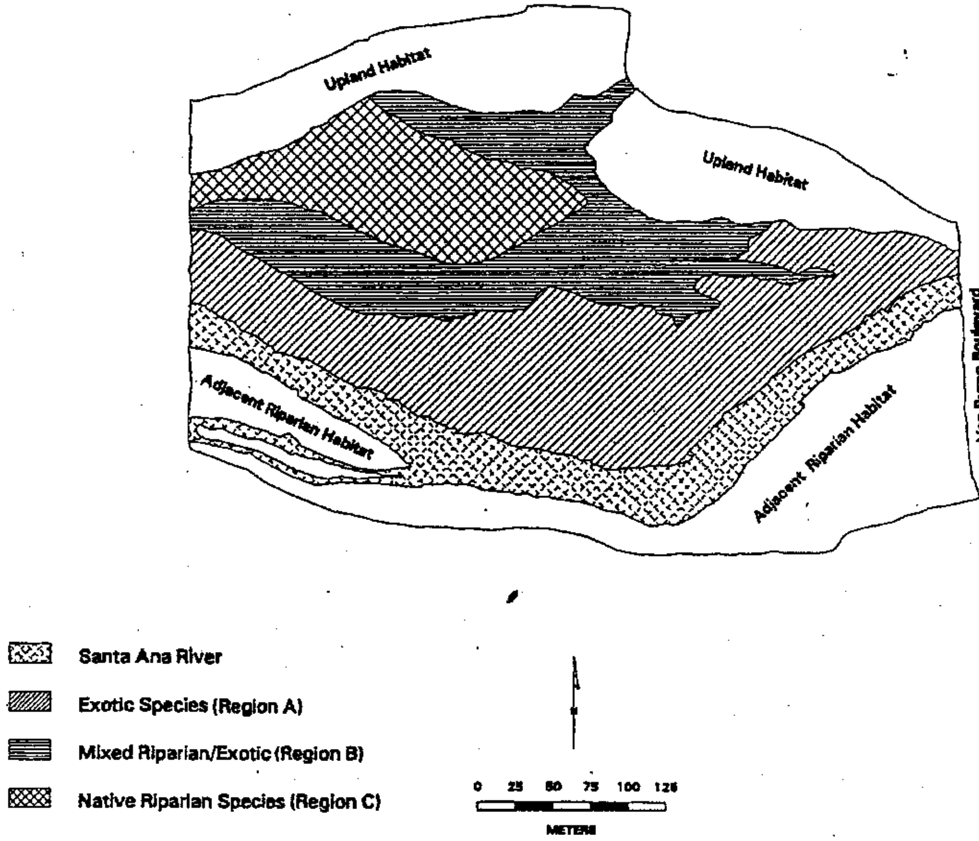

Figure 2. Characteristic regions of the Santa Ana River mitigation bank. The map shows the dominant plant community for each subarea of the mitigation bank prior to initiation of any restoration efforts (e.g., baseline conditions). Mapping was based on aerial photography, dated April 1993. Area C was not included in the mitigation bank because it is existing native riparian habitat.

Table 2. Characteristics of regions A & B of the Santa Ana River mitigation bank. Size, percent of total area, and percent infestation with invasive weeds of the two subareas of the Santa Ana River mitigation bank

Region	Size (ha)	% total area	% invasives
A	12.4	62	100
B	7.6	38	20–40

cally occurring within native vegetation–dominated riparian zones. The reduction of overbank flooding limits aggredation and degradation processes consequently limiting native vegetation propagule dispersal. The high growth rate of *Arundo* combined with its high degree of flammability soon redirects the native riparian community to an *Arundo*-infested riparian zone (Bell 1993). The ecological changes that occur within a riparian zone as a result of *Arundo* infestation include reduction of suitable habitat for native wildlife, highly altered flooding regime, and reduction of biogeochemical processes due to the reduction of surface moisture and presence of noxious chemicals, such as silica, tri-terpines, and sterols (Chanduri and Ghosal 1970, Bell 1997).

Restoration of the Santa Ana River mitigation bank was accomplished using a glyphosate, an EPA-approved herbicide for use in wetlands. The application method varied depending on the extent of *Arundo* infestation and extent of native riparian vegetation present in the treatment areas. The most effective period for applying the herbicide was determined to be during the period when maximum translocation of nutrients to the root is occurring (the period between post-flowering and pre-dormancy) (Bell 1993). Method of application of the herbicide in the SARMB included aerial application (areas >80% *Arundo*), use of all-terrain vehicles (<80% *Arundo*-infested areas easily accessible), and backpack

Table 3. Rating of the two regions in the Santa Ana River mitigation bank. Scores for each criterion for the pre-restoration baseline condition in each subarea. Weighted mean is the average of the criterion score for each subarea adjusted for the subarea's proportion of the total area. Post-project scores reflect the anticipated condition of the site upon maturation of the restoration efforts

Criterion	Region A (62%)	Region B (38%)	Pre-project (weighted mean)	Post-project
ST	0.2	0.6	0.35	1.00
SP	0.2	0.6	0.35	1.00
CNT	0.8	0.8	0.80	0.80
I	0	0.6	0.23	0.80
FPA	0.4	0.4	0.40	0.80
TC	0.2	0.8	0.43	1.0
BR	0.2	0.8	0.43	0.80
H	1.0	1.0	1.0	1.0

Legend: ST = Habitat—Structural Diversity; SP = Habitat—Coverage and Spatial Diversity; CNT = Habitat—Contiguity; I = Invasive Vegetation; FPA = Characteristics and the Flood-prone Area; TC = Topographic Complexity; BR = Biogeochemistry—Vegetation Roughness and Organic Carbon; H = Hydrology.

sprayers (areas difficult to access with vehicles and resprouts). The biomass was cut by hand cutting, chipper, or hydro-ax and removed by hauling to a suitable off-site location or controlled biomass burning. Once the biomass was removed, selective planting was carried out on portions of the bank site to accelerate the natural revegetation process. In the initial 2–3 years treatment or respoutes occurred on a regular basis (2–3 times/year) and continually declined as the native riparian vegetation began to self-recruit and the root mass decomposed. The change in ecological condition of the SARMB became apparent following the third year of treatment as evident by change in characteristics of the flood-prone area, structural diversity of native vegetation, enhancement of topographic complexities (ponds, bars, hummocks, and secondary channels), enhanced biogeochemical processes (due to increase surface moisture and evident by visible microbial activity). The contiguity of the bank area would not be affected as a result of the restoration work, as the site is connected to riparian and upland habitats and no modification is expected to occur in these areas. The SARMB continues to be actively monitored, and it serves as a model for native riparian restoration project throughout California.

Debits at the impact sites are determined by assigning of pre-project and post-project ratings for each criterion. Evaluation of a pre- and post-project at the impact site allows for consideration of any remaining functional characteristics at the impact site following implementation of a project. A hypothetical debiting score scenario to be mitigated at this bank is presented in Table 4, where a project would impact an aquatic resource with a relatively high functional characteristics. The mitigation ratio for the hypothetical debiting scenario for use of the SARMB is calculated to be 2.5:1 (Table 5). This mitigation ratio is based on withdrawal of credits when the credits have reached their expected

Table 4. Sample calculation of debits: This table shows a *hypothetical* example of the application of the crediting and debiting framework to an impact site. For this example, the impact would be complete fill of the stream on the project site

Criterion	Pre-project rating	Post-project rating	Net functions lost
ST	0.8	0	0.8
SP	0.8	0	0.8
CNT	0.8	0	0.8
I	0.8	0	0.8
FPA	0.8	0	0.8
TC	1.0	0	1.0
BR	0.8	0	0.8
H	1.0	0	1.0

Legend: ST = Habitat—Structural Diversity; SP = Habitat—Coverage and Spatial Diversity; CNT = Habitat—Contiguity; I = Invasive Vegetation; FPA = Characteristics and the Flood-prone Area; TC = Topographic Complexity; BR = Biogeochemistry—Vegetation Roughness and Organic Carbon; H = Hydrology.

Table 5. Calculation of credits and debits for the Santa Ana River mitigation bank: Sample application of the crediting and debiting framework to determine a mitigation ratio. Credits are determined by using the criteria scores shown in Table 3. Debits are determined by using the hypothetical scores shown in Table 4

Step 1. Evaluation of credits

$CU = \{[(ST + SP + CNT)I] + FPA + TC + BR\} + 3H$

Pre-bank $CU = \{[0.35 + 0.35 + 0.8)0.23] + 0.4 + 0.61 + 0.43\} + 3(1.0) = 4.78$

Post-bank $CU = \{[1.0 + 1.0 + 0.80)0.8] + 0.8 + 1.0 + 0.8\} + 3(1.0) = 7.84$

Projected Credits Available = 7.84 − 4.78 = 3.06

Step 2. Evaluation of debits

Debits (Functional Units Lost) $= \{[(0.8 + 0.8 + 0.8)0.8] + 0.8 + 1.0 + 0.8\} + 3(1.0) = 7.52$

Step 3. Determination of mitigation ratio

Mitigation Ratio = 7.52/3.06 = 2.45

Legend: ST = Habitat—Structural Diversity; SP = Habitat—Coverage and Spatial Diversity; CNT = Habitat—Contiguity; I = Invasive Vegetation; FPA = Characteristics and the Flood-prone Area; TC = Topographic Complexity; BR = Biogeochemistry—Vegetation Roughness and Organic Carbon; H = Hydrology.

Table 6. Credits available during the first 5 years of operation: Discounting of the mitigation ratio (as determined in Table 5) for years 1 through 5. This hypothetical scenario assumes the mitigation site achieves the performance goals by year 5

Year	Total projected credits	Credits available	Mitigation ratio
1	3.06	3.06 × 0.2 = 0.61	7.52/0.61 = 12.3
2	3.06	3.06 × 0.4 = 1.22	7.52/1.22 = 6.2
3	3.06	3.06 × 0.6 = 1.84	7.52/1.84 = 4.1
4	3.06	3.06 × 0.8 = 2.45	7.52/2.45 = 3.1
5	3.06	3.06 × 1.0 = 3.06	7.52/3.06 = 2.5

restoration potential, which is estimated to take approximately 5 years.

Although mitigation banks should conceptually reach their predicted functional maturity prior to withdrawal of credits, there may be a need to withdraw credits prior to achievement of functional maturity. It should be noted that in these circumstances financial assurance must be secured by the bank sponsor. This crediting and debiting method gives flexibility in withdrawal of credits prior to full functional establishment of an aquatic resource by allowing adjustment of the mitigation ratio to reflect the existing conditions at the mitigation bank. The actual condition of the mitigation bank may be evaluated at a given time interval and the percentage of total expected credits may become available for withdrawal. A simplified example may be a mitigation bank where at the end of the first year credits have 20% of their maximum potential value, 40% of the total potential value in the second year, 60% of potential value in the third year, and 80% of the predicted value at the end of the fourth year (Table 6). Credits would have their full functional maturity at the end of the fifth year. This would allow sale of credits at a partial value to provide funds for the sponsor within the initial establishment period. In addition, if credits have only partial value in the initial 5 years, the mitigation ratios obtained should be high enough to deter the use of this mitigation bank for projects with impacts to riparian habitats with high functional capacity and consequently should encourage avoidance and minimization of impacts to these habitats. By setting a minimum compensation ratio of 1:1 the crediting and debiting methodology prevents loss of acreage.

Discussion

Despite the existence of numerous methods for assessing functions of aquatic resources, compensation ratios are typically determined based on existing policy and/or best professional judgment of decision makers. Existing mitigation banks typically use either an acreage-based or case-by-case best professional judgment determination of functional characteristics and compensation ratios (IWR 1994, Tabatabai 1994). As mitigation banking gains support from the regulated public, entrepreneurs, and the resource and regulatory agencies, a greater need arises for use of an appropriate crediting and debiting methodology in any mitigation bank. Use of detailed functional assessment methodologies or site-specific evaluation of function for determination of credits and debits is far superior to rapid approaches, such as the one we present in this paper. However, the constraints posed by their application (e.g., time and resources) makes their use impractical in the mitigation banking context. The goal of this framework is to provide a rapid assessment of credits and debits that does not require extensive field data collection and where the assessment of structural components of an aquatic resource could be used by nonwetland scientists. The proposed framework meets the six objectives necessary for a crediting and debiting system to be useful in a regulatory context.

(1) It can be tailored to evaluate ecologic condition based on the target resources of a specific mitigation bank. The example presented in this paper illustrates application of the proposed framework to a mitigation bank where the goal is to restore riparian habitat. This framework is currently being applied to a bank where the goal is restoration of vernal pools; therefore, specific criteria have been developed that reflect the ecologic conditions of depressional wetlands. For example, one of the evaluation criteria addresses duration of ponding and is scaled as follows:

- 0 = Ponding is transient following storm events and persists for no more than 1 day.
- 0.2 = Site may pond water for several days following storm events; however, ponding seldom persists beyond 10 days. There may be several ponding events during a season.
- 0.4 = Ponding duration is on the order of several weeks. There may be several ponding events during a season.
- 0.6 = Ponding duration is on the order of several months, but less than 6 months. There may be several ponding events during a season.
- 0.8 = On average, site ponds water for more than 6 months.
- 1.0 = Site ponds water year-round.

(2) It is flexible enough to be used for evaluation of existing or potential ecologic condition at a mitigation

bank. Because credits are determined based on the difference between structural characteristics of the post-restoration condition and pre-restoration (baseline) condition at the bank site, the framework can be applied in a predictive manner. A CU score can be calculated based on the expected future condition at the bank and used as the "enhancement potential" for the purpose of determining mitigation ratios. The success of the restoration can be evaluated by comparing the condition of the resources over time to the expected future condition, and remedial measures can be implemented to ensure the target condition is achieved. This crediting and debiting method also provides the flexibility to account for withdrawal of credits prior to full functional establishment of an aquatic resource by allowing adjustment of the mitigation ratio to reflect the condition of the resources at the mitigation bank at time of purchase of credits.

(3) It is a structured and systematic way to apply data and professional judgment to the decision-making process. The intent of the proposed framework is not to provide an absolute tool for evaluating functional condition. However, it does provide an alternative to subjectively applied best professional judgment by establishing a structure to organize information and apply judgment in an objective manner, based on ecological principles. For example, in instances where a mitigation banking agreement contains limits on the quality of riparian habitat that can use the bank for mitigation, this framework can be used to determine whether the "quality" of the resources at the impact site exceeds the stated threshold. Several proposed banks in the Los Angeles District of the Corps involve restoration or enhancement of existing aquatic resources and have stipulations in the banking instruments that only allow impacts to degraded habitats to be mitigated at the bank. In these cases, a proposed project site which receives a pre-project rating of 4 CUs or greater would be precluded from using the bank. This provides an objective way to ensure that the functions gained through the mitigation bank are commensurate with the impacts for which credits were purchased.

(4) It has an ecologically defensible basis. Credits and debits are based on the structural characteristics and landscape setting of the restoration and the impact sites. The evaluation criteria reflect attributes of wetlands shown to be important to their viability and ability to provide a suite of ecologic functions. Many of the criteria presented for riparian systems are similar to one used in established functional evaluation methods, such as HGM and HEP.

(5) It has ease of use such that the level of expertise and time required to employ the method is not a deterrent to its application. The evaluation criteria have been structured so that they can be applied based on information typically provided in biological resource reports that accompany U.S. Army Corps of Engineers permit applications. Because the criteria are generally descriptive, they can be applied with minimal ambiguity based on information supplied by permit applicants. When being applied in the field, scores can be assigned with a reasonable amount of data collection, yet not so intensive as to be a deterrent to its use. In practice, most sites can be evaluated by review of aerial photography and several hours in the field. This is commensurate with the time and resource constraints of the regulatory program.

(6) It provides a semi-quantitative measure of the condition of aquatic resources that can be translated to a mitigation ratio. Scaling of the evaluation criteria is based on a combination of field data collected during development of a regional HGM assessment model (Lee and others 1997), research on the success of past mitigation projects in southern California (Sudol 1996), and professional judgment of scientists familiar with semi-arid riparian systems. The framework organizes this information in a categorical manner and provides a way to translate information about the conditions of a site to a quantitative mitigation ratio. The framework may also be applicable for determination of out-of-kind compensation ratios. Aquatic resources can be evaluated based on criteria developed for each specific wetland type. The relative conditions can then be translated into a common currency or unit of measure and the compensation ratio assigned using the ratio of debits over credits.

The crediting and debiting framework presented in this work is not designed as a functional assessment methodology; rather, it is intended to be a rapid semi-quantitative measure of structural characteristics of an aquatic resource for the purpose of determining compensatory requirements. The framework, as demonstrated with the southern California riparian model, offers an alternative to use of existing functional assessment methodologies or best professional judgment for determination of credits and debits. We encourage more dialogue and debate among scientists, regulators, and the public on the merits of this approach and the details of its applications, such as choice of indicators, scaling of criteria, and architecture of the CU formula. The ultimate goal should be an objective and systematic way to determine ecologically meaningful mitigation requirements that are commensurate with the impacts and result in a net benefit for the resources protected by the Clean Water Act.

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Exhibit C

SANTA ANA WATERSHED ASSOCIATION OF RCD'S

SANTA ANA RIVER WATERSHED PROJECT WORK SUMMARY, CONTRACT AND BUDGET FOR FY's 2000-01 AND 2001-02

GOALS:
The goal for the Santa Ana Watershed Program is to reduce the threat of invasive plants (especially giant reed and tamarisk) on native habitat and river system function. The oversight for this program is the U.S. Fish and Wildlife Service. The appointed fiduciary, Orange County Water District, will hold and disperse funds as indicated by this approved work plan. Acknowledge SAWA as the working group that will implement and oversee projects focused on the long-term maintenance and enhancement of river system function, while implementing whole watershed health. This work plan will develop projects that further these goals. Those groups that are identified to perform the tasks listed below include (but may not be limited to) East Valley Resource Conservation District, Elsinore-Murrieta-Anza Resource Conservation District, Inland Empire West Resource Conservation District, Riverside-Corona Resource Conservation District, San Jacinto Basin Resource Conservation District.

*The goals for these fourth and fifth years are:

- Complete an exotic plant management report for the Santa Ana River Watershed;
- Complete mapping of all tributaries within the Santa Ana River Watershed;
- Continue the development of a GIS database to track and monitor treatment projects for the SAR Watershed;
- Perform 70.0 acres of exotic plant treatment in the East Valley Resource Conservation District;
- Develop a Watershed Management Plan/seek funding for the San Jacinto River in the Elsinore-Murrieta-Anza Resource Conservation District;
- Perform 25.0 acres of exotic plant treatment in the Inland Empire Resource Conservation District;
- Perform 30.0 acres of exotic plant treatment in the Riverside-Corona Resource Conservation District;
- Develop a Santa Ana Sucker, Arroyo chub and Speckled Dace Fish Recovery Program in the Riverside-Corona Resource Conservation District;
- Perform 16.65 acres of exotic plant treatment in the San Jacinto Resource Conservation District;
- Continue the development of outreach materials and educational programs, and supply information on exotic plant control to private landowners within the watershed;
- Continue to work on a watershed team structure that will coordinate and implement tasks and seek and manage funds for those tasks into the future;
- Implement a second SAWA Field Biologist position to coordinate and monitor invasive plan removal, habitat restoration and least Bell's Vireo/Cow Bird monitoring program within the watershed; the first to be located in the East Valley RCD/San Timoteo Canyon Region, the second to be located in Riverside-Corona RCD/Prado Region;

*The accomplishment of these goals, as outlined in more detail below, will be subject to and entirely dependent upon the amount of funds available for this program. Any changes or additions to this work plan can be done in writing and submitted for approval to the U.S. Fish and Wildlife Service. The tasks and figures were included here to keep all projected expenditures together for reference.

TASK 1 – EAST VALLEY RCD TO COMPLETE THE SANTA ANA RIVER ANNUAL REPORT FOR THE CONTROL OF INVASIVE PLANTS:
Complete and deliver to the partnering agencies The Santa Ana River Watershed Annual Report that shall include but not be limited to the following:

- Introduction to the Santa Ana River Watershed with appendices of sensitive species
- Discussion of giant reed and tamarisk impacts on natural systems
- Techniques and protocol for removal of giant reed and tamarisk
- Guidelines for long-term monitoring program
- Report on completed/ongoing projects and activities through fiscal year 2000-01 and 2001-02 annually

SERVICE YEAR	SALARIES	SUPPLIES	TRAVEL	COMMUNICATION	OVERHEAD	TOTALS
2000-01	8,565	2,325	75	1,175	2,355	14,495
2001-02	8,565	2,325	75	1,175	2,355	14,495

TASK 2 - EAST VALLEY RESOURCE CONSERVATION DISTRICT TO ACT AS INTERMEDIARY AND FACILITATOR OF EPA GRANT APPROPRIATION TO REPLACE FUNDS USED IN 2000-2002 TASKS:
EVRCD will process the necessary paperwork and applications associated with the $950,267 Federal Appropriation required by the US Environmental Protection Agency (EPA). This task will include:

- Prepare 2000-01 Annual Workplan Contract for submission to EPA, USFWS Representative and OCWD for approval
- Prepare and write grant application for submission to EPA
- Prepare quarterly reports of outlined work completed and invoice for payment
- Prepare final report at completion of grant requirements

SERVICE YEAR	SALARIES	SUPPLIES	TRAVEL	COMMUNICATION	OVERHEAD	TOTALS
2000-01	15,000	1,000		1,250	3,347	20,597
2001-02	15,000	1,000		1,250	3,347	20,597

TASK 3 - EAST VALLEY RESOURCE CONSERVATION DISTRICT CONTINUE TO MAINTAIN GIS DATA BASE OF EXOTICS FOR THE ENTIRE SANTA ANA WATERSHED:
EVRCD in cooperation with other agencies in the watershed will map giant reed and tamarisk and enter information into the system. This task will include:

- Obtain data layers (as available) of the entire Santa Ana River Watershed
- Maintain database for the Santa Ana River Watershed
- Continue to map giant reed and tamarisk populations in the upper Santa Ana headwaters
- Map giant reed and tamarisk populations in Mill Creek, and the mainstem Santa Ana River located in Highland and San Bernardino

SERVICE YEAR	SALARIES	CONTRACT	SUPPLIES	TRAVEL	COMMUNI-CATION	OVERHEAD	TOTALS
2000-01	14,500	2,500	7,000	1,000	1,750	5,190	31,940
2001-02	14,500	2,500	7,000	1,000	1,750	5,190	31,940

TASK 4 - EAST VALLEY RCD TO COORDINATE THE TREATMENT OF GIANT REED IN PHASE IV OF SAN TIMOTEO (CREEK) CANYON IN FY 2000/2001:

EVRCD shall contract for services and coordinate with various entities to perform a minimum of 35 acres of giant reed control in the Phase IV/San Timoteo Creek from Allessandro Road to the concrete channel in Loma Linda, and 15.0 acres of Arundo within the Redlands drainage channels. This task will include:

- Secure regulatory permits to perform exotic plant control
- Contract for biomass removal and follow-up treatment
- Contact private landowners, secure written permission to access property to work of project sites in San Bernardino County
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACTS CUT/SHRED	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUN-ICATIONS	TRAVEL	OVERHEAD	TOTAL
38,500	5,000	207,779	89,973	1,500	1,250	750	66,882	411,634

TASK 5 - EAST VALLEY RCD TO COORDINATE THE TREATMENT OF GIANT REED IN HIGHLAND IN FY 2001-2002:

EVRCD shall contract for services and coordinate with various entities to perform a minimum of 20 acres of giant reed control in the Highland area located in and around drainage channel (flows into Santa Ana River) adjacent to Highway 30. This task will include:

- Secure regulatory permits to perform exotic plant control
- Check with SB County Flood Control for right-of-way
- Contract for biomass removal and follow-up treatment
- Contact private landowners, secure written permission to access property to work of project sites in San Bernardino County
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACTS CUT/SHRED	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUN-ICATIONS	TRAVEL	OVERHEAD	TOTAL
16,286	5,000	91,333	45,600	1,500	1,250	500	31,325	192,794

TASK 6 - EAST VALLEY RESOURCE CONSERVATION DISTRICT TO CONTINUE TO MONITOR AND SPRAY THE 65 ACRES LOCATED IN PHASE I AND II IN SAN TIMOTEO CANYON:

East Valley RCD shall contract for additional two years spraying and monitoring of the 65 acres that comprise Phase I and Phase II in San Timoteo Canyon. This task will include:

- Secure regulatory permits to perform exotic plant control
- Contact private landowners, secure written permission to access property to work of project sites in San Bernardino County
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Interface with public/private entities and/or media personnel

SERVICE YEAR	SALARIES	CONTRACT	TRAVEL	OVERHEAD	TOTALS
2000-2002	5,760	59,800	1,200	12,951	79,711

TASK 7 - EAST VALLEY RESOURCE CONSERVATION DISTRICT TO CONTINUE TO HOUSE, SUPERVISE, SUPPORT FIELD BIOLOGIST POSITION:
East Valley Resource Conservation District shall supply headquarters, salary supplies and supervision necessary to support the position of Field Biologist. This task will include:

- Set up traps and monitor least Bell's Vireo, Willow Fly Catcher and Brown-headed Cowbird population in San Timoteo Canyon
- Assist in educational programs for endangered species and invasive plants as requested
- Supervise and monitor invasive plant removal and habitat enhancement programs within the watershed
- Assist with mapping projects for GIS data
- Cooperate with East Valley RCD with the compilation of the SAWA Annual Report
- Cooperate with Riverside-Corona RCD with the structuring and maintenance of the Santa Ana Sucker Program

SERVICE YEAR	SALARY	BENEFITS	SUPPLIES	TRAVEL	COMMUNICATION	OVERHEAD	TOTALS
2000-01	32,885	4,500	2,500	2,500	1,200	8,455	52,040
2001-02	35,351	4,500	2,500	2,500	1,200	8,934	54,985

TASK 8 - ELSINORE-MURRIETA-ANZA RESOURCE CONSERVATION DISTRICT TO DEVELOP A WATERSHED PLAN FOR THE SAN JACINTO RIVER:
Elsinore-Anza-Murrietta RCD shall develop a comprehensive watershed management plan for the San Jacinto River and seek funding for implementation. This task will include:

- Compose San Jacinto River Watershed Plan to presentation to SAWA for approval
- Enlist stakeholders willing to participate in a Watershed Advisory Council
- Formulate organizational and administrative plan
- Apply for watershed planning funds created by Prop 13

SERVICE YEAR	SALARIES	CONTRACTS	MATERIALS/ SUPPLIES	TRAVEL	COMMUN-ICATION	OVERHEAD	TOTALS
2000-01	1,200	1,500	5,000	1,200	1,200	1,959	12,059
2001-02	1,500	2,000	5,000	1,200	1,200	2,115	13,015

TASK 9 - INLAND EMPIRE WEST RESOURCE CONSERVATION DISTRICT TO COORDINATE TREATMENT OF GIANT REED IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN FY 2000-2001:

Inland Empire West RCD shall contract for services and coordinate with various entities to perform a minimum of 15.0 acres of giant reed and tamarisk control in the Lytle Creek area. This task will include:

- Map giant reed and tamarisk populations in the Lytle Creek area
- Contribute collected data to East Valley RCD
- Secure regulatory permits to perform exotic plant control
- Contract private landowners, secure written permission to access property to work on project sites in San Bernardino County
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACTS CUT/SHRED	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUN-ICATIONS	TRAVEL	OVERHEAD	TOTAL
14,250	5,000	68,500	34,200	1,500	725	1,200	24,323	149,698

TASK 10 - INLAND EMPIRE WEST RESOURCE CONSERVATION DISTRICT TO COORDINATE TREATMENT OF GIANT REED IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN FY 2001-2002:

Inland Empire West RCD shall contract for services and coordinate with various entities to perform a minimum of 15.0 acres of giant reed and tamarisk control in the Warm Creek, San Sevine Creek, Duncan Creek , Grapevine Creek and Sycamore Canyon areas. This task will include:

- Map giant reed and tamarisk populations in the Warm Creek, San Sevine Creek, Duncan Creek , Grapevine Creek and Sycamore Canyon areas
- Contribute collected data to East Valley RCD
- Secure regulatory permits to perform exotic plant control
- Contract private landowners, secure written permission to access property to work on project sites in San Bernardino County
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACTS CUT/SHRED	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUN-ICATIONS	TRAVEL	OVERHEAD	TOTAL
14,250	5,000	68,500	34,200	1,500	725	1,200	24,323	149,698

TASK 11 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT SHALL COORDINATE TREATMENT OF GIANT REED, CASTOR BEAN AND TAMARISK IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN FY 2000-2001:

Riverside-Corona RCD shall contract for services and coordinate with various entities to perform a minimum of 16 acres of giant reed, castor bean and tamarisk in Golden Star Creek. This task will include:

- Map giant reed, castor bean and salt cedar populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage
- Secure regulatory permits
- Contact private landowners and secure permission to access property
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACT	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUNI-ATION	TRAVEL	OVERHEAD	TOTAL
14,821	3,000	72,610	63,600	795	795	928	30,405	186,954

TASK 12 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT SHALL COORDINATE TREATMENT OF GIANT REED, CASTOR BEAN AND TAMARISK IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN FY 2001-2002:

Riverside-Corona RCD shall contract for services and coordinate with various entities to perform a minimum of 14 acres of giant reed, castor bean and tamarisk in Woodcrest Dam (10) and Castleview Creek (4). This task will include:

- Map giant reed, castor bean and salt cedar populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage
- Secure regulatory permits
- Contact private landowners and secure permission to access property
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACT	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUNI-ATION	TRAVEL	OVERHEAD	TOTAL
13,143	3,000	64,390	56,400	705	705	823	26,963	166,129

TASK 13 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT SHALL CONTINUE TO OPERATE THE NATIVE PLANT NURSERY FOR SANTA ANA WATERSHED RESTORATION PROJECTS:
Riverside-Corona RCD shall continue to operate and expand the native plant nursery with the capacity for habitat restoration and in cooperation with SAWA members make these services available. This task will include:

- Propagation of native plant cuttings and seedlings for future plantings
- Assistance with planning, planting and streambank stabilization

SERVICE YEAR	SALARIES	SUPPLIES	MAINTENANCE	OVERHEAD	TOTALS
2000-01	4,160	2,000	2,500	1,680	10,340
2001-02	4,160	2,000	2,500	1,680	10,340

TASK 14 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT TO CONTINUE TO MONITOR AND SPRAY THE 30 ACRES OF GIANT REED LOCATED AT RIVER ROAD BRIDGE:
Riverside-Corona RCD shall continue to monitor and spray the 30 acre River Road Bridge Project for two years to prevent re-growth. This task will include:

- Secure regulatory permits to perform exotic plant control
- Develop and coordinate work schedules for crews
- Monitor spraying process
- Interface with public/private entities and/or media personnel

SERVICE YEARS	SALARIES	SPRAYING CONTRACT	TRAVEL	OVERHEAD	TOTALS
2000-2002	2,880	13,800	500	3,333	20,513

TASK 15 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT SHALL PURCHASE AND OPERATE A HAND-HELD GPS MAPPING AND DATA COLLECTION UNIT FOR THE SANTA ANA RIVER WATERHED:
Riverside-Corona RCD shall purchase and operate a hand-held GPS mapping and data collection unit for use in mapping invasives within the Santa Ana Watershed. This task will include:

- Use of belt beacon for real-time differential
- GPS data to be used in GIS programs
- Download data into GIS programs
- Supply East Valley RCD with data

SERVICE YEAR	SALARIES	SUPPLIES	TRAVEL	OVERHEAD	TOTALS
2000-01	8,736	6,200	1,000	3,091	19,027
2001-02	8,736		1,000		11,625

TASK 16 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT TO DEVELOP THE SANTA ANA SUCKER FISH RECOVERY PROGRAM:
Riverside-Corona RCD shall develop a habitat for the rearing and population augmentation for the Santa Ana Sucker, Arroyo Chub and the Speckled Dace. This task will include:

- Construct a 300 foot stream habitat with recirculating pumps and bio-filters
- Construct a set of 18 concrete tanks with recirculating pumps and bio-filters

SERVICE YEAR	SALARIES	EQUIPMENT	SUPPLIES	UTILITIES	OVERHEAD	TOTALS
2000-2002	4,160	20,500	18,500	6,335	9,590	59,025

TASK 17 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT TO HOUSE, SUPERVISE, SUPPORT FIELD BIOLOGIST POSITION:
Riverside-Corona RCD shall supply headquarters, salary supplies and supervision necessary to support the position of Field Biologist. This task will include:

- The monitoring of least Bell's Vireo and Cowbird population in Prado Basin and Hidden Valley
- Assist in the maintenance and monitoring of fish facilities
- Assist in educational programs for endangered species and plants as requested within the watershed
- Assist with mapping projects for GIS data

SERVICE YEARS	SALARY	BENEFITS	SUPPLIES	TRAVEL	COMMUNICATION	OVERHEAD	TOTALS
2000-01	30,000	4,000	1,000	1,000	500	7,081	43,581
2001-02	31,300	4,000	1,000	1,000	500	7,333	45,133

TASK 18 - RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT TO CONDUCT THE PUBLIC OUTREACH PROGRAM FOR SAWA:
Riverside-Corona RCD shall conduct the public outreach program for SAWA and provide the following activities. This task will include:

- Distribute pamphlets and videos to homeowners, PBS stations, elected officials, etc.
- Schedule, setup and tear down arundo traveling displays at libraries, civic centers, etc.
- Coordinate a Santa Ana River Watershed tour for officials

SERVICE YEARS	SALARIES	EQUIPMENT	MATERIALS/ SUPPLIES	TRAVEL	COMMUNI-CATION	OVERHEAD	TOTALS
2000-02	18,200	4,000	5,000	3,000	1,000	6,053	37,253

TASK 19 - SAN JACINTO BASIN RESOURCE CONSERVATION DISTRICT TO COORDINATE TREATMENT OF GIANT REED IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN FY2000-2001:
San Jacinto Basin RCD shall contract for services and coordinate with various entities to perform a minimum of 10.5 acres of giant reed and tamarisk in Four Winds Pheasant Club/Pal Management, Inc., and Juniper Flats. This task will include:

- Map giant reed and tamarisk populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage
- Secure regulatory permits
- Contact private landowners and secure permission to access property
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACT	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUNI-ATION	TRAVEL	OVERHEAD	TOTAL
9,508	3,000	47,845	23,975	1,500	850	400	16,893	103,971

TASK 20 - SAN JACINTO BASIN RESOURCE CONSERVATION DISTRICT COORDINATE TREATMENT OF GIANT REED IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED IN 2001-2002:
San Jacinto Basin RCD shall contract for services and coordinate with various entities to perform a minimum of 6.15 acres of giant reed and tamarisk in San Jacinto River channel, Sunnymead Gravel Pit, Blackburn Canyon and Cajalco Road/Alexander Street. This task will include:

- Map giant reed and tamarisk populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage
- Secure regulatory permits
- Contact private landowners and secure permission to access property
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program
- Interface with public/private entities and/or media personnel

SALARIES	PERMITS	LABOR CONTRACT	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUNI-ATION	TRAVEL	OVERHEAD	TOTAL
5,532	3,000	28,085	14,043	1,000	750	800	10,323	65,533

TASK 21 - SAN JACINTO BASIN RESOURCE CONSERVATION DISTRICT COMPLETE MAPPING OF TAMARISK IN THE FOLLOWING TRIBUTARIES OF THE SANTA ANA RIVER WATERSHED:
San Jacinto Basin RCD shall complete the mapping of Tamarisk located within th Mystic Lake area. This task will include:

- Map giant reed and tamarisk populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage

SERVICE YEARS	SALARIES	SUPPLIES	TRAVEL	OVERHEAD	TOTALS
2000-2002	2,250	1,500	1,000	922	5,672

TASK 22 - SAN JACINTO BASIN RESOURCE CONSERVATION DISTRICT COORDINATE TREATMENT OF GIANT REED LOCATED ON PRIVATE LANDOWNERS PROPERTY WITHIN DISTRICT BOUNDARIES:
San Jacinto Basin RCD shall contract for services and coordinate with various entities to perform a minimum of 1.5 acres of giant reed located within property boundaries of private landowners. This task will include:

- Map giant reed and tamarisk populations in the above areas
- Contribute collected data to East Valley RCD for watershed storage
- Contact private landowners and secure permission to access property
- Contract for biomass removal
- Develop and coordinate work schedules for crews
- Monitor biomass removal process
- Contract for two-year spray and monitoring program

SERVICE YEARS	SALARIES	LABOR CONTRACT	SPRAYING CONTRACT	TOOLS/ SUPPLIES	COMMUNICATION	TRAVEL	OVERHEAD	TOTALS
2000-02	2,450	15,000	10,000	1,500	1,500	1,500	6,198	38,148

TASK 23 - SAN JACINTO BASIN RESOURCE CONSERVATION DISTRICT COORDINATE INVASIVE PLANT PUBLIC EDUCATION / APPEAL PROGRAM FOR PRIVATE LANDOWNERS PROPERTY WITHIN DISTRICT BOUNDARIES:
San Jacinto Basin RCD shall develop an educational program for private landowners affected in Task 20. This task will include:

- Provide a permission form offering services of the district
- Provide information packets to be provided to landowners
- Offer replacement native species

SERVICE YEARS	SALARIES	SUPPLIES	TRAVEL	OVERHEAD	TOTALS
2000-02	5,000	2,500	1,200	1,688	10,388

TASK 24 - EAST VALLEY RESOURCE CONSERVATION DISTRICT SHALL ACT AS COORDINATOR FOR THE WORK PLAN CONTRACT ON BEHALF OF SAWA:
East Valley Resource Conservation District shall work with other SAWA members, US Fish & Wildlife Service and Orange County Water District to implement this contract and set the groundwork for ongoing cooperative management of the Santa Ana River Watershed. This task shall include:

- Act as chair for the Santa Ana Watershed Association to facilitate meetings, workshops, coordinate with core group on agenda items, and work with partners on watershed issues related to invasive plant control/habitat restoration
- Develop and review printed materials used for mailings
- Consult with partnering agencies on protocol for giant reed/tamarisk treatments
- Facilitate /attend meetings between regulatoryagencies and public land managers to help develop long-term invasive plant control strategies
- Actively investigate funding possibilities to continue to build the Santa Ana River Trust Fund into a perpetuitous fund

TOTAL BUDGET FOR 2000-2001 - $1,113,076
TOTAL BUDGET FOR 2001-2002 - $ 923,000

EAST VALLEY RESOURCE CONSERVATION DISTRICT:

TOTAL BUDGET FOR 2000-2001 - $525,574
TOTAL BUDGET FOR 2001-2002 - $399,653

ELSINORE-MURRIETA-ANZA RESOURCE CONSERVATION DISTRICT:

TOTAL BUDGET FOR 2000-2001 - $12,059
TOTAL BUDGET FOR 2001-2002 - $13,015

INLAND EMPIRE WEST RESOURCE CONSERVATION DISTRICT:

TOTAL BUDGET FOR 2000-2001 - $149,698
TOTAL BUDGET FOR 2001-2002 - $149,698

RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT:

TOTAL BUDGET FOR 2000-2001 - $318,296
TOTAL BUDGET FOR 2001-2002 - $291,624

SAN JACINTO BASIN RESOURSE CONSERVATION DISTRICT:

TOTAL BUDGET FOR 2000-2001 - $126,075
TOTAL BUDGET FOR 2001-2002 - $87,637

Signatures of agreement affixed on 5/4/00

Dick Zembal, US Fish and Wildlife Service

Craig Miller, Orange County Water District

Viola Slade, East Valley RCD, Chair SAWA

Gene Frick, Elsinore-Murrieta-Anza RCD/SAWA

Muriel C. Busche, Inland Empire West RCD/SAWA

Shelli Lamb, Riverside-Corona RCD/SAWA

Dick Morton, San Jacinto Basin RCD/SAWA

http://www.latimes.com/news/local/la-me-cane21jul21.story

Exhibit D

THE STATE

Agencies Struggle to Raze Invasive Cane

Conservation: Districts have amassed nearly $25 million to root out the giant stalks clogging Southland waterways.

By JANET WILSON
TIMES STAFF WRITER

July 21 2002

The tractor thrashes through a 40-foot-high wall of jungle, biting off hunks of tangled grasses and spitting them out onto the parched earth.

The work along the bone-dry San Jacinto River in western Riverside County is just one piece of the battle to eradicate a fast-growing invader known as Arundo donax. The giant cane is so thirsty that it is sucking the life out of Southern California waterways.

The world's largest member of the grass family, arundo can grow a foot a day. An acre of it swallows enough water to sustain 10 California households for a year. "It's kind of unstoppable," said Kyle Washburn, who walked ahead of the tractor, hacking at the nearly impenetrable foliage with a machete to uncover abandoned cars or other large objects buried in it.

Worthy of a role in "Little Shop of Horrors," the oversized reed has taken over 20,000 acres of riverbed in three Southern California counties. Nearly every river in the Los Angeles Basin now has some giant cane, experts say, and it has been spotted as far north as Willamette, Ore., and as far east as New Or- leans.

The plant illustrates vividly how a nonnative species transplanted to new territory with no natural enemies can run amok. Cut it down, and new shoots spring up. Let it dry out, and it becomes a superb fire carrier.

Dense dry stands caught fire in the Santa Ana riverbed in a San Bernardino suburb last week, one of numerous river blazes regularly fueled by the cane.

During El Nino storms in the early 1990s, a mass of arundo that had been uprooted and washed downstream by flood waters piled up against a bridge between Corona and Norco. It lifted the bridge 18 inches off its struts, forcing it to close and preventing ambulances from reaching emergency rooms on the other side.

"The only thing I can compare it to is cancer. It spreads so fast, and it won't let anything else live in its midst," said Kerwin Russell, an environmental horticulturist with the Riverside Corona regional conservation district. Russell has spent nine years fighting giant cane, and says he will retire before the war is won.

Accounts of the plant's history and how it first arrived on American soil vary. A native of the Mediterranean and possibly parts of India, it has been around for at least 5,000 years.

The Bible mentions it and it is the likely source of the Pan's pipe of Greek myth, say researchers at the U.S. Department of Agriculture and UC Berkeley.

The cane, with its firm, straight structure, is still considered the best material available for clarinets and other reed instruments. However, efforts to harvest the plant commercially for musical instruments or paper have all failed in California, said Paul Frandsen, head of Riverside County's parks, who has been dubbed "Mr. Arundo" for his unflagging crusade to eliminate the plant.

Frandsen said Spanish settlers used it as a building material for California's missions.

But it wasn't until the federal government began planting arundo along riverbanks in the 1960s to control erosion that the cane began its rampant colonization.

"They had the right idea, but they put it near water," Russell said. "It loves water, and it has no natural enemies here.

"I suspected it was a drinker, and it is," said Frandsen, who commissioned a UC Riverside study in the early '90s that showed the plant consumes more than three times as much water as native plants.

The Santa Ana River has been hardest hit. The river runs 100 miles from the San Bernardino mountains through Riverside to Huntington Beach. At numerous points, the cane fills the river from bank to bank.

Arundo is so all-consuming that it has changed the ecology of much of the Santa Ana River, said Dick Zembal, a longtime biologist with the U.S. Fish and Wildlife Service who now is natural resources manager for the Orange County Water District.

Zembal explained that, for thousands of years, a multitude of creatures evolved in tune with the river's seasonal floods and dry spells. In just a few decades, arundo and other fire-resistant species have taken over, he said, replacing much of the river's plant and animal life.

While the stalks burn fiercely, the plant's massive underground root system allows it to re-sprout overnight.

"The roots act like a belly, or a gas tank--they store water and nutrients that the plant can just live off of, even in dry years," Russell said.

At least a dozen threatened or endangered songbirds, toads and other species that are unable to cope with fire have been pushed out.

Five water districts and an array of conservation districts--all members of "Team Arundo"--have gradually amassed nearly $25 million to root out the pernicious plant from the river.

An eradication campaign began in earnest in 1992 at the river's headwaters, and is moving slowly downstream. Crews work by hand with chain saws and buckets of pesticide, and sometimes with specially fitted tractors.

In the last 10 years, about 1,000 acres has been painstakingly cleared--one-twentieth of the total infested acreage in the watershed.

Once they are bulldozed or ripped out, the stalks must also be shredded, because one green shoot stuck in damp earth can sprout again. The underground root system must also be eliminated.

"This is about three weeks worth of growth," said Russell, standing under seven-foot-high stalks that have grown anew in the tractor's wake.

Biologists say pesticides must be used to ensure that the plants die. An herbicide called Rodeo, recently renamed Aquamaster, that is approved by the Environmental Protection Agency, is applied. The herbicide contains a moderately toxic ingredient, glyphosate, that can be harmful to fish and birds. Studies by UC Berkeley researchers in the early 1990s also found that glyphosate, if inhaled, caused illness in some people who worked near it.

Once the cane is conquered, native plants and animals quickly return, Frandsen said. Songbird counts are increasing rapidly near Riverside's Van Buren Avenue bridge, site of one of the first arundo removal programs.

There are stumbling blocks. For instance, some large nurseries still sell the plant.

A number of residents in rural Silverado Canyon at Orange County's eastern edge don't like the herbicides and worry that, if the erosion-resistant plants are ripped out, their homes might fall into the creek.

"The offending reed is not a 'native.' Well, neither am I, nor my septic line, nor my electricity lines," wrote Cybele Rowe in a community newspaper.

Rowe, who lives 30 feet from Silverado Creek above a bank of the giant cane, said it would cost her thousands to obtain permits to build a retaining wall instead.

"I came to America to be free," said Rowe, a native of Australia. "They can go for it, knock themselves out [taking out the plant]. It's just not necessary on my property."

Russell disagreed, saying if a stand is left in one spot, it can quickly spread downstream. He said conservation districts may provide native replacement plants for free.

Other residents can't wait for the work crews to arrive.

Bonnie Smith, owner of Bonnie's Gardens and a longtime resident of rural Modjeska Canyon, said community cane clearance programs hadn't worked in the past.

"You chop it down, and it just grows right back," she said.

Those who have worked for years to bring attention to the arundo threat are optimistic.

From firefighters and developers to members of Congress, a wide array of interests has gradually joined the fight.

The biggest boost of all may be $20 million worth of park bond money set aside for restoration of the Santa Ana River--most of it for elimination of the giant cane. By 2020, its enemies predict, they'll have licked the last of it.

"We will reach the sea," said Zembal of the Orange County water district.

*

Times staff writer Emily Green contributed to this story.

Exhibit E

MEMORANDUM OF UNDERSTANDING REGARDING THE ESTABLISHMENT OF A SANTA ANA RIVER CONSERVATION FUND PROGRAM

THIS NON-LEGALLY BINDING MEMORANDUM OF UNDERSTANDING ("MOU") has been prepared as of September 26, 1997, by the Orange County Water District ("OCWD"), United States Army Corps of Engineers ("Corps"), and United States Fish and Wildlife Service ("Service") to provide a basis for the cooperative establishment of a Santa Ana River Conservation Fund.

BACKGROUND

- Authority and Objectives of the Parties -

OCWD manages and replenishes the ground water basin within Orange County, primarily from the flows of the Santa Ana River ("River"). For this purpose the agency owns lands in the Prado Basin and conserves flows that reach Prado Dam. The Corps operates Prado Dam for flood control and water conservation purposes and the agency has been engaged in a major flood control project with respect to the River. Moreover, the Corps is responsible for reviewing and approving projects for the dredging and filling of waters of the United States under section 404 of the Clean water Act. The Service is charged with the conservation of fish, wildlife, and plants ("Wildlife") under the Fish and Wildlife Coordination Act, Endangered Species Act, and other Federal conservation laws, and, thereby, the agency has jurisdiction over the conservation of Wildlife within the Santa Ana River watershed ("Watershed"). In addition, the Service has as its mission the conservation of the Nation's wildlife resources. Of particular concern in this regard has been the least Bell's vireo ("Vireo") and southwestern willow flycatcher ("Flycatcher"), two Federal and State listed endangered species.

- Past Success in Collaboratively Addressing Wildlife Conservation -

The parties have previously cooperated successfully to enhance the environmental values of Prado Basin for the Vireo to mitigate the loss of its habitat within the Basin as a result of level in the Prado Basin to an elevation of 505 feet. Although the Vireo management program has been highly successful, the parties are concerned that certain invasive exotic species, in particular the giant reed (Arundo donax) and salt-cedar (Tamarix sp.) ("Exotic Species"), pose a major threat to the ecosystem of the Prado Basin and the entire Watershed.

-Commitment to Provide Mitigation Funds -

As mitigation for the impacts of two major projects in the Watershed, the Corps and OCWD committed to provide "Mitigation Funds" that are to be paid and dedicated to the control of Exotic Species and the re-establishment of native wildlife and their associated habitat within the Watershed ("Conservation Objectives). The long-range goal with respect to these Conservation

Objectives is the restoration of natural river system functions and riparian resource values for the benefit of wildlife, the many affected people along the River, and other interested parties and organizations. The Conservation-Objectives include among others, the creation of 60 acres of riparian habitat, the enhancement of riparian habitat through Exotic Species control and eradication, and management and recovery of the Prado Basin and River for Vireo and Flycatcher populations.

Increase of Prado Basin Water Storage. Pursuant to the Memorandum of Agreement between the Corps and OCWD of January 1994, OCWD, Corps, and Service entered into a Cooperative Agreement dated April 1, 1995, for the purpose of implementing a mitigation plan for the loss of habitat due to the raising the water level in the Prado Basin to an elevation of 505 feet. The mitigation plan includes a dedicated Arundo removal fund as an approach to enhancing the environment of the Prado Basin and Watershed. Pursuant to the agreement OCWD agreed to contribute $1 million to establish a fund that would be used to remove Exotic Species in the Watershed. The contribution was to have been paid in four equal payments of $250,000 each, commencing June 1, 1995, and semi-annually thereafter on January 1, 1996, June 1, 1996, and January 1, 1997.

Seven Oaks Dam Project. As mitigation for riparian and wetland habitat losses resulting from the construction and implementation of Seven Oaks Dam Feature (an element of the Santa Ana River Mainstem Project, a mitigation plan was developed by the Service whereby funds in the amount of $1.35 million were to be paid by the Corps and the Counties of Orange, San Bernardino, and Riverside to a re-create 60 acres of riparian habitat values through control of Exotic Species in the Santa Ana Watershed. These funds will be paid to the District to be held and disbursed for this purpose.

- Need for Watershed-wide Collaboration -

It is acknowledged that to be effective, efforts to remove the Exotic Species must focus first on the furthest upstream tributaries and reaches of the Watershed; which will require the cooperation and permission of multiple land owners to access to these areas. Accordingly, it is recognized that it is desirable to encourage collaboration with other agencies, organizations and interests throughout the Watershed.

-Desire to Promote Watershed Approach -

Thus, the parties determined that it is desirable to enhance the effect of the Mitigation Funds by encouraging watershed-wide collaboration to address the Conservation Objectives. The intent is that this collaboration would develop a strong and diverse network of organizations, efforts, and additional resources to expand upon the Conservation Objectives and achieve the long-term coal for the Watershed.

- Annual Conservation Program -

The Nature Conservancy ("TNC") and others have established the "Santa Ana River Wildlife and Habitat Conservation Project" to obtain, among other things, the Conservation Objectives. TNC, in consultation with the broader constituency of organizations involved has developed a work program, to address the Conservation Objectives.

TNC is working collaboratively with OCWD, Service, and others to transition a consortium of the five Resource Conservation Districts along the River to prepare and implement future "Annual Conservations Programs". The Mitigation Funds may be used to implement these Annual Conservation Programs to achieve the Conservation Objectives.

- Establishment of Santa Ana River Conservation Fund -

The parties are concurrently establishing a "Santa Ana River Conservation Fund" of invested funds, including Mitigation Funds, and will disburse such funds to achieve the Conservation Objectives. Eventually, the parties desire to build this fund to support this program through fund earnings only.

OCWD and Service will concurrently establish a Deposit Agreement whereby OCWD will accept and hold the Mitigation Funds, together with similar funds provided by others, as the Santa Ana River Conservation Fund, and will disburse such funds at the direction of the Service to those entities undertaking projects to achieve the Conservation Objectives and the long-term goal.

BASED UPON THE FOREGOING, the parties desire, support, and intend to take the following actions:

1. Holding of Mitigation Funds.

The Deposit Agreement generally includes provision for the following:

a. OCWD agrees to accept, hold, and deposit funds in an interest bearing account, and to disburse the Mitigation Funds at the direction of the Service or Conservation Coordinators approved by the Service (in consultation with OCWD and the Corps) to the entities ("Project Contractor") undertaking projects to achieve the Conservation Objectives.

b. Other contributors or mitigants may deposit in the Santa Ana River Conservation Fund additional funds with OCWD that shall be held and disbursed substantially as the Mitigation Funds are disbursed.

c. Any Project Contractor shall have entered into an agreement ("Project Agreement") with the Service or Conservation Coordinator (such as TNC, or Resource Conservation District).

d. The Deposit Agreement may be terminated by either OCWD or the Service upon thirty (30) days notice, whereupon OCWD shall pay the remaining portion of the Mitigation Funds at the direction of the Service.

2. Santa Ana River Conservation Fund.

The parties will cooperate and work with other agencies and interests within the Watershed to build a Santa Ana River Conservation Fund to attempt other long-term goals on a watershed-wide basis.

3. Non-binding Nature of this MOU.

This MOU is intended to memorialize the discussions and informal understandings of the parties. It is not legally binding. Further, it shall not be interpreted to increase the financial or manpower burdens of any party beyond its current activities, efforts, and interests within the Prado Basin and the Watershed.

Daniel E. Griset, President Orange County Water District

William R. Mills, Jr. General Manager
Orange County Water District

APPROVED AS TO FORM:
CLARK F. IDE
GENERAL COUNSEL

Robert L. Davis, Colonel
District Engineer
United States Army Corps of Engineers

Gail C. Kobetich, Field Supervisor
United States Fish and Wildlife Service

Exhibit F

Exhibit F

Cooperative Agreement
between the
Orange County Water District,
United States Army Corps of Engineers
and the
United States Fish and Wildlife Service
to Cooperatively Manage
Orange County Water District's Lands
in Prado Basin, Riverside County

Over the past decade, the Orange County Water District (OCWD), the United States Army Corps of Engineers (COE) and the United States Fish and Wildlife Service (USFWS) have worked together to enhance the water conservation and environmental values of Prado Basin, Riverside County, which has been identified as the most significant riparian and palustrine habitat in Southern California and is home to the least Bell's vireo, an endangered species. Numerous documents have been completed by OCWD, COE and the USFWS (the agencies) to develop a staged plan to increase water conservation potential beginning March 1 of each year as mitigation for the least Bell's vireo is planted and matures. Instituted in 1991, one-hundred acres of new vireo habitat has now matured and has allowed the water conservation pool to increase from elevation 494' to 498' in 1995. In an allied effort, OCWD began mitigating for the vireo in 1988 by funding a vireo management program which is administered by The Nature Conservancy. OCWD has committed approximately $600,000 to this program to date. The combination of these two programs has resulted in a highly successful vireo recovery program. In 1986, when the vireo was listed as endangered, 19 pairs existed in Prado Basin. In 1994, 149 pairs existed in Prado Basin, a seven-fold increase that demonstrates a continuing commitment among the agencies.

Today, the agencies have identified Arundo donax, an invasive exotic plant species, as a major threat to the ecosystem of not only Prado Basin but the entire Santa Ana River watershed. Arundo donax is also a heavy consumer of water, far more that native species. Recently, the agencies have recognized the values to work cooperatively together in pursuing a more holistic approach in managing the various resources in Prado Basin and have recognized that the mitigation approach is very costly and time consuming, and that a dedicated Arundo donax removal program will ultimately be more effective in enhancing the environment of Prado Basin and the entire Santa Ana River watershed. Therefore, the agencies agree that the following management concepts are in the best interests of conserving more native Santa Ana River flows and enhancing the environmental values of Prado Basin and the Santa Ana River watershed.

1. The agencies agree to cooperatively manage the environmental values of OCWD lands that have been identified as critical habitat for the least Bell's vireo,

specifically OCWD lands in Prado Basin below elevation 543', fully recognizing the water conservation, water quality and various environmental values of these lands.

2. The agencies agree to meet on a quarterly basis to discuss water conservation, water quality and wildlife enhancement objectives.

3. Least Bell's vireo mitigation completed thus far by OCWD, per the Prado October 1992 EIS, has resulted in significant recovery of the species in Prado Basin. While the Prado October 1992 EIS and other agreements have been beneficial, a more productive use of the efforts of the agencies towards expanding an ecosystem-wide program as quickly as possible, in keeping with the spirit of the Prado October 1992 EIS, will benefit both wildlife and water conservation programs.

4. OCWD and USFWS agree to meet annually to specifically review Arundo donax removal efforts and re-prioritize the program if necessary. In this regard, a goal of treating all of the Arundo donax within a three-year time frame will be established.

5. OCWD shall contribute $1,000,000 to establish a conservation fund that will be used to remove Arundo donax in the Santa Ana River watershed. With respect to the $1 million contribution, OCWD will contribute the money in four equal payments ($250,000 each) beginning June 1, 1995 and semi-annually thereafter on January 1, 1996, June 1, 1996 and January 1, 1997. The use of this conservation fund shall be at the direction of the Service subsequent to input from, and discussions with, OCWD and the Corps. The Arundo donax removal program will be reviewed annually in January of each year by OCWD and the USFWS to determine its effectiveness and to redirect the program if necessary.

6. This Cooperative Agreement is consistent with the implementation of an annual mitigation plan pursuant to the Memorandum of Agreement (MOA), dated January 1994, between the U.S. Army Corps of Engineers and the Orange County Water District for the operation of Prado Dam for seasonal additional water conservation. The Cooperative Agreement fully satisfies the annual mitigation plan to achieve a permanent water conservation pool to elevation 505', per the MOA. Additional mitigation must be implemented by OCWD at a future time to achieve a permanent water conservation pool above 505'.

7. As part of this Cooperative Agreement, OCWD will employ a full-time temporary employee to assist in the vireo management program. This full-time position will be filled in the March through September time frame each year and will then serve as a part-time temporary employee in the October through December time frame each year to assist in completing the vireo management report for The Nature Conservancy. This position will be fully funded by OCWD and will be hired by OCWD, with input from USFWS. After a period of five years (year 2000), the agencies will determine if this position is still necessary and/or explore other options to assist in the vireo management program.

8. If, in the event that the water conservation pool to elevation 505' impacts existing occupied nests of least Bell's vireos, OCWD, in cooperation with USFWS, will dedicate personnel to physically relocate nests to minimize impacts from the higher water conservation pool.

9. From March 1 to August 30 of each year, OCWD agrees to take a flow of 500 cfs or a flow that equals the District's maximum recharge capacity, whichever is greater, up to a pool elevation of 505'. If it is in the agencies best interests to reduce the outflow from Prado Dam below 500 cfs, OCWD and the USFWS must both approve the new outflow program. If weather and hydrologic forecasts and reservoir conditions indicate that the pool elevation may exceed 505' because of a projected disparity between inflow and outflow, the water control manager at the Reservoir Operation Center shall take any and all steps necessary (including the immediate release of water at the maximum possible rate) to (1) prevent the pool elevation from exceeding 505' or (2) to reduce, to the extent possible, the amount of time the pool is above 505' if, in fact, the early release of water at the maximum possible rate does not succeed in keeping the pool elevation below 505'. These requirements shall be followed unless the agencies find that it is in the best interests of the agencies to deviate from this arrangement.

General Manager

President
For Orange County Water District

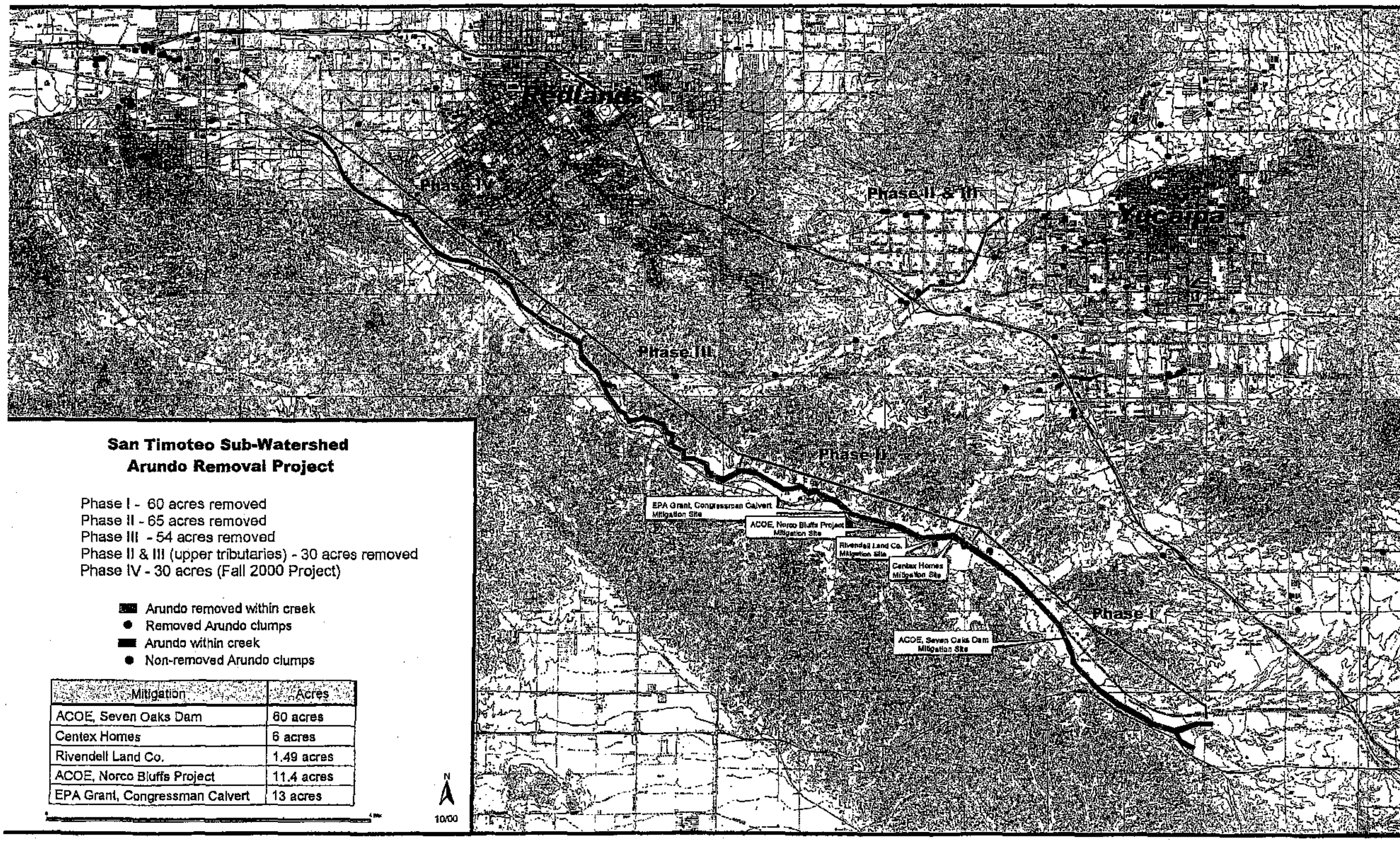
For U.S. Department of Interior /
U.S. Fish and Wildlife Service

APPROVED AS TO FORM
By 4-11-95
General Counsel for
Orange County Water District

This Cooperative Agreement fully satisfies the requirements contained in the Memorandum of Agreement for a permanent water conservation program for elevation 505' at Prado Dam beginning March 1 and ending on August 30 each year.

For U.S. Army Corps of Engineers

Exhibit G



San Timoteo Sub-Watershed
Arundo Removal Project

Phase I - 60 acres removed
Phase II - 65 acres removed
Phase III - 54 acres removed
Phase II & III (upper tributaries) - 30 acres removed
Phase IV - 30 acres (Fall 2000 Project)

- Arundo removed within creek
- Removed Arundo clumps
- Arundo within creek
- Non-removed Arundo clumps

Mitigation	Acres
ACOE, Seven Oaks Dam	60 acres
Centex Homes	6 acres
Rivendell Land Co.	1.49 acres
ACOE, Norco Bluffs Project	11.4 acres
EPA Grant, Congressman Calvert	13 acres

Exhibit 5

Exhibit H

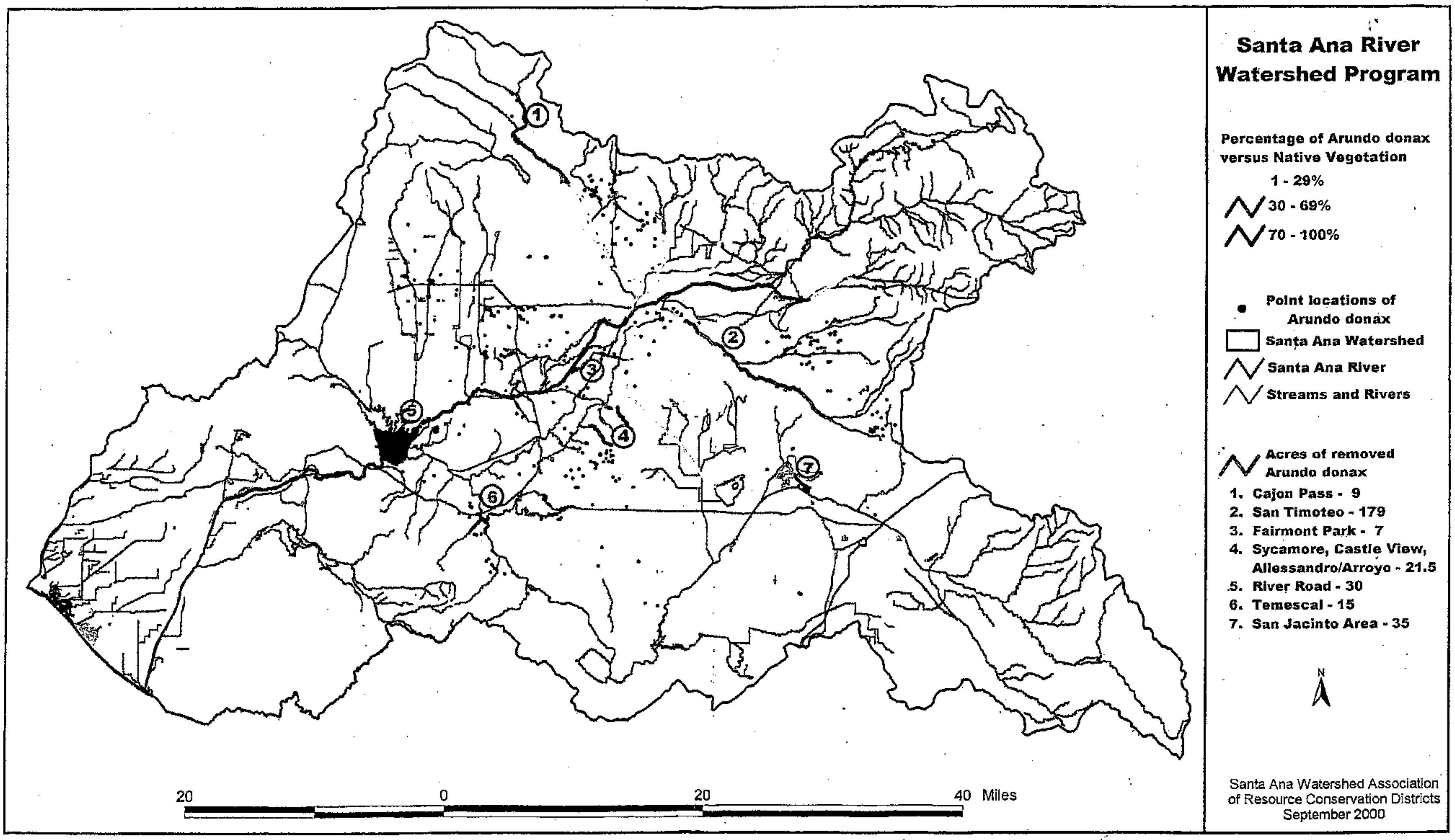

Santa Ana River Watershed Program
Percentage of Arundo donax versus Native Vegetation
1 - 29%
30 - 69%
70 - 100%
Point locations of Arundo donax
Santa Ana Watershed
Santa Ana River
Streams and Rivers
Acres of removed Arundo donax
1. Cajon Pass - 9
2. San Timoteo - 179
3. Fairmont Park - 7
4. Sycamore, Castle View, Allessandro/Arroyo - 21.5
5. River Road - 30
6. Temescal - 15
7. San Jacinto Area - 35
N
20
0
20
40 Miles
Santa Ana Watershed Association of Resource Conservation Districts
September 2000

Exhibit H

Exhibit I

Exhibit I

Santa Ana River Watershed Invasive Plant Program

THE SANTA ANA RIVER WATERSHED TRUST FUND FOR ARUNDO ERADICATION AND HABITAT ENHANCEMENT IN-LIEU FEE MITIGATION PROGRAM

Introduction:

There are several factors that change or influence river system dynamics. Fluctuations in seasonal water quantity, added effluent, constrictions in water flow, and changes in streambed permeability are just a few. All of these factors influence the native vegetation and faunal populations dependent on riverine systems. One of the major catalysts responsible for changes in both river hydrology and habitat has been the proliferation of non-native invasive plant species. These invasive plants reduce the wildlife values and continue to degrade the rivers hydrologic resiliency.

Several non-native plants have moved into our local riparian ecosystems causing a significant change in that systems ability to maintain its structure and function. Two of these plants, giant reed (*Arundo donax*) and saltcedar (*Tamarix sp.*) are responsible for loss of usable habitat by native wildlife, increase in flood damage, loss of available water resources, negative change in water quality, and an increase in fire frequency and intensity. Due to these profound influences in our local waterways, an invasive plant program targeting these species has been developed. The Army Corps of Engineers (Corps), the Santa Ana Watershed Association of Resources Conservation Districts (SAWA), and the Orange County Water District (OCWD) have worked together to create the Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program.

Goals:

- reduce threat of giant reed and other system level invasive plants within the watershed through active eradication programs and follow-up treatments
- monitor treatment programs and recovery of natural vegetation to insure successful outcomes

Program Structure:

Work Plan and Budget:

Each year a work plan will be developed by the SAWA based on mitigation requirements and funds generated from the In-Lieu Fee Program. Work projects will be selected from the program elements listed below. This work plan and budget will be submitted each year by May 30 to the Corps for approval. If no comments are received by June 30 the work plan and budget will be implemented by July 1. Tasks will be carried out by the SAWA directly or through subcontractors. Changes to the work plan and budget may be submitted in writing to the Corps for approval.

Site Selection for Projects:

Maps showing public verses private lands in the Santa Ana River watershed will be used to select treatment sites (See Exhibit G of the Memorandum Of Agreement for the Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program). Sites will be selected starting at the uppermost reaches of the river system and continuing down as sites are under treatment. Projects on public lands will be scheduled through the managing agency. Permits will be secured by managing agency and long-term maintenance agreements will be signed before work is to begin.

Treatments on private land will be scheduled as permission and permits are obtained by the Resource Conservation Districts. Conservation Easements may be purchased through the In-Lieu Fee program to insure long-term maintenance on private lands.

Program Elements:

I. Invasive Plant Treatment

A suite of techniques is needed to eradicate invasive plants due to the variety of conditions found within the watershed. The appropriate techniques for each project site will be outlined in the work plan. Considerations for choosing the techniques include invasive plant stand density, accessibility to site, and presence of non-target species.

A. Herbicide Application

One herbicide currently labeled for wetlands use by the EPA is Rodeo®, produced by Monsanto Corp. Rodeo is a broad-spectrum herbicide which can be used on giant reed, saltcedar, and most other monocots and dicots. It has proven very effective against giant reed. This herbicide will be applied during the most effective season for eradication, fall, unless the use is for reducing biomass then application would be in the spring or early summer. Other compounds (i.e. dye marker) may be added only according to label regulations. The strength of solution will be determined according to label recommendations. Other treatment methods may be developed that will prove to be effective and safe. These methods may be used with prior approval from the Corps.

1. Spray Mature Stands – Direct kill to root system
   Mature uncut stands of invasive plants will be sprayed using backpack or truck spraying equipment (dependent upon accessibility) in the fall.

2. Spray Mature Stands – Kill biomass at surface
   Mature uncut stands of invasive plants will be sprayed using backpack or truck spraying equipment (dependent upon accessibility) in the spring or early summer.

3. Spray Regrowth from Previously Cut or Sprayed Stands

Stands may have been cut at least once during the year and allowed to regrow, greatly reducing the density of the stand, making spraying in the fall much more effective due to better coverage.

4. Helicopter Spraying

Helicopter spray apparatus may be used especially in areas with dense contiguous cover of invasive plant. Herbicide application is more effective and is taken up by the plants more readily due to finer droplet size than other spray equipment. All precautions will be taken if using this method i.e. weather conditions, proximity to native habitats or human environments, label spray recommendations, etc.

5. Cut-Stump – Target Plants are Mixed with Native Plants

If target plants are mixed with native plants, then the area cannot be sprayed safely. Plants will be cut using hand tools or mechanical, motorized equipment at the base of the stalks/stems and then herbicide applied. Timing between cutting and herbicide application is critical. It has been observed that plant stands in full sun should be sprayed no more than 1 minute after being cut, while plants in full shade have up to two minutes.

B. Non-Chemical Methods

Treatment Methods:

1. Mechanical

Mechanical (motorized or hand tools) cutting/mulching of above ground living stalks for most invasive plant species will only stimulate the root system to produce new growth. Machines can be used to pull the plant, roots and all, out of the ground but must be used only in areas with adequate access and little threat to disturbance to streambed stability or viability to support native habitat.

2. Hand pulling

Hand pulling of seedling or small plants may be used if proven effective to eliminate the spread of those plant species.

C. Biomass Removal

Methods for vegetation removal include use of heavy machinery (e.g. bulldozers), hand carrying material, hydro-axe, tub grinder, chipper, burning or removal by vehicle.

II. Revegetation

Sites may need to be revegetated with native plant species due to a lack of natural recruitment in the area. Recommendations on planting techniques and thresholds are listed below:

A. Thresholds

Recommendations for revegetation will be addressed after three years of treatment. Extreme weather conditions (i.e. heavy rain years or drought) will be considered in the lack of natural revegetation. Expectations for site must stay within natural parameters. A site will not be expected to turn to mature cottonwood/willow forest if hydrology, soils, or other natural conditions would not permit. Historical aerials or inspection of reaches in the immediate vicinity should be used to determine the natural condition of the treated area. No plants will be used that would require long-term irrigation.

B. Revegetation Strategies

Revegetation strategies will use plant stock from local area as much as possible to maintain genetic integrity. The strategies will use natural planting schemes (thickets) rather than row planting and plant during normal season for recruitment of plant species (ex: plant propagules, poles in winter and seed in early spring). Revegetation will target plant species that may take the longest to naturally recruit. Plantings will use rooted plants whenever possible for species that do not do well as pole plantings (ex: mule fat). The strategy will enhance sensitive animal species habitat by planting appropriate structure or plant types needed for nesting, foraging, etc.

C. Criteria for Success

Time from start of activities	Criteria
Year 1-2	The project area is treated for removal of non-native vegetation. Non-native vegetation on site consists of 30% of the total vegetation. Necessary grading, irrigation lines, as indicated in any project-specific mitigation plan has been conducted. Re-vegetation with native riparian vegetation has been initiated, if needed. Arundo re-sprouts are being actively treated for removal.
Year 3	Non-native vegetation consists of less that 10% of the total vegetation on site. Successful growth of native riparian vegetation including the herbaceous, shrub and tree species as listed in any site-specific mitigation plan are present.
Year 4-5	Area contains less that 1% exotic vegetation and

showing a start of canopy development, with shrub and herbaceous understory.

III. Project Data Storage, Monitoring, and Mapping

A. Project Data Storage

A GIS system for data storage will be developed to track and coordinate treatment projects. Current treatment project will be mapped and digitized from which future project sites can be identified. Areas under treatment will be identified with respect to which permitted impacts the treatment covers. Other data layers will include native vegetation, sensitive species population distribution, and land ownership. Expenditures will include staff time for updating the database and printing maps for reports or field monitoring.

B. Monitoring Reports

The sites shall be monitored on a quarterly basis. Monitoring reports will be submitted by April 30 of each year to the Corps for review. Monitoring reports shall include 1) a map showing location of the eradicated non-native vegetation; 2) photographs of representative sites using established photo points throughout the site; 3) estimate of the percent ground cover through visual estimates, transects, and/or plots of canopy trees, shrubs, and herbaceous plants as well as any non-native vegetation species; 4) estimates of non-native vegetation regrowth through visual estimates, transects, and/or plots; 5) the species and number of trees planted per acre, if any; 6) the survival rate of planted species; 7) verbal description of the presence, location, and depth of any surface and/or groundwater; 8) documentation of use of the site by native animal species; and 9) recommendations for further treatment. If no comments are received by May 15 then the final report shall be submitted May 30 and recommendations will be incorporated into the next years work plan and budget (see "Program Structure – Work Plan and Budget").

C. Mapping

Project sites will be mapped and reference data will be included into the GIS database. Reference data will include all information related to treatment techniques used, regrowth of target species, costs associated with the project. Target species will be mapped in rough estimates for attribution to project site map elements. Target species will be mapped in standard format to determine exact amount of acreage that has been treated.

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

REPLY TO
ATTENTION OF:

November 18, 2002

Office of the Chief
Regulatory Branch

Shelli Lamb
Santa Ana Watershed Association of Resource
Conservation Districts
4500 Glenwood Drive
Riverside, California 92501

Dear Ms. Lamb:

We are transmitting to you the executed Memorandum of Agreement (MOA) regarding Establishment of the Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program. You are now authorized to begin implementation of the MOA for exotic species control in the Santa Margarita Watershed.

If you have any questions, please contact Mark Durham or Jae Chung of my Regulatory Branch staff at (213) 452-3416 or (213) 452-3292, respectively. Please refer to this letter and 200100898-YJC in your reply.

Sincerely,

Richard G. Thompson
Colonel, Corps of Engineers
District Engineer

Enclosure(s)

4785
R02-10-150

EXHIBIT B

Completed Obligations Under 2002 MOA

- OCWD no longer has responsibility for the "Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program" (contained in the 2002 MOA). SAWA has taken over responsibility for the program and particularly for OCWD's responsibilities in Section II (A through D), which deal with holding the funds, directing the use of funds, reporting and maintaining records and documents. SAWA is now working on renewing the program on its own. OCWD as an organization will not have direct obligations under the new program.
- Neither OCWD nor SAWA is responsible any longer for performing a total of eighty-four (84) acres of exotic plant treatment within four of the resource conservation districts which are part of SAWA. This work has been completed. (See 2000 Biological Opinion attached hereto.)
- OCWD and SAWA have completed first-time treatment on all upper watershed tributaries and mainstem Santa Ana River downstream to Riverside County Parks and Open Space District lands. (See 2000 Biological Opinion attached hereto.)

United States Department of the Interior
Fish and Wildlife Service
Ecological Services
Carlsbad Fish and Wildlife Office
2730 Loker Avenue West
Carlsbad, California 92008

FEB 10 2000

Colonel John P. Carroll
District Engineer
U. S. Army Corps of Engineers, Los Angeles District
911 Wilshire Blvd.
P.O. Box 532711
Los Angeles, California 90053-2325

Attn: Alex Watt and Lois Goodman, Environmental Planning Branch
Carvel Bass, Operations Branch

Re: Formal Section 7 Consultation on the Prado Basin Water Conservation and Water Control Operations Project, Prado Basin, Riverside and San Bernardino Counties, California (1-6-99-F-75)

Dear Colonel Carroll:

This document transmits our biological opinion based on our review of the proposed water conservation and water control operations project located in the Prado Basin in Riverside and San Bernardino Counties, California, and its effects on two federally endangered species, the least Bell's vireo (*Vireo bellii pusillus*, "vireo") and southwestern willow flycatcher (*Empidonax traillii extimus*, "flycatcher"), and their designated critical habitats in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your August 10, 1999, request for formal consultation on the revised project was received on August 11, 1999.

Because the federally threatened California red-legged frog (*Rana aurora draytonii*) and endangered arroyo toad (*Bufo microscaphus californicus*) were not located within the Prado Basin during focused surveys in 1999 (Dr. H. Lee Jones, pers. comm., 1999), we concur with the U.S. Army Corps of Engineers (Corps) that the project will not adversely affect either species. In addition, the Corps has elected not to initiate conference for potential, project-related effects to the Santa Ana sucker (*Catastomus santaanae*), a species proposed for Federal listing as threatened. As a result, these three species will not be addressed further herein.

Consultation History

In October 1992, the Los Angeles District of the Corps released the environmental impact statement entitled (EIS) *Prado Dam Operation for Water Conservation* for the conservation of water behind Prado Dam during the non-flood season up to a maximum elevation of 505 feet above sea level. A fish and wildlife coordination act report and planning aid letter were previously prepared for this proposed project (U.S. Fish and Wildlife Service 1987, 1990). The Orange County Water District (OCWD), which owns all rights to the surface water in the Prado Basin, was and remains the project proponent.

Because the project may adversely affect the vireo, the Corps initiated formal consultation. The proposed action was permitted pursuant to our biological opinion (1-6-93-F-7) issued on February 25, 1993. This opinion addressed the impacts of OCWD's phased water retention and conservation project in the Prado Basin. On February 15, 1994, we amended the opinion, which incorporated written comments submitted by Robert Joe of the Corps in a letter dated October 5, 1993, and subsequent discussions and meetings involving our respective staffs. These meetings and discussions resolved the issues raised in that letter and resulted in the mutual agreement to to amend the original biological opinion.

The EIS, coordination act report, planning aid letter, and amended biological opinion addressed impacts associated with the controlled water storage project, which enabled the ultimate capture of the maximum possible amount of water from March 1 to September 1 of each calendar year at OCWD spreading facilities downstream of the dam. During the prescribed water conservation period, releases were restricted to 450 cubic feet per second (cfs), which was then the recharge capacity of the OCWD spreading facilities downstream. Flows into the Prado Basin in excess of the 450 cfs would thus increase the amount of stored water behind the dam up to an eventual, permitted maximum pool elevation of 505 feet above sea level. However, the combination of runoff and base flow was not sufficient in most years to increase the pool elevations to the permitted maxima.

The implementation of the project was initially phased to allow for the "appropriate replacement of habitats occupied by the vireo that are destroyed or degraded as a result of water conservation activities" (EIS). The Corps further specific in the EIS the conservation pool level to which water could be held based on the acreage of mitigation achieved during any single year. The maximum permitted water conservation pool elevation would be raised incrementally from 494 to 505 feet dependent upon the acreage of replacement habitat that had been created or conserved. Per the EIS and the Corps project description, these requirements are detailed in Table 1.

In concert with the project description for this previously-permitted, phased water conservation project, the Corps limited the rate of water releases from the dam between March 1 and September 30 once the elevation pool was at or below a prescribed elevation. By 1994, a minimum of 83 acres of vireo habitat had been created by the project proponent, which allowed the pool to be raised to an elevation of 497 feet.

By 1995, a minimum of 100 acres of vireo habitat had been created and that an elevation 498 would be the allowed level for that year. However, before the onset of the 1995 water conservation season, we recommended a change in habitat conservation and restoration strategies, which was accepted by the Corps and OCWD. This change in compensation strategy reflected observations of continuing damage to native habitat caused by the uncontrolled spread of giant reed (*Arundo donax*) throughout the Santa Ana River watershed and the vulnerability of created habitats to the frequent, flood-induced damage.

The original restoration strategy called for the removal of giant reed at designated restoration areas and the subsequent planting of native riparian species. However, giant reed propagules were transported to the Prado Basin during years of heavy rainfall, where the alien plant invaded habitats consisting of native plants or impacted areas that had been revegetated or restored. The proposed restoration alternative required the funding of a giant reed eradication program within the Santa Ana River watershed. We hypothesized that native species would be able to revegetate, either naturally or with minimal assistance, in areas cleared of giant reed. The restoration areas that were originally identified in the EIS were still to be revegetated, but over a longer time period.

Subsequent to informal discussions on the conclusion of an informal consultation process, OCWD proposed that the Corps modify the operation of the Prado Flood Control Dam to the accelerate the implementation of the phased water conservation project and that the Department of the Interior and Corps sign a cooperative agreement that formalized this change in operations and OCWD's proposal to incorporate additional compensation measures into the project description. As a result, a cooperative agreement was signed in April 1995 that described in part the revised project and provided for the compensation of unavoidable, project-related impacts relating to the revised OCWD water conservation program. The raising of the water conservation pool to 505 feet, was authorized in light of substantial, additional impact avoidance, minimization and compensation measures.

According to and quoting from the cooperative agreement:

1. The agencies (U.S. Fish and Wildlife Service, Corps, and OCWD) agree to cooperatively manage the environmental value of OCWD lands that have been identified as critical habitat for the least Bell's vireo, specifically OCWD lands in Prado Basin below elevation 543 feet, fully recognizing the water conservation, water quality and various environmental values of these lands.

2. The agencies agree to meet on a quarterly basis to discuss water conservation, water quality and wildlife enhancement objectives.

3. Least Bell's vireo mitigation completed thus far by OCWD, per the Prado October 1992 EIS, has resulted in significant recovery of the species in Prado Basin. While the Prado October 1992 EIS and other agreements have been beneficial, a more productive use of the efforts of the agencies toward expanding an ecosystem-wide program as quickly as possible, in keeping with the spirit of the Prado October 1992 EIS, will benefit both wildlife and water conservation programs.

4. OCWD and U.S. Fish and Wildlife Service (Service) agree to meet annually to specifically review *Arundo donax* removal efforts and re-prioritize the program if necessary. In this regard, a goal of treating all of the *Arundo donax* within a 3-year time frame will be established.

5. OCWD shall contribute $1,000,000 to establish a conservation that will be used to remove *Arundo donax* in the Santa Ana River watershed. With respect to the $1 million contribution, OCWD will contribute the money in four equal payments ($250,000 each) beginning June 1, 1995, and semi-annually thereafter on January 1, 1996; June 1, 1996; and January 1, 1997. The use of this conservation fund shall be at the direction of the Service subsequent to input from, and discussions with, the OCWD and the Corps. The *Arundo donax* removal program will be reviewed annually in January of each year by OCWD and the Service to determine its effectiveness and to redirect the program if necessary.

6. This Cooperative Agreement is consistent with the implementation of an annual mitigation plan pursuant to the Memorandum of Agreement (MOA), dated January 1994, between the U.S. Army Corps of Engineers and the OCWD for the operation of Prado Dam for seasonal additional water conservation. The Cooperative Agreement fully satisfies the annual mitigation plan to achieve a permanent water conservation pool to elevation 505 feet, per the MOA. Additional mitigation must be implemented by OCWD at a future time to achieve a permanent water conservation pool above 505 feet.

7. As part of this Cooperative Agreement, OCWD will employ a full-time temporary employee to assist in the vireo management program. This full-time position will be filled in the March through September time frame each year and will then serve as a part-time temporary employee in the October through December time frame each year to assist in completing the vireo management report for The Nature Conservancy (TNC). This position will be fully funded by OCWD and will be hired by OCWD, with input from the Service. After a period of 5 years (year 2000), the agencies will determine if this position is still necessary and/or explore other options to assist in the vireo management program.

8. If, in the event that the water conservation pool to elevation 505 feet impacts existing occupied nests of least Bell's vireos, OCWD, in cooperation with the Service, will dedicate personnel to physically relocate nests to minimize impact from the higher water conservation pool.

9. From March 1 to August 30 of each year, OCWD agrees to take a flow of 500 cfs or a flow that equals OCWD's maximum recharge capacity, whichever is greater, up to a pool elevation of 505 feet. If it is in the agencies' best interests to reduce the outflow from Prado Dam below 500 cfs, OCWD and the Service must both approve the new outflow program. If weather and hydrologic forecasts and reservoir conditions indicate that the pool elevation may exceed 505 feet because of a projected disparity between inflow and outflow, the water control manager at the Reservoir Operation Center shall take any and

all steps necessary (including the immediate release of water at the maximum possible rate) to (1) prevent the pool elevation from exceeding 505 feet or (2) to reduce, to the extent possible, the amount of time the pool is above 505 feet if, in fact, the early release of water at the maximum possible rate does not succeed in keeping the pool elevation below 505 feet. These requirements shall be followed unless the agencies find that it is in the best interests of the agencies to deviate from this arrangement."

The original biological opinion, as amended, did not address (1) potential impacts of the revised project on the flycatcher, which was listed as endangered by the U.S. Fish and Wildlife Service (Service) on February 27, 1995, (2) impacts to critical habitat for the vireo, which was designated on February 3, 1994, or (3) the proposed, immediate implementation of the project at the maximum pool elevation of 505 feet. Therefore, because of the project's potential to adversely affect the flycatcher, vireo, and the latter species' designated critical habitat and the participation of the Department of the Interior in the signing and implementing the cooperative agreement, we initiated an internal formal consultation that addressed the Department's action in a biological opinion (1-6-95-F-28).

Although that internal opinion addressed effects of the project to the vireo, flycatcher, and vireo critical habitat, the document did not address subsequent, proposed alterations to the operation of the dam or impacts of the project to flycatcher critical habitat, which was designated by the Service on August 20, 1997 (62 FR 39129, 62 FR 44228). This biological opinion addresses the revised project description and associated, projected impacts to the vireo, flycatcher, and to both species' designated critical habitats.

As part of past species and habitat conservation efforts, OCWD:

- has spent approximately $50,000,000 on capital projects to improve its ability to capture and recharge Santa Ana River flow since 1988. These improvements have increased OCWD's recharge capability from 190,000 acre-feet to over 290,000 acre-feet (OCWD letter #1) and enabled an increase in Prado Dam discharges from 450 cfs to a maximum of 600 cfs during past water conservation programs. The OCWD is committed to further increase its recharge capacity, and is actively planning future projects, including the development of a "Deep Basin Clean Device," the construction of additional recharge basins, and the diversion or retention of water at Gypsum Canyon Reservoir or Aliso Canyon Reservoir, to accomplish this end (OCWD letter #1).

- funded the 1989 and 1990 California State University, Long Beach Foundation vireo management and monitoring program in the Prado Basin at a cost of $70,000.

- dedicated the 124-acre plot known as PR3 (see Table 1) for purposes of habitat creation and restoration in 1991,

- contributed another $50,000 for habitat restoration and an additional $50,000 to the vireo management fund administered by TNC and removed approximately 40 acres of *Arundo donax* on OCWD property designated as PR6 (see Table 1)in 1992.

- contributed $50,000 to each of the habitat restoration and vireo management funds in 1993.

- refurbished 10 vandalized brown-headed cowbird (*Molothrus ater*) traps in 1994, and subsequently conducted ongoing repairs of broken and vandalized traps and provided decoy cowbirds for numerous other cowbird management programs in Orange, San Diego, Riverside, and San Bernardino counties.

- contributed $1,000,000 to augment giant reed removal and habitat restoration efforts within the Santa Ana River watershed in 1995. The cooperative agreement provided for a one-time contribution in this amount to provide for the removal of giant reed and habitat restoration within the Santa Ana River watershed. The various cash contributions have led to the creation of the Santa Ana River Conservation Trust Fund (trust fund), which is used for endangered species and habitat management. This fund is managed cooperatively by the Service and OCWD. Vireo work in relation to the project has been conducted since 1989; habitat management work in relation to the project has been conducted since 1991.

- began funding a permanent full-time position to assist in the vireo/flycatcher monitoring and management program and provide for giant reed eradication and habitat restoration on OCWD-owned lands in Prado Basin in 1995. Per the cooperative agreement, two full-time seasonal OCWD positions are funded through the trust fund for vireo and flycatcher monitoring and cowbird trapping within Prado Basin. Although the salaries for these two positions are funded through the trust fund, OCWD does incur some administrative costs for maintaining these positions.

- established the Santa Ana Watershed Conservation Fund Program in 1995. The OCWD continues to manage the fund, in cooperation with the Service. The funds, which now exceed $3.8 million dollars (James Van Haun, consultant to the OCWD, *in litt.*, 1999), are dedicated to giant reed removal and habitat restoration the Santa Ana River watershed. In addition, two full-time seasonal OCWD positions are funded through the trust fund for vireo and flycatcher monitoring and cowbird trapping within Prado Basin. Although the salaries for these positions are funded through the trust fund, OCWD does incur administrative costs for maintaining these positions.

- provided a four-wheel drive vehicle to vireo/flycatcher monitors for access to off-highway locations for cowbird trapping and vireo monitoring from 1995 to 1999. The OCWD additionally provided office space and computer equipment for vireo monitors from 1995 to 1999, a residence and vehicle to one vireo monitor in 1996, and two-way radios to all monitors to increase safety and facilitate coordination efforts.

- removed approximately 10 acres of giant reed just downstream of River Road bridge and allowed for natural revegetation in 1996.
- provided host sites on OCWD property for mule-fat plantings adjacent to lower lying areas impacted by the project in 1997. The project was in cooperation with TNC and East Valley Resource Conservation District staff providing guidance.
- created and maintained access to a 124-acre revegetation area and other inaccessible sites by clearing giant reed and other debris with OCWD equipment. In 1996 through 1998, this aided in the discovery of several vireo nesting locations that were previously unknown.
- established and maintained a native plant nursery at the Prado field office with input from TNC from 1997 through 1999.
- provided site for removal of 30 acres of giant reed upstream of River Road bridge and provided OCWD staff to coordinate efforts with other agencies in 1998.
- dedicated lands for the restoration of vireo and flycatcher habitat (Table 2). The EIS called for the restoration of 228 acres of vireo habitat and 278 acres of wildlife habitat (prior to holding water to the 505 feet elevation) and for the creation of a fund to manage vireo within the basin.

Your original request was dated February 8, 1997, and received by facsimile on that same day. Formal consultation was subsequently suspended until the project description could be reviewed and subsequently amended. Although the Corps requested the initiation of consultation again on January 22, 1999, this request was withdrawn in a subsequent letter dated March 11, 1999, which cited the need for additional minor clarifications to the project description. We provided a species list to the Corps in a letter dated April 13, 1999. In a letter dated August 10, 1999, the Corps requested the initiation of consultation on the revised project and associated final biological assessment (BA) on August 11, 1999. We acknowledged the initiation of formal consultation in a letter dated September 20, 1999.

This biological opinion was prepared in large part using the following information: 1) Prado Dam Operation for Water Conservation, U.S. Army Corps of Engineers Draft Environmental Impact Statement, October 1992; 2) Prado Basin Water Control Plan, U.S. Army Corps of Engineers, Los Angeles District; September, 1994; 3) Fish and Wildlife Coordination Act Report dated July 1990; U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement, Laguna Niguel, California; 4) Planning Aid Letter dated July 1987, regarding Water Conservation in Prado Reservoir; U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement, Laguna Niguel, California; 5) Supplemental Biological Information, Evaluation of Potential Impacts to the Least

Bell's Vireo, Prado Basin Water Conservation Study; December 1987; Dames and Moore, Santa Barbara, California; 6) Prado Dam Water Conservation Study, Draft Engineering/ Hydrology Report; May 1987; U.S. Army Corps of Engineers, Los Angeles District; 7) Biological Opinion (1-6-93-F-7), issued by the U.S. Fish and Wildlife Service on February 25, 1993; 8) Amendment to Biological Opinion (1-6-93-F-7) dated February 15, 1994; 9) Internal Biological Opinion (1-6-95-F-28) dated April 19, 1995, 9) Biological Assessment for the Prado Dam Water Conservation and Supply Feasibility Study, Riverside and San Bernardino Counties, California; Corps of Engineers, Los Angeles District; August, 1999; 10) OCWD transmittal to the Service dated August 25, 1999 (OCWD letter #1); 11) OCWD transmittal to the Service dated December 8, 1999 (OCWD letter #2); 12) the biological literature (see "Literature Cited and References" below); and 13) other communications with the Corps and the OCWD (on file).

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The Prado Dam, located in Riverside County near Corona, Riverside County, California (Figures 1, 2) has been operated by the Corps according to the procedures outlined in the Prado Basin Water Control Plan of September, 1994 and the our 1995 internal biological opinion. Since the issuance of the previous biological opinions addressing the proposed project, the Corps has proposed to modify the project description to reflect necessary changes in the operation of the dam. Nevertheless, the dam will continue to be operated to (1) prevent flooding of areas along the Santa Ana River downstream from the dam; (2) conserve water to the extent possible pursuant to the terms and conditions of permitted water conservation projects; and (3) minimize the environmental impacts associated with prolonged inundation of sensitive, wetland habitats in the Prado Basin.

The stated purposes of all past and present water conservation projects in the Prado Basin are to conserve water and to improve, overall, the quality of water that is stored in underground aquifers in Orange County, California. OCWD is presently the sole owner of rights to surface waters in the project area. Increased water conservation capabilities would additionally preclude or diminish the need for the OCWD to import water from the Colorado River or elsewhere in the region.

The Corps is responsible for operating the dam for flood control and water conservation purposes. The following description of the proposed procedures for operating the dam is derived largely from the BA, which contains the complete description of the proposed operations and maintenance parameters associated with the future operation of the dam and is incorporated herein by reference. Although the analysis and conclusions summarized or stated herein were generated subsequent to a consideration of this precise project description, no other potential operations and maintenance project features were envisioned and, thus, none were analyzed for their potential effect on vireo, flycatcher, or both species' designated critical habitats.

In general, water releases from Prado Dam will be dictated by the Prado Dam Water Control Plan. This plan was designed to enable the dam to capture potential flood waters and limit the exposure of the downstream channel to possible structural damage by controlling smaller flood events by making relatively small nondamaging (to the channel) releases, and reserving larger reservoir releases for larger flood events. During large flood events, releases from Prado Dam are increased up to 5,000 cfs (or greater). As is discussed in detail in the water control plan, the maximum non-damaging (to the downstream channel and other structures in the channel such as bridges) release rate is 5,000 cfs. As downstream channel improvements are completed, releases in excess of 5,000 cfs can be made from Prado Dam provided that the downstream channel can safely convey such release magnitudes.

The water control manager's decisions regarding the regulation of Prado Dam are based upon available weather and runoff forecasts. Because weather and runoff forecasts are rarely 100 percent accurate, the target water surface elevations (WSEs) likely will, at times, be exceeded. Whether the water control manager deems it necessary to implement the regulation guidelines of the next release range will depend upon the magnitude of encroachment into the next release range, and the current weather and runoff forecast. The dam is operated differently at various WSE ranges, which are discussed individually below.

WSE 460.0 - 490.0 (Debris Pool) (Release Range: 0 - 600 cfs). The debris pool is allowed to fill prior to flood control releases to prevent debris from entering and plugging the outlet works. No seasonal restrictions exist for inundation of the debris pool. Releases from the debris pool are normally coordinated with the OCWD and are set equal to the spreading capacity of the downstream groundwater recharge facility.

WSE 490.0 - 494.0/505 (Buffer Pool) (Release Range: 200 - 2,500 cfs). Due to the channel erosion problems previously experienced in the Santa Ana River channel when prolonged releases from Prado Dam have exceeded 2,500 cfs, a buffer pool has been established which allows the water control manager to control small flood events without making large and potentially channel damaging releases. Due to the increased need for water conservation and the presence of the endangered vireo and flycatcher within the Prado Flood Control Basin, buffer pool regulation differs slightly during the winter flood season and the nonflood season as described below:

- Winter Flood Season (October 1 to February 28). A release of 200 to 2,500 cfs is made as necessary so as not to exceed elevation 494 feet. The drawdown release rate is coordinated with the OCWD to maximize the conservation of water through ground water recharge (Note: a minimum release of 200 cfs is required except for temporary release cutbacks to facilitate OCWD reconstruction of in-stream diversion dikes). Releases greater than 800 cfs can damage OCWD's in-channel sand diversion dikes.

  If a significant amount of inflow to the dam is in the forecast, the reservoir can be drawn down to the debris pool elevation of 490 feet within 24 hours, while releasing nondamaging flows (i.e., releases at or below 2,500 cfs).

- Non-Flood Season (March 1 to 30 September 30). In compliance with the MOA between the Corps and OCWD to increase water conservation, the regulation of the dam is modified during the nonflood season. Beginning in March, the allowable maximum reservoir water surface elevation is increased from WSE 494 feet to WSE 505 feet by 10 March at a rate of 1.1 feet/day, or higher, as determined by the water control managers at the Reservoir Operation Center (ROC), based on current reservoir status, forecasted inflow, and capacity/condition of the downstream channel. The reservoir level may be maintained as high as WSE 505 feet until September 30, provided that hydrologic forecasts and reservoir conditions do not indicate the reservoir elevation rising above elevation 505 feet.

  Because paragraph 9 of the 1995 Cooperative Agreement was found to be inconsistent with the physical and operational capabilities for Prado Dam, the Corps has revised the minimum release rates during the nonflood season. During the period from March 1 - September 30, the release rates when the pool is between elevations 494 and 505 feet may range from 350 cfs to 650 cfs provided that the running average outflow is always greater than or equal to 500 cfs. Release rates tend to be higher at the beginning of the season and taper off toward the end of the season. Therefore, the running average for the period from March 1 - September 30 when the pool is between 494 and 505 feet would tend to start out above 500 cfs and gradually approach 500 cfs as the season progresses. In addition, when the OCWD spreading capacity exceeds 500 cfs, the outflow from the dam will be increased up to a level of the recharge capacity of the OCWD downstream recharge basins.

  However, if, based on observed precipitation, hydrologic forecasts and reservoir conditions indicate that the WSE will exceed 505 feet because of high inflow, the water control manager at the ROC will match inflow with outflow, up to 5,000 cfs to prevent the reservoir pool elevation from exceeding elevation 505 feet, or an elevation within 3 feet of the elevation of the lowest occupied vireo nest located lower than 505 feet. OCWD shall furnish the elevation of the lowest occupied vireo nest to the Corps Reservoir Regulation Section and shall update this information as necessary throughout the vireo nesting season (March 15 - July 31). If vireo nests can be relocated to a higher position, the level of the water surface can be raised to an elevation no higher than 3 feet below the elevation of the lowest relocated nest, to a maximum elevation of 505 feet. If no occupied nests exist below elevation 505 feet, water can be held to 505 feet as long as the lowest vireo nest is located no lower than 506 feet. If a pool elevation of 505 feet is exceeded, dam releases at the maximum nondamaging rate (i.e., 5,000 cfs) will be maintained until the pool level has declined to 505 feet.

  Typically, if sufficient inflow is available, the water conservation pool is incrementally raised (per the 1994 Water Control Plan and adjusted operations for water conservation) from 494 feet to 505 feet between March 1 and March 10. However, if the reservoir is empty and an impending storm may fill the water conservation pool after March 10, the

Corps will contact the Service and OCWD to coordinate the movement of vireo nests, if necessary.

The months of July, August and September are designated for maintenance purposes. However, if summer flood runoff occurs during these months, the dam can be operated to store water for water conservation up to WSE 505 feet, provided that the impoundment does not interfere with maintenance requirements.

WSE 494.0/505.0 - 520.0 (Release Range: 2,500 - 5,000 cfs or above). The water control manager computes a release magnitude based upon the criteria of not exceeding WSE 520 feet. If it is predicted that a pool elevation of 520 feet will be exceeded at any time, the release rate will be 5,000 cfs.

WSE 520.0 - 543.0 (Release: 5,000 cfs or above) Reservoir stages above 520 feet require the maximum scheduled release of 5,000 cfs.

WSE 543.0 - 544.3 (Spillway Flow) (Release: 5,000 cfs or above) Flood control releases through the outlet works are reduced as the reservoir pool level rises above the spillway crest so as to maintain outflow from spillway plus outlet works at a maximum outflow of 5,000 cfs. As the WSE approaches the spillway, frequent communication between the ROC and the dam tender should occur so that the transfer of reservoir outflow from the outlet works to the spillway can be closely monitored.

WSE 544.3 and above (Spillway Flow) (Release Range: 5,000 cfs and above) All outlet gates are closed at reservoir pool levels of 544.3 feet and above, which results in uncontrolled spillway discharge only. Under the extremely remote circumstance that the dam embankment was in danger of overtopping, the outlet gates are to be opened to minimize the possibility of dam failure. The maximum design release from the outlet works is 17,000 cfs and that the design capacity of the outlet stilling basin is 10,000 cfs.

The rates of change for water releases from the dam are dictated by the current version of the water control plan. The 1994 Water Control Plan also updated (from the 1991 version) the rates of change of releases under normal operating conditions, as follows:

Current rate of release (cfs)	Maximum rate of change per ½ hour (cfs)
0 - 300	100
300 - 1,000	250
1,000 - 2,500	400
2,500 - 5,000	625
5,000 +	625

These release rate adjustments were intended to allow rate changes to occur more quickly over a shorter, ½-hour time period.

Base Flows. As defined in the 27th Annual Report of the Santa Ana River Watermaster, base flow is that portion of the total surface flow passing a point of measurement (either Riverside Narrows or Prado Dam) which remains after deduction of storm flow, nontributary flows, exchange water purchased by OCWD, and certain other flows as determined by the Watermaster. Base flows were recorded at 38,402 acre-feet in the 1970-71 water year and increased to 136,676 acre-feet for the 1996-97 water year. Wastewater flows from wastewater treatment plants upstream of Prado Dam contribute to base flows into the dam; these flows have increased over time and are expected to further increase in the future.

Imported Water. OCWD purchases water for groundwater replenishment; however, this purchased water does not contribute to the water conservation pool (494 - 505 feet) behind Prado Dam between March 1 - September 30. In periods where water is pooled behind Prado Dam for water conservation, OCWD will not store additional imported water upstream of Prado Dam for groundwater recharge, unless an agreement has been reached by the Corps, OCWD, and Service.

Deviation from Normal Operations. The procedures for different kinds of deviations from normal dam regulation are contained in section 7-15 of the 1994 Water Control Plan. Occasionally the regulation of Prado Dam to needs to deviate from the established flood control plan described in the 1994 Water Control Plan. Prior approval of deviations is required from the South Pacific Division (SPD) office in San Francisco, except for emergencies as described below.

Emergencies may take the form of drownings or other accidents, chemical spills, and failure of operational facilities. In any action taken, assessment of the situation by the dam tender should rely on his knowledge of the dangers involved. The ROC must be informed of any deviations by the dam tender, due to emergencies, as soon as practical. Emergency deviations do not require prior approval by the Corps South Pacific Division (SPD), but coordination with SPD must be made as soon as practical.

In accordance with the section 7 regulations regarding emergencies (50 CFR § 402.05), the Service shall be notified of these emergency deviations as soon as practical. In addition, we are to be notified of planned and unplanned deviations as defined in the plan and included herein by reference.

Unplanned Minor Deviations. Instances arise periodically that require minor deviations from the normal regulation of the reservoir. Examples of minor deviations include, but are not limited to: construction work, maintenance, and inspection. Each request is analyzed on its own merits. Consideration is given to the potential of flooding and possible alternative measures. A formalized correspondence summarizing the proposed deviation should be sent to SPD for approval before the action. The Service and OCWD shall be notified of these minor deviations.

Planned Deviations. Planned deviations cover all other proposed deviations to approved water control plans. Each condition is analyzed on its own merits. A formalized correspondence summarizing the proposed deviation should be sent to SPD for approval before the action. The Service and OCWD shall be notified of these planned deviations.

Monthly Gate Exercise. To ensure that the outlet works gates remain functional throughout the year and to free any accumulations of sediment or debris from the gate pulley and cable mechanisms, a monthly gate exercise is performed on the first Monday of each month. This exercise may be postponed if conditions so warrant. The monthly gate exercise is as follows:

1) The dam tender checks with the ROC to determine the "wait" period between gate exercises.

2) The dam tender checks the downstream channel from the downstream gate to the outlet works to assure no one is immediately downstream of the outlet works.

3) All gates are closed.

4) Each gate is individually raised to 5-ft and then immediately closed. When an impoundment exists at Prado Dam, the water control manager will determine a wait period between the opening of each individual gate.

5) All gates are returned to the original settings.

6) The downstream gate is checked to verify the outflow has returned to pre-gate exercise conditions.

Drought Contingency Plan. Engineer Regulation 1110-2-1941 (Drought Contingency Plans) directs water control managers to "evaluate and establish the limits of flexibility under existing authorities to modify project regulation and to use existing storage to respond to periods of water shortages." Although the entire storage space of the normally dry Prado Reservoir is allocated for flood control, water conservation is a project purpose. Therefore, the adopted water control plan for Prado Dam was formulated with features that maximize the amount of water that can be conserved without adversely affecting the level of flood protection provided, or significantly impacting environmental resources.

An emergency water conservation operation plan for Prado Dam was implemented during March and April 1991 and 1992, in response to the region's 5-year drought. As part of the arrangements to permit the emergency water conservation operation, the OCWD agreed to either fund or directly implement appropriate environmental mitigation measures. Future drought contingency plans would require an agreement between the Corps, OCWD, and Service.

Agency Communication. Both the Corps and Service are committed to ensuring that open and direct communication occurs on all issues at Prado Dam that could ultimately result in impacts to endangered species. Rapid and responsive communication between the two agencies is critical to the success of this mission. In many instances, early warning may allow the Service to take the necessary measures in the field to prevent the loss of endangered species, particularly the vireo.

The lead office biologist assigned to the Prado Basin (currently Loren Hays) will be the primary Service point of contact on environmental issues within the Prado Basin, and the person to be contacted during "emergencies" where endangered species may be affected. An alternate biologist assigned to Prado Basin (currently Jon Avery) and the Division Chief for Riverside-San Bernardino Counties (currently Jeff Newman) will serve as secondary contacts. Individuals in the Corps Reservoir Regulation and/or Hydraulics and Hydrology Sections (currently Joe Evelyn and Brian Tracy, among others) will contact the lead office biologist assigned to Prado Basin directly to inform him/her of current operations and the status of the rising pool elevations. The Corps has added a notification to this office to their Manual of Instructions for Reservoir Operations Center Personnel to better ensure that we are informed of rising pool conditions in the reservoir during vireo nesting season. The Manual of Instructions will be updated, at a minimum, each year prior to the flood season. With respect to deviations from the approved water control plan, the Corps will notify this office regarding emergency deviations, and will coordinate planned and unplanned deviations with this office and other agencies.

Conservation Measures

Impact avoidance, minimization, and compensation measures have been, and will be completed in accordance with the 1992 EIS, 1993 biological opinion, 1995 cooperative agreement, 1995 biological opinion and negotiations conducted during the informal and formal consultation processes associated with considerations of the currently proposed project. The adaptive management of the Prado Basin vireo and flycatcher populations and giant reed eradication and revegetation efforts funded by the project proponent have minimized (and will minimize) impacts to these species and their designated critical habitats and maximize the prospects for the regeneration of critical habitat elements.

As part of ongoing habitat conservation efforts,:

- OCWD contributed, in 1991, $450,000 to TNC to create a non-wasting endowment for the vireo management program for habitat management and restoration. The funds in this account have sustained the program through 1999 and have accumulated in excess of $990,000. These funds are now in the Santa Ana River Conservation Trust Fund.

- OCWD contributed, in 1991, and additional $450,000 to TNC to create 124 acres of vireo (and flycatcher) habitat on OCWD owned property in Prado Basin, as part of the ongoing vireo management program. TNC revegetated the restoration site in 1992 and 1993. The Orange County Environmental Management Agency reimbursed OCWD the $450,000 in 1992 as part of its compensation package for the Santa Ana River Mainstem project. Approximately $95,000 remains in the account today and approximately 100 acres are in viable vireo habitat. The remaining funds are now in the Santa Ana River Conservation Trust Fund .

Current conservation measures within the Santa Ana River watershed are being undertaken, under the direction of this office, by the OCWD and a group of resource conservation districts known as the Santa Ana Watershed Association (SAWA). The FY 1999-2000 work summary calls for implementing measures to reduce the threat of invasive plants, particularly giant reed and tamarisk, on native habitat and river system function. The primary tasks currently being undertaken to achieve this goal are as follows:

- Complete an exotic plant management report for the Santa Ana River Watershed;
- Continue the development of a GIS data base to track and monitor treatment projects for the Santa Ana River watershed;
- Perform a total of 84 acres of exotic plant treatment within four of the resource conservation districts which are a part of SAWA;
- Continue the development of outreach materials and educational programs, and perform public workshops on exotic plant control that are directed at private landowners within the watershed;
- Continue to work on a watershed team structure that will coordinate and implement tasks and manage funds for those tasks in the future;
- Continue to support the SAWA field biologist position. This person will be responsible for coordinating and monitoring the SAWA invasive plant removal and habitat restoration program and for participating in the vireo/flycatcher management and monitoring program within the Santa Ana River watershed.

SAWA has additionally completed a document entitled *Santa Ana Watershed Management Five Year Program (1998 - 2003).* This document discusses the purpose and goals of continued work within the watershed. The purpose of the program is to effectively control giant reed and other invasive plants within the Santa Ana River watershed through cooperative partnerships. The long-term goals of the program are as follows:

- Perform first-time treatment on all upper watershed tributaries and mainstem Santa Ana river downstream to Riverside County Parks and Open Space District lands;
- Establish a follow-up program with each land management entity that will gradually increase their capabilities to perform long-term maintenance;
- Provide education to private landowners through written materials, workshops and hand-on assistance;

- Maintain a database that will include areas of infestation, current projects, sensitive species and native vegetation recovery.

Most recently, :

- OCWD has agreed to operate four cowbird traps, during the vireo and flycatcher nonbreeding seasons at dairies within close proximity of the Prado Basin;
- OCWD has agreed to continue to repair and store all cowbird traps;
- OCWD has agreed to supply seeds and other supplies for the cowbird traps year-round;
- OCWD has agreed to supply four-wheel drive vehicles to flycatcher/vireo management staff; and
- OCWD has agreed to propagate and plant, in coordination with the Service and Corps, 10,000 mulefat plants from 2-inch containers each fall on OCWD and Corps lands not already dedicated as restoration areas for other OCWD projects (OCWD letter #2).

STATUS OF THE SPECIES

Least Bell's vireo

The least Bell's vireo is a small, olive-gray neotropical migratory songbird that presently nests and forages almost exclusively in riparian woodland habitats in California and northern Baja California, Mexico (Garrett and Dunn 1981, Gray and Greaves 1981, Miner 1989; AOU 1998). Bell's vireos as a group are highly territorial (Barlow 1962, Fitch 1958, Salata 1983a) and are almost exclusively insectivorous (Chapin 1925, Miner 1989).

Least Bell's vireos generally begin to arrive from their wintering range in southern Baja California, and, possibly, mainland Mexico, and establish breeding territories by mid-March to late March (Garrett and Dunn 1981; Salata 1983a, 1983b; Hays 1989; Pike and Hays 1992). However, a singing vireo was on territory in the Prado Basin on March 2, 1994 (James Pike, pers. comm.). A large majority of the breeding vireos in the Prado Basin typically depart their breeding grounds by the third week of September and only a few Bell's vireos are found wintering in California or the United States as a whole (Barlow 1962, Nolan 1960, Ehrlich et al. 1988, Garrett and Dunn 1981, Salata 1983a, 1983b, Pike and Hays 1992).

Least Bell's vireo nesting habitat typically consists of riparian woodlands with well-developed overstories, understories, and low densities of aquatic and herbaceous cover (Zembal 1984, Zembal et al. 1985, Hays 1986, Hays 1989, Salata 1983a, RECON 1988). The understory frequently contains dense subshrub or shrub thickets. These thickets are often dominated by sandbar willow (*Salix hindsiana*), mule fat (*Baccharis salicifolia*), young individuals of other willow species, such as arroyo willow (*Salix lasiolepis*) or black willow (*S. gooddingii*) and one or more herbaceous species (Salata 1983a, 1983b, Zembal 1984, Zembal *et al.* 1985). Significant overstory species include mature arroyo willows and black willows. Occasional cottonwoods (*Populus* sp.) and western sycamore (*Platanus racemosa*) occur in some vireo habitats and there additionally may be locally important contributions to the overstory by coast live oak (*Quercus agrifolia*).

Although the least Bell's vireo occupies home ranges that typically range in size from 0.5 to 4.5 acres (Regional Environmental Consultants 1988), a few may be as large as 10 acres (J. Greaves, pers. comm.). In general, areas that contain relatively high proportions of degraded habitat have lower productivity (hatching success) than areas that contain high quality riparian woodland (Jones 1985, RECON 1988, Pike and Hays 1992).

Because of a documented, drastic decline in numbers and continuing threats to the species and its riparian woodland habitats, the least Bell's vireo was listed as an endangered species by the State of California Department of Fish and Game in 1980. Subsequently, the vireo was listed as endangered by the Service on May 2, 1986 (51 FR 16474). Critical habitat for this species, which includes all riverine and floodplain habitats with appurtenant riparian vegetation in the Prado Basin below the elevation of 543 feet, was designated by the Service on February 3, 1994 (59 FR 4845).

Southwestern willow flycatcher

The southwestern willow flycatcher (*Empidonax traillii extimus* [Phillips]), a relatively small, insectivorous (passerine) songbird, is approximately 15 centimeters (5.75 inches) in length. Both sexes of southwestern willow flycatchers have grayish-green back and wings, whitish throats, light gray-olive breasts, and pale, yellowish bellies. The song is a sneezy "fitz-bew" or "fitz-a-bew" and the typical call is a breathy "whit" (e.g., Unitt 1987).

The southwestern willow flycatcher is a recognized subspecies of the willow flycatcher (*Empidonax traillii*). Although previously considered conspecific with the alder flycatcher (*Empidonax alnorum*), the willow flycatcher is distinguishable from that species by morphology (Aldrich 1951), song type, habitat use, structure and placement of nests (Aldrich 1953), eggs (Walkinshaw 1966), ecological separation (Barlow and MacGillivray 1983), and genetic distinctness (Seutin and Simon 1988).

In turn, the southwestern willow flycatcher is one of five subspecies of the willow flycatcher currently recognized (Hubbard 1987, Unitt 1987, Browning 1993). The willow flycatcher subspecies are distinguished primarily by differences in color and morphology. Although the subspecific differences in color have been termed "minor" (Unitt 1987), P.E. Lehman (recognized expert field biologist, pers. comm.) has indicated that the southwestern willow flycatcher in California is distinguishable in the field from other forms of willow flycatchers that might be present (in migration) within the breeding range of the former. Unitt (1987) and Browning (1993) concluded that the southwestern willow flycatcher is paler than other willow flycatcher subspecies. Preliminary data also suggest that the song dialect of the southwestern willow flycatcher is distinguishable from other willow flycatchers.

The breeding range of the southwestern willow flycatcher includes southern California, southern Nevada, Arizona, New Mexico, and western Texas (Hubbard 1987, Unitt 1987, Browning 1993). The species may also breed in southwestern Colorado, but nesting records are lacking. Records of breeding in Mexico are few and confined to extreme northern Baja California and Sonora (Unitt 1987, Howell and Webb 1995). Willow flycatchers winter in Mexico, Central America, and northern South America (Phillips 1948, Ridgely 1981, AOU 1983, Stiles and Skutch 1989, Ridgely and Tudor 1994, Howell and Webb 1995).

Breeding southwestern willow flycatchers are often present and singing on territories in mid-May (exceptionally in late April in southern California). Southwestern willow flycatchers are generally gone from breeding grounds in southern California by late August (The Nature Conservancy 1994) and are exceedingly scarce in the United States after mid-October (e.g., Garrett and Dunn 1981). The first southwestern willow flycatcher of the 1998 Prado Basin breeding season were detected on May 4 and the last was noted on August 9. In 1997, the first bird of the breeding season was detected on May 7 and the last (a juvenile) was noted on September 10.

The southwestern willow flycatcher breeds in riparian habitats along rivers, streams, and other wetland habitats where dense growths of willows (*Salix* spp.), coyote-bush (*Baccharis* spp.), arrowweed (*Pluchea sericea*), buttonbush (*Cephalanthus occidentalis*) [not found in southern California], or other plants of similar structure and configuration are present. The flycatcher nests in thickets of trees and shrubs approximately 4 to 7 meters (13 to 23 feet) or more in height with dense foliages from approximately 0 to 4 meters (0 to 13 feet) above ground. Overstories are often present in occupied habitats and composed of willows or cottonwoods or, in some portions of the species' range, tamarisks (*Tamarix*, spp.) (e.g., Phillips 1948, Grinnell and Miller 1944, Whitmore 1977, Hubbard 1987, Unitt 1987, Whitfield 1990, Brown 1991, U.S. Fish and Wildlife Service 1993, 1995). Although nesting willow flycatchers of all subspecies generally prefer areas with surface water nearby (Bent 1960, Stafford and Valentine 1985, Harris et al. 1986), the southwestern willow flycatchers in the Prado Basin virtually always nest near surface water or saturated soil (e.g., The Nature Conservancy 1994).

All known southwestern willow flycatcher territories within the Prado Basin have been situated in relatively close proximity to water-filled creeks or channels. In addition, territories have usually consisted of overgrown clearings containing varying amounts of nettles and with, at least, a few moderately tall, often dense, willows. Among the five nests found in 1996, two were placed in arroyo willow, one was found in a red willow (*Salix laevigata*), one was placed in a sandbar willow, and one was placed in a tamarisk. During the 1997 season, both nests that were discovered had been placed in arroyo willow. Nests have been placed as low as 0.61 meters above ground level.

All three resident subspecies of the willow flycatcher (*E. t. extimus*, *E. t. brewsteri*, and *E. t. adastus*) were once considered widely distributed and common within California wherever suitable habitat existed (e.g., Grinnell and Miller 1944). The historic range of *E. t. extimus* in California apparently included all lowland riparian areas of the southern third of the state. Nest and egg collections indicate the bird was a common breeder along the lower Colorado River near Yuma in 1902 (T. Huels, University of Arizona, *in litt.*). Willett (1933) considered the bird to be a common breeder in coastal southern California. Most recently, Unitt (1987) concluded that the southwestern willow flycatcher was once fairly common in the Los Angeles basin, the San Bernardino/Riverside area, and San Diego County.

The southwestern willow flycatcher is apparently vulnerable to the same factors that have caused the decline of the vireo within those species' shared ranged in the Californias and thus has almost been extirpated as a breeding species throughout much of southern California (e.g., Garrett and Dunn 1981, Unitt 1987). Because range-wide, recent surveys have essentially corroborated these assumptions, the current status of *E. t. extimus* is likely much more precarious than that of the vireo, which has begun to recover in southern California.

On July 23, 1993, the Service proposed the southwestern willow flycatcher as an endangered species throughout its range (58 FR 39495) and simultaneously proposed critical habitat for the species. Although deferring a decision on the designation of critical habitat, the Service listed the flycatcher as endangered on February 27, 1995 (59 FR 10693). Critical habitat for the flycatcher, which includes much of the Prado Basin, was designated by the Service on August 20, 1997 (62 FR 39129 and 62 FR 44228). Breeding willow flycatchers are listed as endangered by the States of California and Arizona.

ENVIRONMENTAL BASELINE

Least Bell's vireo

During the 1999 breeding season, the least Bell's vireo population in the Prado Basin and environs was studied and managed for the fourteenth consecutive year. Study areas included the Basin proper and contiguous reaches of the Santa Ana River and Chino Creek. The data necessary to determine vireo status and distribution, breeding chronology, reproductive success, and nest site preferences were obtained, when possible, during daily visits to appropriate riparian woodland habitats throughout the basin. In addition, brown-headed cowbirds present in vireo home ranges were routinely censused, and modified Australian crow traps were once deployed throughout the basin and adjacent Santa Ana River in an attempt to control this brood-parasitic and rapidly expanding species.

Of the 336 territorial male vireos that were detected within the Prado Basin study area in 1999, 224 of these birds were found to be paired (Pike and Hays 1999). By contrast, 270 pairs were recorded in 1998, 195 pairs were detected in 1996, and 164 pairs were located in 1995 (Pike and Hays 1998). The reason for this substantial decrease in the number of breeding pairs remains unknown.

In 1999, a minimum of 489 known fledged young was produced by Prado Basin vireo breeding pairs, resulting in a 10 percent increase over the corresponding total recruitment (450) in 1998. Nesting success in 1999 was 57 percent, which exceeded the corresponding figures for 1998 (41 percent) and 1997 (50 percent) (Pike and Hays 1999). Although the average number of fledglings per breeding pair (2.2) in 1999 was the highest recorded since 1995, this average is substantially below the 1988-1991 fledglings-per-pair average of 3.1. In recent years, significantly fewer pairs have elected to renest after successfully fledging young on their first attempt (Pike and Hays 1999).

By the end of the breeding season in 1998, 2,333 cowbirds had been trapped and removed from vireo and flycatcher habitats within the Prado Basin and an additional 105 cowbirds were removed from Hidden Valley Wildlife Refuge adjacent to the Santa Ana River in Norco. More than 1,314 cowbirds were removed from in or near vireo and flycatcher habitat in 1997. Correspondingly, the 13 percent parasitism rate in 1998 was the lowest recorded within the Prado Basin. Vireos continued to demonstrate a strong preference for nesting and foraging in willows and mule fat (Pike *et al.* 1998). Of all nests in 1997 for which data were available (N=239), 54 percent were placed in various willow species and 40 percent were found in mule fat (The Nature Conservancy 1997).

The vireo has been historically described by multiple observers as common to abundant in the appropriate riparian habitats from as far north as Tehama County, California, to northern Baja California, Mexico (Grinnell and Storer 1924, Willett 1933, Grinnell and Miller 1944, Wilbur 1980). Widespread habitat losses have fragmented most remaining populations into small, disjunct, and widely dispersed sub-populations. The remaining birds are concentrated in San Diego and Riverside counties (U. S. Fish and Wildlife Service 1998).

Although the species has begun to recover and approximately 2,000 vireos were on territories within California in 1998 (Service, unpublished data), preliminary data indicate that the United States breeding population in 1999 was almost certainly smaller. Population declines were noted at Marine Corps Base, Camp Pendleton, the Prado Basin, and at other locales throughout the range of the species in 1999 (Service, unpublished data). The reason for this apparent, recent population decline is unknown. Nevertheless, the Prado Basin population of vireos remained the second largest overall and the largest by far north of San Diego County. The largest population of vireos range-wide continues to be located on Marine Corps Base, Camp Pendleton in San Diego County. In recent years, the Camp Pendleton and Prado vireo populations have represented over approximately 60 percent of all known vireo territories.

The past, unparalleled decline of this California landbird species (Salata 1986, U.S. Fish and Wildlife Service 1986a) has been attributed, in part, to the combined, perhaps synergistic effects of the widespread and relentless destruction of riparian habitats, habitat fragmentation, and brood-parasitism by cowbirds (Garrett and Dunn 1981). The historic loss of wetlands (including riparian woodlands) in California has been estimated at 91 percent (Dahl 1990). Much of the remaining habitat is fragmented or infested with alien plants (e.g., giant reed) and exotic animals (e.g., cowbirds). Reductions in vireo numbers in southern California and the San Joaquin and

Sacramento Valleys were evident by the 1930s and were "apparently coincident with increase of cowbirds which heavily parasitize this vireo" (Grinnell and Miller 1944).

Southwestern willow flycatcher

The Prado Basin southwestern willow flycatcher population was studied and managed for the 14th consecutive year within the Prado Basin, adjacent Santa Ana River, and environs during the 1999 breeding season. The data necessary to determine southwestern willow flycatcher status and distribution, breeding chronology, reproductive success, and nest site preferences were obtained whenever and wherever possible during daily visits to appropriate riparian woodland habitats throughout the basin. In addition, cowbirds present in southwestern willow flycatcher home ranges were routinely censussed, and modified Australian crow traps were once deployed throughout the basin and adjacent Santa Ana River in an attempt control this brood-parasitic species and thus maximize the local breeding success of the vireo, flycatcher, and a large number of other sensitive passerine bird species.

Despite 14 consecutive years of cowbird management and habitat conservation efforts within the Prado Basin, a total of only five flycatcher home ranges was detected within the Prado Basin during the 1999 breeding season. Four of the five territorial flycatchers were likely returning to home ranges that were occupied during the previous season. Pairs were eventually found in only three of these home ranges. Two of the three pairings resulted in successful breeding, producing a total of five fledglings.

Although flycatcher home ranges have been detected nearly throughout the surveyed portions of the Basin, successful breeding prior to 1996 had been detected only in North Basin and West Basin (Chino Creek). From 1996 to1998, however, the only successful breeding occurred in two adjacent home ranges in South Basin. Regardless, given that only three breeding pairs of southwestern willow flycatchers were present within the survey area during the 1999 breeding season, southwestern willow flycatchers likely are in danger of disappearing from the Prado Basin and environs.

The available information suggests that all three willow flycatcher subspecies breeding in California have declined substantially, with declines most critical in *E. t. extimus*, the southwestern willow flycatcher, which remains only in small, disjunct nesting groups (e.g., Unitt 1987, U.S. Fish and Wildlife Service 1995), like those found in the Prado Basin. Status reviews or analyses conducted before the listing of the southwestern willow flycatcher considered extirpation from California to be possible, even likely, in the foreseeable future (e.g., Garrett and Dunn 1981, Harris et al. 1986).

The Prado Basin population is one of only six permanent breeding sites that now exist in California, and only three southwestern willow flycatcher populations in California contain 20 or more nesting pairs. Despite the virtual elimination of impacts from livestock grazing to the large and important flycatcher population on the South Fork of the Kern River (Harris et al. 1986, Whitfield 1990), numerical declines in the population levels were observed in 1991 and 1992.

Fortunately, increases in nesting success were realized in 1992 and 1993; these increases were attributed to removing cowbird eggs or nestlings found in southwestern willow flycatcher nests, and cowbird trapping (Whitfield and Laymon, Kern River Research Center, *in litt.*, 1993). The Kern River population consisted of 29 pairs in 1996 (M. Whitfield, pers. comm., 1996). Another large, and relatively stable, nesting population is along the Santa Margarita River on Marine Corps Base Camp Pendleton, where cowbird numbers have also been reduced by trapping. Approximately 20 pairs were detected on Camp Pendleton in 1996. The third and last "large" population persists on the Upper San Luis River, where 25 pairs were detected in 1996 (Bill Haas, pers comm., 1996).

Although five other nesting groups were known in southern California in 1996, all but one of these consisted of four or fewer nesting pairs in recent years (Service, unpublished data). A total of 104 pairs of southwestern willow flycatchers was recorded in California in 1996 and preliminary data indicate that 100 pairs were present in the state in 1998 (Service, unpublished data).

Unitt (1987) reviewed historical and contemporary records of the southwestern willow flycatcher throughout its range and determined that the species had declined precipitously during the last 50 years. Unitt (1987) argued convincingly that the southwestern willow flycatcher is faring poorly throughout much of its breeding range (see also Monson and Phillips 1981, Garrett and Dunn 1981, U.S. Fish and Wildlife Service 1995). Unitt (1987) has postulated that the "total population of the subspecies is well under 1,000 pairs; I suspect that 500 is more likely." Recent range-wide surveys have corroborated Unitt's hypothesis.

Throughout the known range of the flycatcher, occupied riparian habitats have been, and remain, widely separated by vast expanses of relatively arid lands. However, the southwestern willow flycatcher has suffered the extensive loss and modification of these cottonwood-willow riparian habitats due to due to grazing, flood control projects, and other water or land development projects (e.g., Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Dahl 1990; U.S. Fish and Wildlife Service 1995). Estimated losses of wetlands between 1780 and the 1980's in the American southwest are; California (91 percent), Nevada (52 percent), Utah (30 percent), Arizona (36 percent), New Mexico (33 percent), and Texas (52 percent) (Dahl 1990). Changes in riparian plant communities have resulted in the reduction, degradation, and elimination of nesting habitat for the willow flycatcher, curtailing the ranges, distributions, and numbers of western subspecies, including *E. t. extimus* (e.g., Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Ehrlich et al. 1992).

The species is alos impacted by a variety of other factors, including brood parasitism by cowbirds (Unitt 1987; Ehrlich et al. 1992; U.S. Fish and Wildlife Service 1993, 1995). Parasitism rates of flycatcher nests have recently ranged from 50 to 80 percent in California (Whitfield 1990; M. Whitfield and S. Laymon, unpublished data) to 100 percent in the Grand Canyon in 1993 (U.S. Fish and Wildlife Service 1993). Mayfield (1977) concluded that a species or population might be able to survive a 24 percent parasitism rate, but that much higher losses "would be alarming." In any case, a composite of all current information indicates continuing declines, poor reproductive performance, and continued threats to most of the extant populations of flycatchers (e.g., Brown 1991; U.S. Fish and Wildlife Service 1992; Whitfield and Laymon (Kern River Research Center, *in litt.*, 1993); U.S. Fish and Wildlife Service 1993, 1995; Service, unpublished data).

EFFECTS OF THE ACTION

The project involves conserving water within the flood control storage space behind Prado Dam both during and after the flood season (BA). Riparian habitat suitable for the flycatcher and vireo would be subject to inundation as a result of the project. Over the past 6 years, earlier water conservation programs have resulted in the prolonged inundation of riparian woodland habitats in the Prado Basin. For instance, during the 1998 breeding season, water conservation resulted in the holding of water at or above an elevation of 505 feet from February 25 until May 31, during which time habitats below that elevation were entirely unavailable to vireos and flycatchers.

Management of the vireo and flycatcher populations in the Prado Basin during past water conservation efforts, literature reviews, and analyses of the effects of other Prado Basin projects and activities have resulted in an elucidation of some of the real and potential effects associated with the implementation of the proposed project. In particular, the flooding of vireo riparian woodland habitats in 1995 and 1998 in conjunction with previously authorized water conservation projects in the Prado Basin have resulted in; (1) degradation and destruction of riparian habitat elements below an elevation of 505 feet and a resultant redistribution of vireo home ranges, (2) a marked increase in the use of exotic (primarily upland) plant species for nest placement, (3) an inability to deploy cowbird traps in optimum, proven locations, and, perhaps as a result, and (4) an elevated nest parasitism rate in the most affected area (West Basin) during, at least, 1 year (The Nature Conservancy 1995, The Nature Conservancy 1996, Pike and Hays 1998).

The proposed project is not likely to directly impact local flycatcher breeding pairs, home ranges, or habitats that are apparently "preferred" by the species. No known flycatcher nests within the Prado Basin, past or present, have been in home ranges established below an elevation of 510 feet, and no home ranges have been established below 505 feet, the maximum pool elevation allowed. However, a flycatcher male was observed at an elevation of 505 feet, and the establishment of home ranges or placement of nests in appropriate habitat below that elevation is not precluded or unexpected.

The pooling of water to an elevation of 494 feet during the winter (October 1 - February 28) would not directly affect the vireo, as the species is not present within the project area during this time period. Vireos typically arrive in the Prado Basin and southern California in mid to late March, with territory establishment and nesting taking place from March through late July (Pike and Hays 1999). Dispersal of fledglings and mature adults typically occurs in August and September. Vireos are only rarely detected in the Basin from 1 October to 15 March of each nonbreeding season (see, for instance, Pike and Hays 1999).

However, suitable habitat for the vireo and, apparently, flycatcher does occur below an elevation of 494 feet (Service, unpublished data). Thus, holding water at elevation 494 feet or below from March 1 to September 30 could directly impact the vireo and, possibly, the flycatcher. Water held from 494 feet to 505 feet during the nonflood season from March 1 to September 30 has, and could again, substantially inundate vireo habitat within the basin and thus preclude its use during the breeding season or displace or impact vireo pairs attempting to breed within that range of elevations. Based on 1999 data, approximately 70 pairs of vireos occurred in home ranges that could have been partially or substantially flooded if water was held at an elevation of 505 feet during the breeding season. The inundation of vireo habitat may reduce the number of successful breeding pairs for that particular season, cause a delay in breeding due to the forced relocation of pairs to areas of suitable habitat, and force a reduction in the number of nesting attempts.

Direct impacts to vireo (and flycatcher) nests, eggs, or nestling young are not expected to occur because the location and elevation of vireo nests will be closely monitored each year to ensure that flooding of occupied vireo nests does not occur. As is discussed in the BA and Corps project description, dam releases of up to 5,000 cfs will be made in an effort to prevent the reservoir pool elevation from exceeding elevation 505 feet, or an elevation within 3 feet of the elevation of the lowest occupied vireo nest located lower than 505 feet. If elevation 505 feet is exceeded, dam releases at the maximum nondamaging rate (i.e., 5,000 cfs) will be maintained until the pool level has declined to 505 feet. As a further safeguard, vireo nests may be relocated, if possible, to higher elevations to avoid swamping. Such measures should prevent the destruction of vireo nests and concomitant death of vireo young or eggs.

Although it is intended that vireo and flycatcher adults, nests, and young will not be directly impacted by the project and only occupied vireo habitat will be affected, the Corps has concluded in the BA that the loss of riparian habitat within the basin is an unavoidable adverse impact to the vireo, flycatcher, and both species' designated critical habitats.

Given the geographic distribution and elevations of vireo nests in the Prado Basin during the 1999 breeding season (OCWD letter #2; OCWD, unpublished data), the expected rebound of the vireo population to 1998 levels or beyond, and the anticipated redistribution of breeding pairs to higher elevations, we conclude that the habitat of as many as 90 pairs of vireos may be impacted as a result of the implementation of the project as discussed below. In addition, as many as 5 additional pairs may be harassed due to indirect effects of the project. Critical habitat for the vireo, which includes floodplains below 543 feet in the Prado Basin and all appurtenant vegetation, will be the most significantly affected.

Although the effects of flooding on riparian habitat are difficult to quantify, water conservation within Prado Basin may result in; (1) vegetation mortality (i.e., reduction in the aerial extent of willow riparian habitat); (2) reduction in species diversity, as plants intolerant of flooding are reduced within the basin; and (3) structural changes within the habitat, especially a loss of shrubby understory. The primary impacts on vireo include the indirect effects associated with the inundation of riparian habitat, the required nesting and foraging habitat for this species.

Past studies of the effects of prolonged or periodic water storage in the Prado Basin have resulted in conclusions that the inundation of riparian vegetation can alter or permanently destroy constituent vireo and flycatcher critical habitat elements. Subsequent to comprehensive studies of riparian woodland habitats with the Prado Basin proper, the Service concluded that "the lack of plant species diversity and the sparsity of shrubby understory development below 490 feet in the Prado Basin is attributable to the past frequency, duration, and timing of inundation" (Zembal *et al.* 1985). Frederickson (1979) had previously concluded that plant species diversity at three Missouri study sites declined greatly as inundation levels became increasingly pronounced. In general, flooding of trees can cause "the depletion of oxygen to respiring roots, accumulation of carbon dioxide in the soil, establishment of anaerobic conditions around the roots, and accumulation of toxins (organic acids) in and around the roots" (Dames and Moore 1987). Submergence during the growing season (when plants are actively respiring) may be particularly damaging.

Impacts to vegetation from inundation depend upon the depth and duration of inundation, and time of year of flooding, among other factors. One of the primary effects of flooding is to create hypoxic or anaerobic soil conditions, which in turn can affect the physiological processes of the plant, including respiration and photosynthesis. Plants adapted to flooding exhibit a variety of mechanisms to cope with anaerobic soil conditions, including the formation of adventitious roots and hypertrophied lenticels for oxygen acquisition, and altered metabolic pathways which avoid the buildup of toxic end products associated with anaerobic respiration.

In general, willow species, especially black willow (*Salix gooddingii*) are fairly tolerant of flooding during the growing and dormant seasons. Black willow cuttings have survived flooded soil conditions (approximately 4 centimeters above the soil line) for a period from April 1997 through March 1998 (J. Altergott, Corps of Engineers, unpublished data). Flooding during the winter or dormant season is not expected to adversely affect deciduous species, which lose their leaves prior to becoming dormant.

Less information is known about understory species, particularly mulefat (*Baccharis salicifolia*), which may be less tolerant of flooding during both the growing season and the winter. Mulefat cuttings have survived flooded soil conditions (approximately 4 centimeters above the soil line) for a period from April 1997 through March 1998 (J. Altergott, unpublished data). Mulefat is not truly deciduous and during the non-growing season may have higher oxygen requirements than deciduous species, which reduces the species' flood tolerance during the winter. Mulefat and other understory shrub and herbaceous species would be more likely to be subject to complete rather than partial inundation, which may increase the adverse effects associated with water conservation.

Observations of riparian habitats in the Prado Basin in 1997, 1998, and 1999 revealed that mulefat was substantially impacted and almost entirely eliminated in the Basin below an elevation of 505 feet subsequent to storage of water at that elevation during the spring of 1998. Although not present in all vireo home ranges, mulefat is a primary component of the understory used by most breeding vireos (and flycatchers); impacts to this plant species may affect the structural composition of the habitat, thus reducing its value for both the vireo and flycatcher.

In the extreme, prolonged water conservation may sufficiently damage critical habitat to the extent that is no longer vireo (or flycatcher) habitat. Vireos no longer breed in riparian woodlands in the far western portion of the South Basin that have been subjected to repeated, recent inundations (Pike and Hays 1992, The Nature Conservancy 1993, The Nature Conservancy 1997). These woodlands, although suitable (and occupied) as recently as 1989, are now almost entirely devoid of suitable nesting microhabitat. Essential nesting habitat elements in the lower (generally western) portions of the South Basin evidently have been markedly altered and reduced as a result of inundation. Apparently, the "niche-gestalt" (James 1971) of these areas has been altered to the extent that the habitats extant no longer have the characteristic vegetational requirements found in habitats that are normally selected, or "preferred" by vireos.

In 1991, the Corps prepared an EA/FONSI to document impacts associated with year-round water conservation between elevations 490 and 494 feet. No significant impacts to vireos were identified at that time. The Corps has concluded that flood control operations since the dam was built and more recent water conservation operations have resulted in the survival of only minimal amounts of vireo habitat within the geographic total of 313 acres (J. Altergott, Corps of Engineers, *in litt.*, 1999) that occur between 490 and 494 feet within Prado Basin. Nevertheless, riparian habitats below 494 feet were used by vireos during the 1999 breeding season (OCWD, unpublished data) and such habitats are increasingly available to the species during dry years, during which time the vegetation recovers to varying degrees.

Approximately 642 acres of critical habitat for the vireo are located between elevations 494 and 505 feet (Larry Munsey International 1999). Because the proposed conservation of water could, and eventually will, flood vireo critical habitat after essential habitat constituents have emerged from dormancy, we conclude that all vireo and flycatcher habitat between 490 and 505 feet eventually could, at least occasionally and temporarily, be directly impacted by the proposed project up to the target elevation. Because future climatological events or other extenuating circumstances cannot be predicted with any reasonable degree of precision, future project-related impacts to critical habitat are equally unpredictable. However, assuming that: (1) a long-term average of 50 percent of existing vireo habitat is degraded, destroyed, or otherwise rendered unsuitable or unavailable as a result of the project (e.g., EIS); and 2) 50 percent of the 311 acres between elevations 490 and 494 feet is vegetated, approximately 400 acres of vireo critical habitat, on average, could be substantially affected by the project. In any event, pursuant to the data and analysis in the Fish and Wildlife Coordination Act report prepared for the project (Zembal et al. 1985), as much as 228 acres of habitat capable of supporting the vireo and, potentially, flycatcher may eventually be lost in conjunction with the initial proposed project for water conservation up to an elevation up to 505 feet.

According to our regulations at 50 CFR § 402, we are required to analyze effects of the Federal action that may be interrelated to, or interconnected with, the subject proposed project and/or "reasonably expected to occur" as the result of the implementation of the project. Potential interrelated or interconnected indirect effects of the action include, but are not necessarily limited to, an increased presence of humans in smaller habitat areas, increased ambient noise levels and vibration in habitats occupied by breeding vireos and flycatchers (due to the past documented movement of vireos to higher elevations closer to Prado Basin roads and airport operations), the infestation of exotic plants and animals and artificial concentration of predators and brood parasites in remaining (post-project) habitats, and the dispersal of environmental contaminants.

Because of the apparent degradation of habitats at relatively low elevations, the center or core of the South Basin population of vireos has moved significantly to the east and higher in elevation (see The Nature Conservancy 1993a,b). In addition, whenever water is stored at elevations approaching 505 feet, vireo pairs have been displaced to the far western portions of the Basin immediately adjacent to State Route 71. Thus, as a result of past water conservation, comparatively more vireo pairs are now breeding (or have bred) on or near the outer edges of protected habitats and thus are in closer proximity to roads and Basin facilities and developments, including the Corona Municipal Airport. We therefore conclude that the recent, water conservation-induced modification, destruction, or inundation of vireo and flycatcher habitats in the lower elevations of the Prado Basin have subjected vireos and, possibly, flycatchers, to a variety of indirect threats that are the result of an increased human presence in occupied habitats at higher elevations outside of the project area.

This increased presence in the outer portions of the Basin is problematical in part because, as has been repeatedly observed, vireos often react strongly to the close approach of humans, particularly when nestling or fledgling young are also present. Research has also documented that the presence of humans at or near cowbird traps compromises the success of trapping efforts, particularly if the traps are damaged or stolen (e.g., The Nature Conservancy 1997). Moreover, the available data (e.g., Salata 1987b) suggest that unnecessary human disturbances may otherwise jeopardize vireo nesting success. Predators and cowbirds may both be capable of "homing in" on agitated vireos and subsequently destroy nearby nests. In addition, much of the Prado Basin near higher elevation roads continues to be used for recreational shooting, dumping, camping, paint-ball games, and cultivation of illegal plants. Many of these activities have adversely affected occupied critical habitat for the vireo and flycatcher.

The project-related creation and maintenance of habitat that may favor exotic plants and animals could potentially significantly impact the vireo, flycatcher, and their riparian habitats and artificially concentrate predators in unflooded areas. Specifically, the routine flooding associated with the proposed project could: (1) induce the establishment or dispersal of castor bean and giant reed, two alien plants that displace and destroy native riparian habitats; or (2) degrade or modify riparian habitats to the benefit of the exotic cowbird.

The increase and spread of alien plants, notably giant reed, is continuing in the Santa Ana River in general and Prado Basin in particular. Although this escaped alien can colonize natural areas after natural flood events, invasion of this aggressive plant is greatly increased by disturbances such as changes in flow/flood regimes. Undisturbed areas vegetated with native species are much more resistant to invasion by this and other alien plants. The disturbance associated with water storage is expected to substantially increase the potential for invasive species to propagate or become established in project area.

The cowbird populations in the Prado Basin and contiguous reaches of the Santa Ana River apparently are of a comparatively higher abundance and density (see Pike and Hays 1999). This apparent, relative abundance of cowbirds within the Prado Basin may well be the result of the rather close juxtaposition of host-rich riparian habitats and expansive feeding areas in and around nearby dairies, livestock operations, and agricultural fields (see, Zembal *et al.* 1985, Hays 1987, and Lowther 1993).

In support of this hypothesis, the available data reveal that the number of cowbirds removed from Prado Basin habitats from 1986 to 1989 (3,115) obviously far exceeds the number (1,282) that were removed during this same time frame (or any other 4-year period) from the well-managed and much larger Camp Pendleton locale (Salata 1987b; Slader Buck, Marine Corps Base, Camp Pendleton personal communication; Sweetwater Environmental Biologists 1989; Fish and Wildlife Service, unpublished data). Sweetwater Environmental Biologists (1989) reported a yield of 0.17 cowbirds per trap day at Camp Pendleton during 1988; the corresponding figure for the Prado Basin in 1988 and 1989 was 0.9 cowbirds per trap day. However, these same authors reported that the cowbird parasitism rate at Camp Pendleton had been reduced to less than 1 percent in 1988 and 1989, a figure that is far less than any 1-year average reported thus far for the Prado Basin (see Pike and Hays 1999).

Accordingly, because the rate of parasitism of vireo nests in the Prado Basin has been as high as 100 percent (Zembal *et al.* 1985), any project-related feature that prevents the management of this species is highly problematical. Previous studies have revealed that the storage of water in the Prado Basin has prevented the deployment of cowbird traps in optimum, proven locations, and, apparently as a result, caused or contributed to an elevated nest parasitism rate in the most affected area (West Basin) (The Nature Conservancy 1995, The Nature Conservancy 1996, Pike and Hays 1998). The available evidence also suggests that cowbirds are able to efficiently exploit nests that they are easily able to detect in fragmented landscapes or in habitats with reduced vegetation densities and volumes. In essence, because "female cowbirds find nests by watching other birds and by actively searching for nests" (Van Tyne and Berger 1976: 527), nest-finding by cowbirds and predators may be facilitated in areas that are devoid of luxuriant, near-ground vegetations or otherwise disturbed. In addition, the expected increase in human presence at less remote, higher elevations within the Prado Basin could compromise management efforts to effectively control cowbirds. The vandalism of cowbird traps has been, and remains, problematical in the higher (more accessible) portions of the Prado Basin and adjacent Santa Ana River and Temescal Creek.

Given the discussion immediately above and because implementation of the project will effectively reduce the amount and quality of habitat available to the listed species and predators alike, predation of vireo and flycatcher rates may increase. Not surprisingly, the 1998 rate of depredation on vireo nests (45 percent) was one of the two highest figures recorded during the 14 year monitoring and management effort in the Basin (Pike and Hays 1999). Due to the availability of water and sustained water conservation during the 1998 breeding season, the pool elevation remained at 505 feet until June and did not fall to 500 feet until July (Corps, unpublished data).

Although the proposed project does not directly increase the potential for noise and vibration impacts to vireos, the displacement of vireos to the vicinity of the Corona Airport, State Route 71, and other Basin roads could pose an indirect, potential threat to the vireo and the flycatcher within the project action area (e.g, RECON 1988; Pike and Hays 1992). Noise and vibration are thought to be potentially harmful to a variety of bird species (Gunn and Livingston 1974, RECON 1988, Pike and Hays 1992). Many birds have acute senses of hearing (Dooling 1978, Knudsen 1978, Fay and Feng 1983) and researchers have documented and described the negative effects of noise on birds. For instance, Fletcher et al. (1971) reported that few, if any, of the reported or suggested effects of noise on wildlife would benefit them or increase their chances for survival, whereas known, detrimental noise effects may decrease their chances for survival or even lead to their death. In the extreme, the apparent effects of noise can be devastating to wildlife populations.

Upon reviewing the body of relevant scientific research, Dufour (1980) of the Environmental Protection Agency (EPA) identified four major categories of noise effects on wildlife: 1) auditory physiological, 2) nonauditory physiological, 3) behavioral, and 4) masking. Although masking (i.e., interference with the reception of auditory signals because of interfering environmental noise) and behavioral considerations are of primary concern in this instance, Dr. R. J. Dooling (1987), bioacoustics expert from the University of Maryland, stated and documented that "as studies with humans have shown, noise has other deleterious effects (other than masking) and there is no reason to think that noise would not effect animals in the same way." For instance, Gunn and Livingston (1974) reported that a bird population exposed to helicopter disturbances and human activity suffered (in contrast to the control population) lower hatching and fledging success and increased rates of nest abandonment and the premature disappearance of nestlings. Woolf et al. (1976) concluded that prenatal auditory stimulation can affect the development (and, therefore, the physiology) of an avian embryo inside an egg.

"Masking," however, may be most detrimental to small perching birds, like the vireo and flycatcher. In essence, "excess sound can interfere with the perception of important, relevant auditory signals" (Miller 1974). Whether a vireo or flycatcher receives potentially vital auditory information depends on such noise parameters as environmental attenuation, signal to noise ratios, and discrimination of the receiver given the background noise. The pertinent biological literature suggests that birds utilize their sense of hearing to locate their young and mates, to establish and defend territories, and to locate and evade predators (Scherzinger 1970 and Shen 1983). The latter author observed that the ability of a bird to detect vibration may be crucial for sensing approaching predators, particularly if the birds are sleeping. The life of a vireo or flycatcher may well depend upon its detection of an alarm call given by another vireo or flycatcher (or other source) that warns of the approach of potential predators.

Masking noise may also affect the breeding behaviors of affected birds. Dooling (pers. comm., 1987) concluded that, if "noise masks vireo song for the human (at some given distance) then it probably also significantly masks vireo song for the vireo." Dooling continued that "the human almost certainly does better than the vireo in hearing a signal in noise around 2 to 4 kilohertz (probably about twice as good)." Given Dooling's remarks concerning the relative acuities of human and vireo hearing and the aforementioned dependence of the vireo (and many other bird species) on their sense of hearing, unabated, masking noise could adversely affect vireo or flycatcher pairs or individuals that are present in, or adjacent to, the subject action area.

Over the course of the past 14-year study of the vireos and flycatchers in the Prado Basin, it has become increasingly apparent that ambient noise, particularly that caused by low-flying helicopters and fixed-wing aircraft involved in "touch and go" exercises, have posed a threat to vireos, flycatchers, and a large number of other species in the southern and western portions of the Prado Basin.

Most recently, aircraft noise was particularly problematical in 1997 in the southern portions of the Prado Basin. Routine censuses and data collection historically have been difficult in portions of the basin because of nearly continuous aircraft noise that masks the vocalizations of subject birds (and virtually every other ambient sound). Noise was often contributed simultaneously by three (or more) aircraft and was frequently, apparently problematical for periods up to 90 minutes in length (The Nature Conservancy 1997).

The continuing implementation of the project also creates an increased risk of habitat degradation and impacts to individual vireos and flycatchers resulting from the dispersal of environmental contaminants. The storage, use, and potential spillage of herbicides, oil, fuel, petroleum products, solvents, in an area that is within a designated flood control basin and water conservation project areas occupied by the vireo and the flycatcher would appear to be problematical. The unmitigated dispersal of environmental contaminants (e.g., crude oil) as result of the implementation of the project during spring and summer months could have catastrophic consequences to breeding vireos, flycatchers, and their designated critical habitats.

During the course of the current study of the vireos and flycatchers within the Prado Basin and environs, several apparently well-incubated vireo clutches failed to produce a single viable nestling (e.g., Hays 1989). Entire clutches failed to hatch in three cases and all vireo nestling young failed to survive in two other instances during the early part of the 1988 breeding season. In 1994, four full clutches failed to hatch. One apparently infertile female is thought to be responsible for 2 of these clutches. In 1997, a nestling with a deformed upper mandible was observed in a nest. Such abnormalities are often the expressed result of exposure to environmental contaminants.

Preliminary investigations by office personnel have resulted in the discovery of abnormalities in invertebrate specimens that were collected within the Prado Basin that often are attributable to toxic levels of various pollutants. Specifically, crayfish (*Procambius clarkii*) with abnormal appendages have been found and several Chinese river clam (*Corbicula fluminea*) specimens exhibited shell ring patterns that indicated irregular growth (Service, unpublished data). The Service concluded also that several age classes of Chinese river clams appeared to be missing from the riverine habitats that were surveyed. This phenomenon may be the result of episodic, lethal exposures to toxic substances. Most importantly, preliminary data derived from the toxicological testing of specimen, abandoned vireo eggs from the Prado Basin by the Service have revealed the presence of DDE (a metabolite of DDT) in concentrations that could cause eggshell thinning (Service, unpublished data).

Given all available information on the subject, the bioaccumulation of toxic substances may have caused, or contributed to, observed vireo reproductive failures. Because of the potential toxic effects of all herbicides, pesticides, crude oil, aircraft and automobile fuels, and noxious chemicals that are normally associated with operations and maintenance activities, these environmental contaminants cannot be allowed to disperse within the Basin.

Given the scope and extents of the above-described potential project-related impacts, we conclude that project-induced habitat destruction and alteration in the project area is likely to significantly adversely affect the vireo, flycatcher, and their designated critical habitats. We further conclude that project-related activities, as described, could result in the further fragmentation and destruction of vireo and flycatcher habitat or otherwise significantly impact the species and their critical habitats. A composite of all such impacts likely could jeopardize the vireo and adversely modify critical habitat for the vireo and flycatcher in the absence of substantial impact avoidance, minimization, and compensation measures proposed by the project proponent.

Although management efforts evidently have resulted in significant increases in local vireo recruitment and population size (Pike and Hays 1999) and progress towards the eradication of giant reed in the Prado Basin and Santa Ana River Watershed as a whole, we do not believe that the Prado Basin population has entirely recovered or that it would continue to prosper in the absence of effective management, which largely depends on the detection and removal of exotic biota from vireo and flycatcher habitat and the elimination of other threats to the species. For instance, given the relevant data analysis regarding impacts of cowbird parasitism on the vireo and flycatcher and the efficacy of cowbird management programs (e.g., Pitelka and Koestner 1942; Mumford 1952; Barlow 1962; Salata 1983a,b, 1984, 1986, 1987a,b; Jones 1985; U.S. Fish and Wildlife Service 1986, U.S. Fish and Wildlife Service 1995, U.S. Fish and Wildlife Service 1998), it seems reasonable to conclude that the Prado Basin population of vireos would have been subjected to much higher rates of cowbird parasitism and suffered greater rates of reproductive failure in 1986 (Hays 1986), 1987 (Hays 1987), 1988 (Hays 1988), 1989 (Hays 1989), 1990 (Hays and Corey 1991), 1991 (Pike and Hays 1992), 1992 (The Nature Conservancy 1993a), 1993 (The Nature Conservancy 1993b), 1994(The Nature Conservancy 1994), 1995 (The Nature Conservancy 1995), 1996 (The Nature Conservancy 1996), 1997 (The Nature Conservancy 1997), 1998 (Pike and Hays 1998) and 1999 (Pike and Hays 1999), in the absence of an effective, proactive cowbird management program. Recent, published treatises on the efficacy of cowbird trapping programs as part of comprehensive vireo and flycatcher management efforts corroborate this fundamental assumption (i.e, Kus 1999, Whitfield and Sogge 1999, and Whitfield *et al.* 1999).

Although approximately 228 acres of vireo habitat may be eventually destroyed or degraded as a result of the project and 400 acres of vireo critical habitat may be affected, we anticipate that the amount of vireo (and flycatcher) habitat will eventually increase in the Prado Basin in light of OCWD's past and present commitment to replace habitat values and proposal to manage their property to maximize resource (including riparian woodland) values. The OCWD has already replaced approximately 100 acres of vireo habitat and is committed to continue restoring (and allow the restoration of) floodplains and wetland habitats on OCWD lands. Based on additional compensation offered by the OCWD, we expect that an additional 130 acres of vireo and flycatcher habitat can be replaced within the next 5 to 10 years. Any habitat created above and beyond this amount on the remainder of OCWD or Corps lands would result in a net increase in habitat extent. Given the current and proposed size of the compensation fund endowments and the additional commitment of OWCD to replace substantial quantities of mulefat on OCWD and Corps lands, this net increase is fully expected within the next 10 to15 years.

Perhaps more importantly, the endowment established with proposed funding will permit the perpetual management of restored riparian habitats and habitats elsewhere in the Santa Ana River Watershed. As is reflected in the "Description of the Proposed Action" (above), this management will largely consist of exotic plant control. Without such control measures, giant reed and other exotic species likely would eventually degrade or destroy significant portions of the native riparian habitats present in the Basin and adjacent watershed now and in the future. Upstream reaches of the Santa Ana River are presently heavily infested with giant reed, a species that creates fire and flood hazards wherever it occurs. This species, which successfully invades (and ultimately replaces) native riparian habitats, has no known wildlife habitat value.

For these reasons, the Corps, Service, and OCWD have identified giant reed as a major threat to the ecosystem of not only Prado Basin but the entire Santa Ana River Watershed. Recently, the agencies have recognized the value of working cooperatively in pursuing a more holistic approach in managing the various resources in Prado Basin and have recognized that a dedicated giant reed removal program will ultimately prove to be essential in conserving and sustaining local wetland and riparian woodland habitats and thus enhance Prado Basin and Santa Ana River Watershed ecosystems occupied by the vireo, flycatcher, and a large array of other sensitive plant and animal species.

Fortunately, the Riverside County Parks and Open Space District and a multiagency task force led by the resource conservation districts of Riverside and San Bernardino Counties and the OCWD have begun the process of combating the spread of giant reed within the Santa Ana River watershed. As is noted previously, the OCWD has made substantial contributions to the Santa Ana River Conservation Fund, which funds exotic plant control projects administered by the aforementioned Resource Conservation Districts. In addition, the OCWD has committed to use their own personnel to eradicate giant reed on OCWD properties, selectively revegetate portions of the Prado Basin, and fund a resource conservation district employee charged with overseeing giant reed eradication and revegetation efforts in the watershed as a whole.

Secondly, OCWD's commitments to fund the equivalent of four full-time seasonal employees to participate in the current vireo and flycatcher monitoring and management effort and continue the cowbird eradication efforts year-round will almost certainly maximize the potential for maximum reproductivity and population growth for both species. This recent implementation of this impact minimization measure has effectively doubled the person-hours dedicated to management efforts each year (see Pike and Hays 1999). Based on the results and analyses of 14 years of local vireo and flycatcher management efforts within the Basin and elsewhere within the range of the these two species, we fully expect that the numbers of vireos and, perhaps, flycatchers will increase as a direct result of increased management efforts (e.g., Salata 1983a,b 1984, 1986, 1987a,b; Hays 1986; Hays 1987, 1988, 1989, 1990; Hays and Corey 1991; Pike and Hays 1992; The Nature Conservancy 1993a,b; The Nature Conservancy 1994; The Nature Conservancy 1995; Pike and Hays 1998, 1999). In any case, past management efforts in the Prado Basin, which have been funded largely by the OCWD, apparently have been largely responsible for an increase in the vireo population from 19 pairs in 1986 to 224 pairs in 1999 and for potentially preventing the otherwise likely extirpation of the local flycatcher population.

In summary, although direct and indirect impacts to the vireo and designated critical habitats are substantial, the magnitude and nature of the impact avoidance and compensation measures that will be implemented and minor changes in the projects that have been invoked by the Service pursuant to the Federal regulations at 50 CFR §402.14(I)(2) are expected to prevent impacts that may otherwise threaten the survival and recovery of the vireo (and flycatcher) and irreparably damage those species Prado Basin habitats.

Because we cannot assess with any certainty the relative impacts of the repeated storage of water associated with future, as yet unknown, inflows, the present analysis assumes only that the average yearly precipitation during the life of the currently proposed project will not exceed the average for the past 14-year study period and that wastewater discharges above the Prado Basin will not will significantly increase base flows beyond the present average. The present analysis does not, for instance, include considerations of: (1) future, as yet unknown, water control operations at the Seven Oaks Dam; (2) any potential increases in base flow resulting from petitions by the project proponent to import additional water into the project area, including a proposal to "appropriate up to 800 cfs for storage and up to 146,800 afa by storage in Prado Dam" and additional locations in Orange County (State Water Resources Control Board, *in litt.*, 1999); or (3) wastewater effluent base flows above the recently-observed average of 260 cfs (Corps, unpublished data).

Although rising groundwater and watershed runoff inflows contribute, treated wastewater from the sewage treatment plants upstream currently is a significant input source and may eventually exceed 450 cfs (EIS). In fact, wastewater effluent discharged above the Prado Basin in the Santa Ana River watershed increased 39 percent from 1986-1987 (110,780 acre-feet) to 1996-1997 (154, 290 acre-feet) (Santa Ana River Watermaster 1997). However, recent proposals to reclaim wastewater now discharged by the San Bernardino/Colton RIX facility and the Inland Empire Utilities District into the Santa Ana River watershed above the Prado Dam render as speculative future predictions regarding future base flows into the Prado Basin. Additional direct, indirect, or interrelated or interconnected effects of the action, as yet unknown, must necessarily be addressed if and when they become known or apparent per the regulations at 50 CFR § 402.

CUMULATIVE EFFECTS

Cumulative effects are those impacts of future non-Federal (State, local government, or private) activities on endangered or threatened species or critical habitat that are reasonably certain to occur during the course of the Federal activity subject to consultation. The action areas of several proposed Federal (e.g., Corps, Bureau of Land Management, Bureau of Reclamation) projects include, or overlap with, the action area of the project considered herein. In addition, the Corps owns the majority of land behind Prado Basin, much of which is leased out for recreation use. However, Federal projects and land use authorizations that affect listed species within the foreseeable future elicit direct Federal involvement through Federal regulatory processes. Moreover, the two species considered herein largely and routinely utilize habitats that are within jurisdictional wetlands or waters of the United States, under the jurisdiction of the Corps and EPA. Future Federal actions are subject to the consultation requirements established in section 7 of the Act and the implementing regulations pertaining thereto and, therefore, are not considered cumulative in the proposed project.

Other projects without a demonstrated federal nexus could result in significant cumulative effects to the species or its designated critical habitat. However, section 9 of the Act prohibits the take of the vireo and flycatcher. The development of a habitat conservation plan (HCP) is required for the issuance of an incidental take permit that would allow vireos to be taken outside of the conservation areas established pursuant to the terms and conditions outlined in an acceptable HCP and its accompanying implementing agreement. Thus far, the Service has not approved any such HCP within the project action area and, therefore, has not issued an incidental take permit for the vireo or flycatcher. In the absence of illegal take or the unauthorized destruction of protected wetlands or waters of the United States or riparian vegetations protected by State law, no further loss of occupied habitat would be anticipated unless and until a permit is issued pursuant to section 10(a) of the Act and its implementing regulations.

Given the history of land use in the project action area, other authorized and unauthorized land use activities may result in direct, cumulative effects to the species. Within the last few years, we have documented at least 30 instances where clearing or filling of riparian habitat has occurred in Orange and western Riverside counties. Most recently, a Corps lessee mowed, in 1998 and 1999, less than 2 acres of riparian habitat suitable for the vireo and flycatcher within the basin adjacent to Chino Creek. In addition, Corps operations and maintenance work completed in late 1998 resulted in the clearing of less than one acre of riparian habitat suitable for the vireo and flycatcher (see BA). The Corps Operation Branch is working with this office to address these issues. Also, in the fall of 1999, approximately 2 acres of critical habitat was destroyed or degraded in conjunction with the construction of roads, apparently on OCWD property, in the western portion of the Basin. The Corps Regulatory Branch and Service are working to resolve this additional, apparently unauthorized deposition of fill involving concomitant impacts to occupied vireo habitat.

In addition, infrastructure repairs following storm events and other projects within the Prado Basin and adjacent Santa Ana River often have not been permitted by Federal and State regulatory agencies, or the permitting has occurred after the fact. Although some apparently unauthorized destructions of habitat have resulted in enforcement actions by the Corps and EPA, many unauthorized activities go unresolved. These types of activities all have the potential to impact the vireo and the flycatcher directly through mortality or indirectly due to loss or degradation of habitat.

Although the unauthorized destruction of riparian habitat within the Prado Basin seems to be slowing, overall, in recent years, the unauthorized destruction of this habitat type likely will continue in the foreseeable future within the ranges of the two considered species. Some of this habitat apparently could be utilized by the vireo and flycatcher for nesting and foraging. Nonetheless, the Santa Ana River Conservation Trust Fund is intended to manage sensitive biological resources from a watershed perspective, thus lessening the likelihood of future cumulative impacts (BA).

CONCLUSION

After reviewing the current status of the vireo and flycatcher, the environmental baseline for the action area, the effects of the proposed projects and the cumulative effects, and the commitment of the Corps and project proponent to prevent or minimize the destruction of occupied vireo and flycatcher habitat to the extent possible, it is our biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the vireo or flycatcher. Although the proposed action will alter designated critical habitats for both species, we conclude, on the basis of project-related impact avoidance, minimization, and conservation measures, that such alteration will not appreciably diminish the value of these critical habitats for the survival and recovery of both listed species and, thus, the proposed action will not result in the destruction or adverse modification of critical habitat for the vireo and flycatcher. We base this conclusion on the following reasons:

1) Although the number of vireos that may be harmed or harassed as a result of the project is anticipated to be large relative to the total population numbers remaining in the Prado Basin, substantial measures have been, and will be taken by the project proponent to minimize, overall, potential impacts to the vireo and flycatcher and provide for the recovery of both species.

2) The direct and indirect impacts of this proposed action to the vireo and flycatcher populations have been minimized through project conservation features.

3) Although the primary constituent elements supporting vireo and flycatcher are present within each project area and as much as 400 acres of vireo critical habitat may be impacted or altered, on average, over the life of the proposed project as conditioned herein, implementation of the proposed action, along with the proposed avoidance, minimization, and conservation measures, likely will not result in the destruction or adverse modification of designated critical habitat for either species by appreciably diminishing the value of these critical habitats for both the survival and recovery over time. Substantial measures have been taken, and will be taken, to sustain the quantity and quality of vireo and flycatcher critical habitat within the project action area and remainder of designated critical habitat within the Santa Ana River watershed.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps so that they become binding conditions of any grant, permit, or agreement issued to the OCWD, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the OCWD to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Corps and/or OCWD must report the progress of the action and its impact on the species to this office as specified in the incidental take statement. (50 CFR §402.14(i)(3))

AMOUNT OR EXTENT OF TAKE

We anticipate that the following amounts and types of take could occur as a result of the proposed action and hereby authorized over the life of the project:

1. The harassment of 10 vireos that may be indirectly impacted (e.g., depredated, parasitized, impacted by noise) as a result of the implementation of the project, and
2. The harm of 90 pairs of vireos or 180 individual vireos over the life of the project due to the periodic, temporary flooding, destruction or degradation of occupied habitat.
3. Zero take of the flycatcher is anticipated.

The death or harm of embryos in vireo and flycatcher eggs, the death or harm of vireo and flycatcher nestling or fledgling young, and the death or harm of juvenile and adult vireos and flycatchers is not expected as a result of the implementation of the proposed project and is, therefore, not authorized.

EFFECT OF THE TAKE

In the accompanying biological opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

We believe the following reasonable and prudent measures are necessary and appropriate to minimize take of vireos and flycatchers:

1) Take of flycatchers shall be avoided and take of vireos shall be minimized through the implementation of best management practices, strict adherence to the project description including all proposed conservation features, compliance with all wildlife protection statutes to minimize direct and indirect impacts to the species, and the adherence to strictly-delineated project boundaries.

2) The degradation or destruction of vireo and flycatcher critical habitats in the project action area will be avoided or minimized by the conservation, to the extent possible, of existing riparian and wetland habitats in the project action area, the prevention of project-related impacts to critical habitat elements in the project action area, the proposed replacement of project-related losses of habitat values, and the conservation of vireo critical habitat in the Prado Basin and remainder of the Santa Ana River watershed.

TERMS AND CONDITIONS

To be exempt from the prohibitions of section 9 of the Act, the Corps and OCWD must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

1.1 The Corps and the OCWD shall implement the project exactly as described in the sections entitled "Description of the Proposed Action" and "Conservation Measures" (above), and shall, in addition, implement all impact avoidance and minimization measures described above in the "Conservation Measures" section, biological assessment, and all other relevant letters and documents. The Corps or OCWD or their agents shall ensure that these measures are executed for the life of the project. In particular, the Corps and OCWD shall ensure that vireo and flycatcher monitoring and management efforts shall meet or exceed 1998 levels for the life of the project.

1.2 The Corps, OCWD, or their agents shall obtain all necessary local, State, and Federal permits to implement the project. In particular, the Corps and OCWD must obtain any necessary permits from California Department of Fish and Game. The incidental take authorization in this biological opinion is not in effect in the absence of any or all such permits.

1.3 If, in the event that raising the water conservation pool to elevation 505 feet threatens existing occupied nests of vireos or flycatchers, the Corps, OCWD, and the Service shall dedicate the necessary personnel to physically relocate nests or take other steps as necessary to prevent the unauthorized take of vireos and flycatchers.

1.4 The Corps and OCWD or their agents and lessees shall not attempt to implement the project if such implementation could result in the dispersal of crude oil, petroleum products, or any other toxic substance or hazardous material into vireo or flycatcher habitats. To this end, the Corps, OCWD, or their agents shall implement the project if and only if no crude oil, petroleum products, or any other toxic substance or hazardous material is detected that would be inundated or dispersed by water in the project area. No equipment that is determined to be leaking fuel or other fluids shall be utilized in the project area. No mechanized equipment shall be used within 10 feet of any pipelines or other infrastructure transporting or containing crude oil or petroleum; or petroleum products on Corps-owned lands. The Corps, OCWD, or their agents shall be responsible for inspecting the project area to insure that habitat and habitat restoration areas are free from petroleum products and contaminant spills prior to, and during, the implementation of the project.

1.5 The Corps, OCWD, or their agents shall, pursuant to the regulations implementing section 7 of the Act; (1) monitor pre-project and post-project conditions, and (2) report yearly on the extent of critical habitat altered and the number of vireos and flycatchers harmed or harassed as a direct or indirect result of the implementation or enabling of project-related activities. This report is due on December 15 of each calendar year. The report shall contain an introduction and methods, results, and discussion sections consistent with the scientific method.

2.1 The Corps, OCWD, or their agents shall create proposed replacement habitat pursuant to the following requirements:

a. Giant reed eradication and habitat restoration areas above 505 feet in elevation that are specifically and uniquely authorized for that purpose by the OCWD or Corps shall be identified prior to the initiation of the water conservation project.

b. Giant reed eradication and revegetation and restoration efforts, including appropriate monitoring and maintenance efforts, shall commence immediately upon the initiation of any project feature that results in the destruction or degradation of critical habitat and shall continue until the replacement habitat is deemed to be "acceptable." Replacement riparian habitat shall be deemed acceptable habitat if: (1) the habitat is occupied by a breeding pair of vireos or flycatchers; or (2) the habitat is occupied by breeding yellow-breasted chats (*Icteria virens*); or (3) the habitat is demonstrated, to the satisfaction of the Corps and Service, to be not significantly different statistically in terms of structure and composition from Prado Basin vireo-occupied habitat or willow woodland habitats with understory as characterized by Zembal *et al.* (1985) and Zembal (1986); or (4) the Corps and Service biologists concur that the habitat apparently has the appropriate "niche-gestalt" (James 1971) characteristics and is suitable for occupation by breeding pairs of vireos or flycatchers. Once any approved OCWD restoration project is proposed to be complete, the Service and the Corps must be notified in writing;

c. All revegetation efforts shall be conducted according to a plant palette subject to the approval of the Service and Corps.

d. To avoid conflicts with nesting vireos (and, possibly, flycatchers), the OCWD shall conduct giant reed eradication and restoration and revegetation activities only before March 15 or after September 15 of each calendar year unless specifically authorized to do otherwise by the Corps and Service. Although in some cases weeding and other restoration site maintenance activities will be necessary and prudent during the vireo and flycatcher breeding seasons, authorizations must be obtained in advance to preclude the unauthorized take of listed species, which is increasingly likely as the restoration habitat matures.

e. The OCWD or its agents or lessees shall develop methods and measures to protect created and restored habitat areas from attracting or propagating exotic predators (e.g., rats, *Rattus* sp.; bullfrogs, *Rana catesbiana*) and alien plants (e.g., giant reed). To this end, the OCWD or its agents or lessees shall ensure that trash, other dumped debris, abandoned vehicles, equipment, or other potential exotic rodent shelter is removed from habitat areas, habitat restoration areas, and their environs.

2.2 The Corps, OCWD, or their agents or lessees shall not disturb or destroy existing vireo habitat including willow riparian, riparian scrub, or marsh habitats during the implementation of the project except as specifically permitted pursuant to this biological opinion. The Corps, OCWD, and their agents or permittees shall immediately replace or restore, any and all critical habitat altered as a direct or indirect result of any dam operation activities that are not consistent with the project description described herein. All habitat that is destroyed/ degraded that is not in the identified project footprint shall be disclosed immediately to the Service for possible reinitiation of consultation.

2.3 The Corps or its agents or lessees shall remove, under the supervision of the Service, all invasive, alien vegetation (e.g., giant reed, castor bean, tamarisk) to the extent practicable and feasible, from the project areas and habitat restoration areas for the life of the projects.

2.4 The Corps and its agents shall ensure that all habitat, conservation or habitat restoration areas are not used for any purpose that would change or otherwise interfere with their value as wildlife habitat. To this end, the Corps or its agents shall restrict land uses in the project area to those stated in the Corps permit application for the life of the project. Any deviations from stated land uses shall be disclosed and coordinated with the Corps and the Service.

2.5 The Corps, OCWD, or their agents or lessees shall not erect any permanent or temporary structure in the created habitat areas nor light these areas without the expressed consent of the and the Corps and Service.

2.6 The Corps, OCWD, or their agents or lessees shall provide access to the project area (including all restoration areas) and provide, upon request, keys to any locks placed on fences, steel ropes, or other structures in or adjacent to the habitat and habitat restoration areas and their environs to the Service, Corps, and other regulatory agency personnel to facilitate site inspections and the management and monitoring of protected and listed species.

2.7 All employees, agents, lessees, or sublessees of the Corps and OCWD involved in the implementation of the project, including associated giant reed eradication and revegetation efforts shall be: a) informed of the sensitivity of the habitat and restoration areas, and the associated federally listed species; and b) instructed as to the content of the this biological opinion, and special permit conditions or terms and conditions delineated herein.

2.8 The Corps and OCWD shall ensure that the Service retains the right to access and inspect the project site and restoration/enhancement areas for compliance with the proposed project description and with the terms and conditions of this biological opinion.

2.9 Unless specified otherwise above, the implementation and execution of all preceding terms and conditions shall begin immediately upon the issuance of this biological opinion and shall continue, in earnest, for the life the project and until all compensation measures have been fully implemented and executed.

2.10 All preceding terms and conditions shall be entered as a special permit condition or conditions for any and all Corps permits or other authorizations pertaining to the proposed project.

2.11 As the Federal action agency, the Corps is ultimately responsible for the implementation of all preceding terms and conditions in the event of the financial or institutional incapacity of the OCWD or their agents to perform them.

We believe that no more than 180 vireos will be taken in the form of harm and 10 vireos in the form of harassment, and zero flycatchers will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. We will not refer the incidental take of the any federally listed, migratory bird, including the vireo and flycatcher, for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein. If, during the course of the action, this level of incidental take is exceeded or if a vireo or flycatcher is taken in a manner not authorized above, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. In addition, the Corps and OCWD or their agents must cease the activity resulting in take, and the Corps and/or the OCWD or their agents shall provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Disposition of Sick, Injured, or Dead Specimens

This office is to be notified within 3 working days should any endangered or threatened species be found dead or injured as a direct or indirect result of the implementation of this project. Notification must include the date, time, and location of the carcass, and any other pertinent information. Dead animals should be marked in an appropriate manner, photographed, and left on-site. Injured animals should be transported to a qualified veterinarian. Should any treated animals survive, this office should be contacted regarding the final disposition of the animals. The Service contact person is Mr. Hays, who may be contacted at the letterhead address or at (760) 431-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" has been defined as Service suggestions regarding discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information. The recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of the Federal agency's section 7(a)(1) responsibility for these species.

Over the course of a 14-year study and management effort in the Prado Basin involving the Corps, Nature Conservancy and their contractors, OCWD personnel and office staff and volunteers, subpopulations of vireos, flycatchers and many other sensitive animal and plant species were subjected to risks and pressures that individually or collectively could potentially compromise the reproductive success of these species or otherwise jeopardize the survival of constituent populations, subpopulations, or individual organisms. Therefore, because the vireo population has increased from 19 to 224 confirmed pairs over the course of the study period, this species likely is a worthwhile management subject and a good candidate for recovery. Although current management efforts evidently have resulted in substantial increases in local vireo recruitment and population size, the Prado Basin population has not entirely recovered nor would the population continue to prosper in the absence of effective management. Many other vireo populations in the state are either declining, maintaining, or moderately increasing. Only the Camp Pendleton population has demonstrated similar, sustained, significant increases in population size since the vireo was federally listed in 1986. Also, the Prado Basin is one of only 6 locales in California that supports permanent populations of the flycatcher, which is apparently currently critically endangered.

Therefore, to ensure the recovery of the vireo and flycatcher and other sensitive or declining species in the Prado Basin and environs, we recommend the implementation or continuation of the following management and conservation practices in the Prado Basin as recommended by TNC (1997) and Pike and Hays (1999):

3. We recommend the Corps seek to restore and protect all habitats consisting of native plant communities and natural, physical features in the Prado Basin. During the course of the past 14 years, habitat within known vireo home ranges was destroyed or degraded as a result of livestock grazing, off-road vehicle activity, stream diversions, documented, apparently unauthorized dredge and fill operations, incursions of heavy equipment (including bulldozers, mowing machines, and road graders), repeated fires, oil spills, and vandalism. All such activities should be strictly prohibited, curtailed to the extent possible, or appropriately compensated. Past losses of habitat that can be traced to the responsible party or parties should be appropriately prosecuted or remediated. Because vireo and flycatcher habitat has been only rarely created, however, the avoidance of impacts to existing habitat is of paramount importance.

4. We recommend the Corps seek to control or remove all invasive/exotic biota from riparian habitats in the Prado Basin. The existing cowbird management program should be continued indefinitely and expanded to maximize the reproductive success of the vireo, flycatcher and many other sensitive avian species, and that invasive, exotic plants such as giant reed and castor bean be eliminated or controlled to the extent possible. Although cowbird trapping apparently is the single most effective means to initiate and sustain the recovery of a number of sensitive avian species, the large-scale control of noxious plants should be continued and expanded if riparian habitats are to continue to provide the elements necessary to accommodate the vireo, flycatcher, and a large variety of other sensitive animal taxa.

Fortunately, the prospects for long-term cowbird trapping, habitat creation and restoration, and vireo and flycatcher management seem to be assured because of current and projected compensation obligations that result from ongoing and planned projects within the Prado Basin. In addition, it is encouraging to note that a multi-agency task forces have begun a giant reed eradication in the basin and upstream reaches of the Santa Ana River in Riverside and San Bernardino counties. The Corps should continue to participate in, and expand, existing programs to adequately conserve the sensitive fauna (and flora) with the Prado Basin and environs.

5. We recommend the Corps seek to restrict human presence and activities in vireo and flycatcher home ranges and environs. During the course of the present study, vireos often react strongly to the close approach of humans, particularly when nestling or fledgling young are also present. Moreover, the available data (e.g., Salata 1987b) suggest that unnecessary human disturbances may impact vireo nesting success. Predators and cowbirds may both be capable of homing in on agitated vireos and subsequently destroy nearby nests. In addition, much of the Prado Basin continues to be used for illegal hunting and recreational shooting. Spent cartridges, freshly-broken skeet, and the carcasses of animals that had obviously been shot were found throughout most of the Prado Basin in 1986 and, to lesser extents, each year from 1987 to 1999. Obviously target shooting in or near habitats occupied by vireos places individual birds (or their breeding attempts) in jeopardy. Moreover, the presence of humans at or near cowbird traps appears to compromise the success of trapping efforts. "No trespassing" signs near occupied vireo habitats near Temescal Creek and the South Basin locale were apparently responsible for a reduction in the foot and vehicular traffic within wetland habitats at those locales in 1990, 1991, 1992, and 1993, but further measures to restrict or curtail unauthorized or unauthorized or illegal human activities (including paint ball games, illegal hunting and the destruction or theft of traps) appear to be in order throughout the Prado Basin and environs. As was reported above, cowbird traps have been repeatedly vandalized in recent years in scattered locales throughout the Prado Basin.

Accordingly, we recommend the Corps implement the following specific conservation measures:

a) Erect a gate where Butterfield Drive becomes Clearwater Drive within the City of Corona lease. The purpose of this gate would be to bar access to a dirt parking area that has become the site of trash dumping, the abandonment of automobiles, and other apparently illicit activities. We further recommend that a fence be constructed on the remainder of Clearwater Lane to prevent vehicles from traversing the agricultural field and thus circumventing the existing gate.

b) Erect fencing or concrete or equivalent barriers around or below the highway turnouts along State Route 71 adjacent to lower Chino Creek vireo habitat. These turnouts are commonly used for trash-dumping, including hundreds of automobile tires, and as unauthorized access points for human and automobile traffic. In 1996, two cowbird traps on Lower Chino Creek were closed after being vandalized by persons who apparently had driven into the Pardo Basin from the northernmost of the three State Route 71 turnouts.

c) Post "no trespassing" signs every 50 meters around the perimeter of key vireo and flycatcher breeding areas. Particular areas of concern are the turnouts along State Route 71 (see above), the northern border of vireo habitat along lower Chino Creek, Clearwater Lane and Rincon Street in Corona, and along the forest edge adjacent to Prado Regional Park in Chino. "Critical wildlife habitat" signs recently posted by the OCWD appear to be effective and are recommended for use in conjunction with "no trespassing" designations. Although unlikely to dissuade all potential trespassers, these signs would remove any ambiguity that exists as to where access is restricted or prohibited.

In order for that office be kept informed of actions that either minimize or avoid adverse effects or that benefit listed species or their habitats, we request notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the Prado Basin Water Conservation and Dam Operations Project on OCWD and Corps-owned lands in the Prado Basin, Riverside County, California. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation. As required by 50 CFR § 402.16, reinitiation of formal consultation is required if the action is significantly modified in a manner not discussed above, if new information becomes available on listed species or impacts to listed species, or if the incidental take limit is exceeded.

We would appreciate notification of your final decision on this matter. Any questions or comments should be directed to Loren Hays of my staff at (760) 431-9440.

Sincerely,

Jim A. Bartel
Assistant Field Supervisor

Enclosures

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Table 1. Maximum permitted water conservation pool elevation versus required acreages of vireo and wildlife habitat from 494 to 505 feet dependent.

Water conservation elevation	Required acreage of vireo habitat	Required acreage of wildlife habitat
495	50	86
496	67	109
497	83	133
498	100	156
499	116	180
500	133	203
501	152	218
502	171	233
503	190	248
504	209	263
505	228	278

Table 2. Dedicated lands for vireo and wildlife habitat restoration.

Required for elevation 505 feet	Vireo habitat (228 acres)	Wildlife habitat (278 acres)
CH-1, Chino Creek		34
CH-2, Chino Creek		90
PR-1, Small Pheasant Field	14	
PR-2 Southern Pheasant Field	65	
PR-3 Northern Pheasant Field	124	
PR-5 Southern Pheasant Field	32	
AR 1&2 *Arundo* Removal Areas		200
Total Required	228	278
Total Completed	235	324

Source: Corps Biological Assessment (August 1999)

Figure 1. Project Area Map

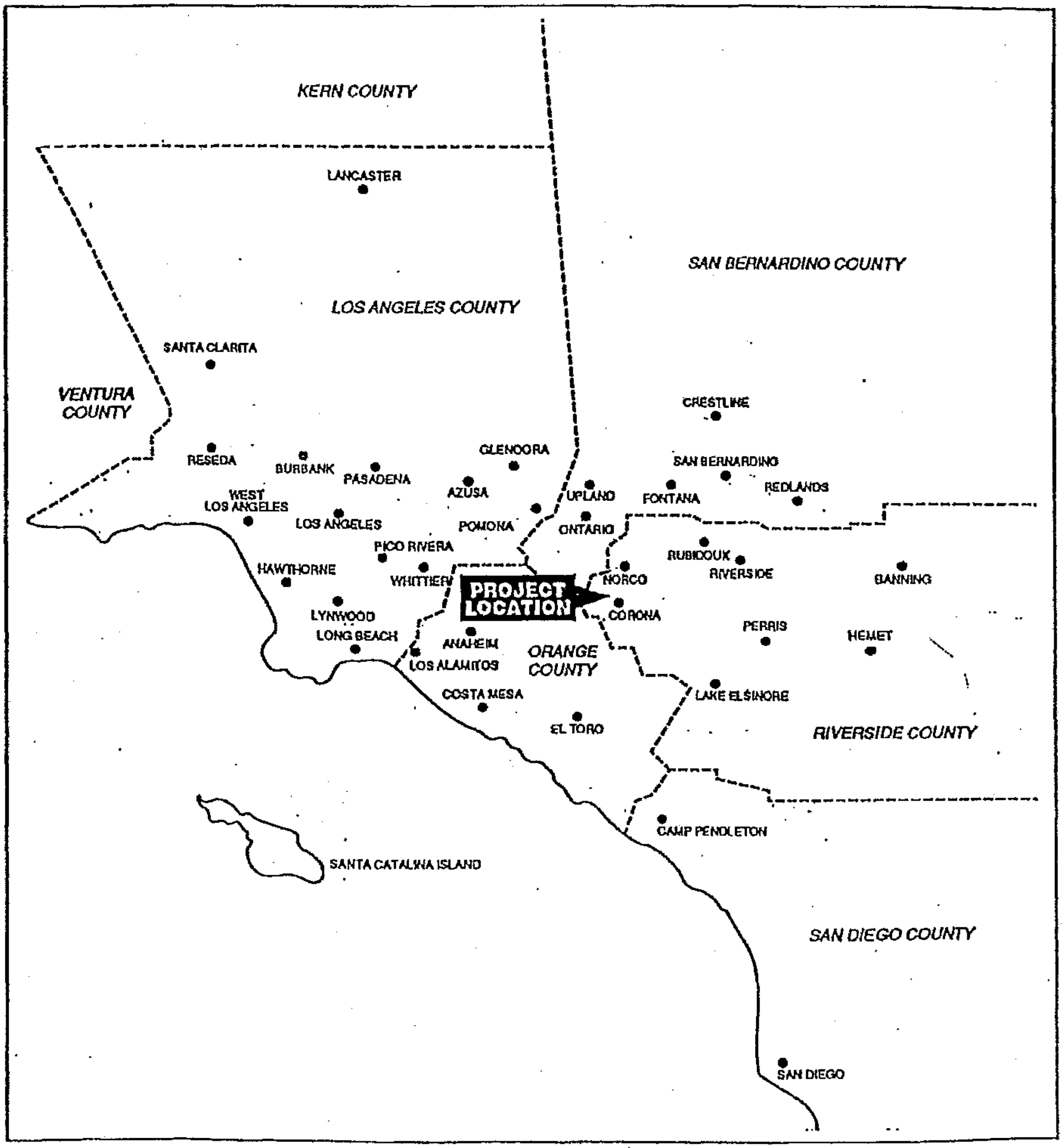

Figure 2. Project Vicinity Map

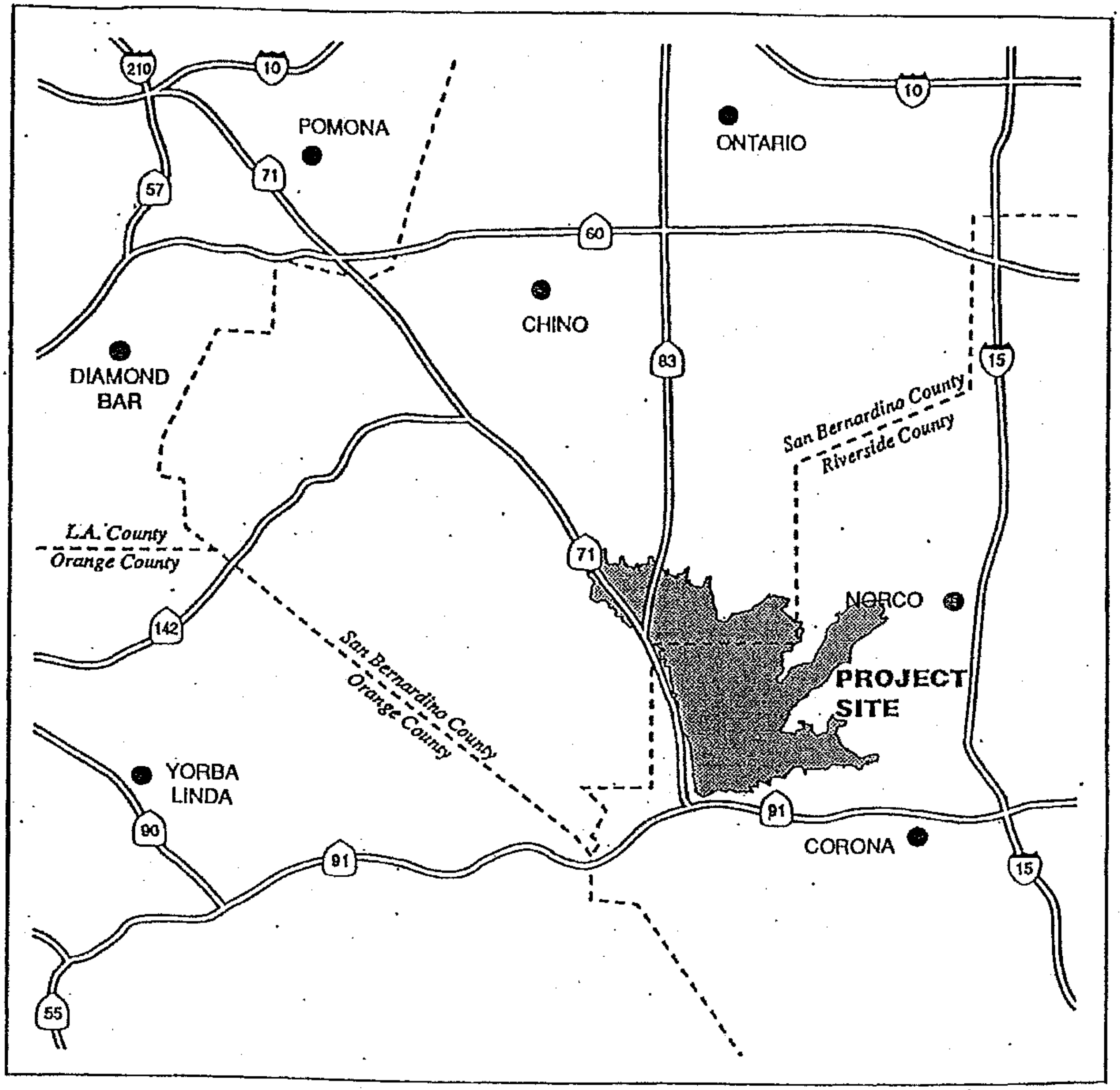

EXHIBIT C

Ongoing Obligations Under 2002 MOA

- SAWA is solely responsible for obligations under the "Santa Ana River Watershed Trust Fund for Arundo Eradication and Habitat Enhancement In-Lieu Fee Mitigation Program" (contained in the 2002 MOA). SAWA has taken over responsibility for the program and particularly for OCWD's responsibilities in Section II (A through D). SAWA is renewing the program on its own. OCWD as an organization will not have direct obligations under the new program.

- OCWD remains responsible for providing one full-time employee, with funding for said employee provided to SAWA by OCWD, to assist with the vireo management program in the Prado Basin and for supporting the SAWA field biologist position. (See 2000 USFWS Biological Opinion.)

- SAWA remains responsible for providing one full-time employee to assist with the vireo management program in the Prado Basin, with funding for said employee provided by the OCWD account for this purpose. (See 2000 USFWS Biological Opinion.)

- SAWA and OCWD remain responsible for the continuing development of public outreach materials and educational programs on exotic plant control and native wildlife directed to the public throughout the Santa Ana River Watershed. (See 2000 USFWS Biological Opinion.)

- OCWD remains solely responsible for operating and maintaining four cowbird traps in the Prado Basin during each breeding season. (See 2000 USFWS Biological Opinion.)

- OCWD remains solely responsible for maintaining a database that includes areas of infestation, current projects, sensitive species and native vegetation recovery within the Prado Basin. (See 2000 USFWS Biological Opinion.)

- SAWA and OCWD remain responsible for continuing development of a GIS database to track and monitor treatment projects, including biological monitoring in the Santa Ana Watershed. (See 2000 USFWS Biological Opinion.)

- SAWA and OCWD remain responsible for continuing to work on a watershed team structure that will coordinate and implement tasks and manage funds for those tasks in the future. (See 2000 USFWS Biological Opinion.)

- OCWD remains solely responsible for submitting an annual mitigation report summarizing restoration progress and wildlife management efforts to the US Fish and Wildlife Service and the US Army Corps of Engineers for the Prado Basin pursuant to OCWD's 1994 and 2000 Cooperative Agreements with these agencies.

- OCWD remains solely responsible for planting 10,000 native plantings per year in the Prado Basin.
- OCWD and SAWA have completed first-time treatment on all upper watershed tributaries and mainstem Santa Ana River downstream to Riverside County Parks and Open Space District lands, but are still both responsible for monitoring and maintenance. (See 2000 Biological Opinion.)