



IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE

FI-165

JUL 30 1997

1

**Sacramento Fish and Wildlife Office
3310 El Camino Avenue, Suite 130
Sacramento, California 95821-6340**

July 28, 1997

Mr. Lester S. Snow
Executive Director
CALFED Bay-Delta Program
1416 Ninth Street, Suite 1155
Sacramento, California 95814

Subject: San Francisco Estuary Institutes's Category III Exotic Species Control Proposals

Dear Mr. Snow:

The Sacramento Fish and Wildlife Service Office supports the eight proposals submitted by the San Francisco Estuary Institute for exotic species research and control in the Sacramento-San Joaquin Bay-Delta estuary. These eight projects fit within the recommended actions in the Delta Native Fishes Recovery Plan and will help recover listed species in the estuary.

The Service recommends funding of these projects. Such projects are consistent with our mission of preserving fish and wildlife and recovering natural ecosystems and watersheds.

If you have any questions or concerns about the above, contact Robert Pine at (916) 979-2725.

Sincerely,

Wayne S. White
Field Supervisor

CC: San Francisco Estuary Institute, Richmond, California

a. **Project Title:** Control of Invasive-Introduced Plants in Wetlands and Watersheds

Applicant's Name: The San Francisco Estuary Institute.

Principal Investigators: Dr. Joshua N. Collins; Dr. Andrew N. Cohen.

97 JUL 28 PM 2:55

b. **Project Description and Objectives.** The San Francisco Estuary Institute (SFEI) is currently managing an effort, funded by CALFED, to identify regional priorities for control of introduced tidal wetland plants. We have found that there is a generally recognized need to control certain species, particularly those that are spreading or that are aggressive invaders of restored wetlands. At the same time Federal and State wetlands protection agencies, including the USFWS and CDFG, are concerned that control efforts should proceed cautiously while essential biological and distributional information is developed. The USFWS is especially concerned that large-scale control efforts only proceed in the context of a regional understanding of what processes or factors control colonization and dispersal. Building on our existing effort, this project would take a 3-component approach toward a regional program of invasive-introduced plant control.

1. *Initiate experimental control projects for two priority plant species, testing the efficacy of mechanical and/or chemical controls.* These projects would include comparative tests of priority methods of control as identified by SFEI's current survey of regional plant ecologists and wetlands managers. The experimental tests will include measures of control impacts and of local environmental recovery where introduced plant species have been controlled.
2. *Compile information on the biology and distribution of all priority invasive-introduced wetland plant species within the Delta and Bay Area.* Large-scale control of the most invasive species will require understanding of their natural habitat controls and responses to disturbance. A practical approach to gain such understanding is to map the pattern of colonization and dispersal through space and over time. The required information would be compiled in the Bay Area EcoAtlas (the multi-agency GIS of the San Francisco Bay and adjacent creeks), with reference to habitat type, habitat condition, and disturbance regime. The EcoAtlas will be extended through the Delta and into local watersheds as needed.
3. *Based upon this information, develop a strategy for comprehensive control and monitoring for priority species.* It is clear that some invasive plant species are spreading among jurisdictions of different agencies such that no single agency has authority to implement comprehensive control measures. It is also clear that the preferred control methods may vary among species, patch sizes within a species, and habitat conditions. What is therefore required is a set of guidelines to select best control methods that can be shared among the different wetlands protection agencies.

c. **Approach/Tasks/Schedule.** The proposed work would be conducted over a period of three years at an estimated cost of about \$259,565. Work would begin concurrently on all three objectives. Control methods would be tested in experimental field treatments while an extensive effort is undertaken to investigate the distribution and abundance of priority species throughout the region. Wetlands protection agencies and other interested parties would be briefed regularly on the results, building on the foundation of interagency communications about introduced species now being developed by SFEI.

d. **Justification for Project Funding by CALFED.** Undesirable species interactions, including especially the introduction of exotic species, is a major stressor for native wetlands plants and wildlife. Introduced-invasive species are especially problematic for wetlands restoration, since the early successional stages of wetlands evolution seem most conducive to invasion by exotic plant species. There is considerable concern among scientists and managers that wetlands restoration may not succeed on a large scale if exotic plants species cannot be controlled.

- e. **Budget Costs and Third Party Impacts.** The overall budget for this proposal is \$259,565 for three years. No third party impacts are anticipated.
- f. **Applicant Qualifications.** SFEI was established to provide the scientific understanding required to manage and protect the estuary and its natural resources. SFEI has strong inter-agency support for regional programs in trace substance monitoring, wetlands monitoring, watershed science, and introduced species. The principal investigators are leading experts in wetlands, estuarine ecology and biological invasions.

Joshua N. Collins received his Ph.D. in Entomological Sciences at the University of California at Berkeley and has done post-doctoral studies in Geography and Ecology at the University of California at Berkeley and Davis. His research is about the biotic and abiotic controls for the structure of freshwater, palustrine communities and the evolution of tidal wetland ecosystems. Dr. Collins has been a professional ecologist in the Public Utilities Industry and a consulting ecologist in private practice for wetlands restoration design and review. In his current position he is the Director of the Wetlands and Watersheds Program and the Science Coordinator for the Bay Area Wetlands Ecosystem Goals Project.

Andrew N. Cohen holds M. S. and Ph. D. degrees in Energy and Resources from the University of California at Berkeley. He is the author of the 1995 USFWS report on nonindigenous species in the San Francisco Estuary and of papers on other aspects of marine and aquatic invasions. Dr. Cohen has worked on and written about water system planning and economics, public health and contaminants in fish, and environmental mitigation; and has written articles and books for the general public on water and environmental policy and history. His work on invasions in the Estuary was profiled last year in the *New York Times Science Page*, and he was recently nominated to co-chair the Western Regional Panel on Aquatic Nuisance Species. He currently directs the San Francisco Estuary Institute's research program on biological invasions.

- g. **Monitoring and Data Evaluation.** This proposal involves developing and using regional protocols to monitor the distribution and abundance of introduced species, and experimental field tests of population control methods. These protocols, monitoring results, and experimental design will be subjected to review by SFEI Committee of Science Advisors. Additional peer review will be solicited from other regional wetlands experts. The results from this project will be submitted for formal scientific publication in a refereed journal.
- h. **Local Support/Coordination with other programs/Compatibility with CALFED objectives.** Although introduced wetlands species are generally regarded as a threat to wetlands restoration, there is little existing effort outside of CALFED and SFEI to examine the problem and set a course of action. Part of the problem is a lack of regional assessment of invasion. An exception is the East Bay Regional Park District and the County of Marin, both of which have been attempting to eradicate or control introduced species of *Spartina* from recent tidal marsh restoration sites. In both cases, SFEI has been approached to assist with the control efforts. This proposal is a large part of our response to local concerns. The proposed work would be conducted throughout the Estuary, and would extend into local watersheds as necessary to discover and map outlying and source populations.

Title Page

A. Title: Control of Invasive-Introduced Plants in Wetlands and Watersheds

B. Applicant: Joshua N. Collins, Ph.D.
Andrew N. Cohen, Ph.D.
San Francisco Estuary Institute (SFEI)
180 Richmond Field Station
1325 South 46th Street
Richmond CA 94804
Ph. 510 231 9539
fx. 510 231 9414
em. Josh@sfei.org
acohen@sfei.org

C. Type of Organization: SFEI is a non-profit organization under section 501(c)(3).

D. Tax Identification Number: 94-2951373

E. Technical and Financial Contact Person: Joshua N. Collins, Ph.D. (see above).

F. Participants/Collaborators: The principal investigators are Joshua N. Collins and Andrew N. Cohen, Environmental Scientists with SFEI. All GIS compilation and analysis will be conducted by SFEI. To the extent necessary, SFEI will subcontract University faculty and graduate students to assist with the field experiments.

G. RFP Project Group Type: Services

III. Project Description

A. Project Description and Approach

The proposed work would be conducted over a period of three years at an estimated cost of \$259,565. Work would begin concurrently on all three objectives. Mechanical and/or chemical control methods would be tested in experimental field treatments while an extensive effort is undertaken to investigate the distribution and abundance of priority species throughout the region. Wetlands protection agencies and other interested parties would be briefed regularly on the results, building on the foundation of interagency communications about introduced species now being developed by SFEI.

The estuarine wetlands ecosystem of the San Francisco Estuary is a fragmented array of small habitat patches with abundant edge and susceptibility to natural and man-induced disturbance. There only a few relatively large patches of historical marshland that exhibit a predominance of natural form and function. All of the marshlands are subject to mosquito control practices that, although implemented with considerable care and regulatory oversight, are to varying degrees ecologically disruptive. Much of the marshlands along the bayshore are low-elevation, relative to the tides (i.e., below Mean Higher High Water), and are therefore subject to accumulations of wrack and flotsam. These conditions of disturbance are generally thought to be conducive to exotic species invasion.

The riparian zones and instream habitats of local watersheds are similar disturbed. Chronic incision of the channel beds in the upper and middle reaches has led to bank erosion and downstream aggradation. Large magnitude sediment transport processes have combined with a drought-deluge climate to prevent formation of a stable bed configuration. Furthermore, most of the large channels are subject to regular alteration for flood control. These processes and events create a dense mosaic of opportunities for the introduction or expansion of exotic plant populations.

The San Francisco Estuary Institute (SFEI) is currently managing an effort, funded by CALFED, to identify regional priorities for control of introduced tidal wetland plants. We have found that there is general recognition of an urgent need to control certain species, particularly those that are spreading or that are aggressive invaders of restored wetlands. At the same time Federal and State wetlands protection agencies, including the USFWS and CDFG, are concerned that control efforts should proceed cautiously while essential biological and distributional information is developed. The USFWS is especially concerned that large-scale control efforts should only proceed in the context of a regional understanding of what processes or factors control colonization and dispersal. Building on our existing effort, this project would take a 3-component approach toward a regional program of invasive-introduced plant control.

1. *Initiate experimental control projects for two priority plant species, testing the efficacy of mechanical and chemical controls.* These projects would include comparative tests of priority methods of control as identified by SFEI's current survey of regional plant ecologists and wetlands managers. The experimental tests will include measures of control impacts and of local environmental recovery where introduced plant species have been controlled.
2. *Compile information on the biology and distribution of all priority invasive-introduced wetland plant species within the Delta and Bay Area.* Large-scale control of the most invasive species will require understanding of their natural habitat controls and response to disturbance. A practical approach to gain such understanding is to map the pattern of colonization and dispersal through space and over time. The required information would be compiled in the Bay Area EcoAtlas (the multi-agency GIS of the San Francisco Bay and adjacent creeks), with reference to habitat type, habitat condition, and disturbance regime. The EcoAtlas will be extended into local watersheds and through the Delta as needed.
3. *Based upon this information, develop a strategy for comprehensive control and monitoring for priority species.* It is clear that some invasive plant species are spreading among jurisdictions of different agencies such that no single agency has complete authority to implement comprehensive control measures. It is also clear that the preferred control methods may vary among species, patch sizes within a species, and habitat conditions. What is therefore required is a set of guidelines to select best control methods that can be shared among the different wetlands protection agencies.

B. Location and/or Geographic Boundaries of the Project

The proposed work would be conducted wherever necessary to map the full extent of the selected target species within the San Francisco Estuary and local watersheds. The experimental work would be conducted among large patches of these species in locations that do not present logistical problems.

C. Expected Benefits

This project will address exotic wetland plant species as major stressors to wetlands and riparian restoration. It will develop regional maps of the colonization sites and patterns of dispersal of priority introduced-invasive plants which will help define the scope of these stressors and will provide new insights into the relationships between dispersal and habitat type, habitat quality, and disturbance regime. The maps will be essential for monitoring changes in these dispersal patterns. The field experiments will demonstrate differences in efficacy among candidate control methods, allowing managers to select the best method for a particular situation. The development of a common basemap for compiling, analyzing, and visualizing information about introduced-invasive plant species should promote inter-agency coordination, and should provide a basis for a regional management plan.

D. Background and Biological/Technical Justification

Introduced plant species vary markedly in their abilities to exploit local and regional habitats. Successful colonization usually relates to a reproductive strategy and/or phenology that enables the introduced species to exploit short-term disturbances or periods of dormancy for native plant species. Rapid expansion of an introduced plant species among locales usually involves a physical process, such as tidal flux, or a biological process, such as transport by wildlife or by human activity. For example, it is now known that rapid dispersal of *Spartina alterniflora* after its singular introduction for erosion control was due in part to the accidental but repeated transport of rhizomes by commercial dredges. In another example, the Giant Reed, *Arundo donax*, is distributed by local nurseries as a creek-side ornamental, propagules of which are later distributed downstream by high flows. The success of peppergrass, *Lepidium latifolium*, in brackish tidal settings (and perhaps elsewhere) may be related to its early growth that leaves native wetlands plants, including bulrushes, in the shadows. From just these three examples it can be seen that the control of introduced wetland plants must involve careful assessment of the relationship between plant natural history, biology, and habitat condition. No single control method is likely to work everywhere for any introduced-invasive plant species.

Three approaches are required at this time to develop an effective program of control of introduced-invasive wetlands plants on a regional scale. For each priority species, the regional condition and its likely causes must be assessed, and the various local conditions that invite the species need to be matched to one or more candidate control methods. Based upon a consensus understanding from these investigations, a strategy of regional control can be developed. This proposal will make significant progress along all three of these approaches.

E. Proposed Scope of Work

Objective 1: Initiate experimental controls

- Task A: Based upon the current SFEI survey of concern about introduced plant species, select at least two target species and two candidate control methods for field experiments.
- Task B: Compile existing biological information.
- Task C: Based upon the best available information about the distribution of the target specie, select experimental sites.
- Task D: For each species, develop and experimental design that permits statistical analysis of treatment effects and interactions among treatments.
- Task E: Conduct experiments over one full growing season.
- Task F: Analyze and report experimental results.

Objective 2: Map the distribution and abundance of the target species

- Task G:* Develop a regional basemap in GIS by extension of the EcoAtlas, as needed, into local watersheds and the Delta.
- Task H:* Develop criteria for classes of size and vigor of plant patches, for clasifying habitats (e.g., habitat typology of the Wetlands Ecosystem Goals Project), and for describing disturbance regimes (e.g., spatial correspondence with fetch, channel edge, infrastructure, dredging, levee maintenance, erosion, etc.).
- Task I:* Distribute the basemap and mapping criteria to local interests in whatever medium is most useful (paper or electronic) for local, community-based mapping of plant patches.
- Task J:* Conduct intensive investigations of the bayshore sand selected local creeks to augment the community-based mapping
- Task K:* Compile in the GIS all known records of colonization of each species, based upon interviews with local experts.
- Task L:* Analyze the spatial information with regard to habitat type and disturbance regime, and report findings.

Objective 3: Develop a strategy for comprehensive control of priority species

- Task M:* Convene a workshop of wetlands ecologist and managers to review study findings and outline a course of action.
- Task N:* Based upon the study results and the workshop, develop a regional strategy for control of the priority target species.

F. Monitoring and Data Evaluation

This proposal involves developing and using regional protocols to monitor the distribution and abundance of introduced species, and experimental field tests of population control methods. These protocols, monitoring results, and experimental design will be subjected to review by SFEI Committee of Science Advisors. Additional peer review will be solicited from other regional wetlands experts. The results of this proposal will be submitted for formal scientific publication in a refereed journal.

G. Implementability

SFEI and the principal investigators have a strong record of inter-agency coordination and field science. Existing relations between SFEI and the wetlands protection agencies and managers assures that all necessary permits for field experimentation will be awarded. The EcoAtlas of SFEI provides a strong foundation for regional ecological mapping. The involvement of SFEI and the principal investigators in a variety of regional ecological programs, including the

Regional Monitoring Program for Trace Substances, the Interagency Ecological Program, the Regional Wetlands Ecosystem Goals Project, Team Arundo Del Norte, and the Napa-Sonoma Marsh Complex Restoration Committee, enhanced the likelihood that this project will be integrated into other regional ecological planning efforts.

IV. Costs and Schedule to Implement Proposed Project

Budget Costs

Phase & Task	Direct Labor hours	Direct Salary and Benefits	Overhead, General & Admin.	Misc. & other direct cost	Total cost
Objective 1 yr 1	600	\$ 20,127	\$ 10,466	\$ 20,500	\$ 51,093
Objective 1 yr 2	600	\$ 21,133	\$ 10,989	\$ 21,525	\$ 53,648
Objective 1 yr 3	300	\$ 8,679	\$ 4,513	\$ 2,651	\$ 15,844
Objective 2 yr 1	700	\$ 22,414	\$ 11,655	\$ 3,000	\$ 37,069
Objective 2 yr 2	700	\$ 23,535	\$ 12,238	\$ 3,150	\$ 38,923
Objective 2 yr 3	0	\$ -	\$ -	\$ 3,307	\$ 3,307
Objective 3 yr 1	50	\$ 3,085	\$ 1,604		\$ 4,688
Objective 3 yr 2	50	\$ 3,239	\$ 1,684		\$ 4,923
Objective 3 yr 3	600	\$ 32,458	\$ 16,878	\$ 735	\$ 50,071
TOTAL	3,600	\$ 134,669	\$ 70,028	\$ 54,868	\$ 259,565

B. Milestones: For Objective 1, base mapping will be complete within 6 months after funding begins. Mapping of plant distributions and habitats will continue throughout the project. Under Objective 2, species and site selection will be completed within 6 months after funding is received. Field experiments will continue throughout the project. Under Objective 3, the workshop will be held early in the third year, followed by the completion report and control strategy.

IV. Applicant Qualifications

San Francisco Estuary Institute (SFEI)

SFEI is a non-profit research organization charged with fostering scientific understanding of the Estuary. It provides science support for four major programs: the *San Francisco Estuary Regional Monitoring Program for Trace Substances*, the *Bay Area Wetlands Ecosystem Goals Project*, a *Watersheds Science Program* and an *Biological Invasions Program*. SFEI has a track record of providing scientific support for multi-agency teams, and organizing teams of qualified technical experts comprised of agency, academic, private sector, and non-governmental organization staff. The Institute has a staff of 22 including scientists, education specialists, data analysts, and support personnel. The Institute also employs graduate students and undergraduate interns from area Universities.

SFEI's Biological Invasions Program researches issues of scientific and policy interest related to the introduction of nonindigenous species into marine and freshwater ecosystems. The research program is directed toward five objectives: (1) assisting efforts to prevent future invasions through scientific and policy research on vectors and the control of vectors; (2) developing an effective regional monitoring program to identify new invasions and track the spread of nonindigenous species that are present in the region; (3) understanding how factors in the environment affect the success of invasions; (4) assessing the impacts of invasions; (5) prioritizing and assessing efforts to control nonindigenous species that are present in the region.

Current projects in the Biological Invasions Program include:

- Developing methods for prioritizing efforts to control exotic marsh plants in the Estuary.
- Assessing the potential range and abundance of zebra mussels in California waters.
- Research on the introduction of organisms in the marine baitworm trade.
- Research on the invasion of the California coast by a Japanese foraminifer.
- Developing a regional monitoring plan for exotic organisms.
- Modelling the effect of invasion "incubators" on the success of obligate sexually-reproducing invaders.
- Review of open coast invasions, with a case study of the invasion of the Southern California Bight by a New Zealand sea slug.
- Reviewing the effect of fragmentation and interconnection of river systems on the spread of nonindigenous species.

Principal Investigators

Joshua N. Collins, Ph.D., Environmental Scientist Dr. Collins received his Ph.D. in Entomological Sciences at the University of California at Berkeley and has done post-doctoral studies in Geography and Ecology at the University of California at Berkeley and Davis. His research is about the biotic and abiotic controls for the structure of freshwater, palustrine communities and the evolution of tidal wetland ecosystems. Dr. Collins has been a professional ecologist in the Public Utilities Industry and a consulting ecologist in private practice for wetlands restoration design and review. In his current position he is the Director of the Wetlands and Watersheds Program and the Science Coordinator for the Bay Area Wetlands Ecosystem Goals Project.

Andrew N. Cohen, Ph.D., Environmental Scientist Dr. Cohen received M. S. and Ph. D. degrees in Energy and Resources from the University of California at Berkeley. He is the author of the 1995 USFWS report on nonindigenous species in the San Francisco Estuary and of papers on other aspects of marine and aquatic invasions. Dr. Cohen has also worked on and written about water system planning and economics, public health and contaminants in fish, and environmental mitigation; and has written articles and books for the general public on water and environmental policy and history. His work on invasions in the Estuary was profiled last year in the *New York Times* Science Page, and he was recently nominated to co-chair the Western Regional Panel on Aquatic Nuisance Species. He currently directs the San Francisco Estuary Institute's research program on biological invasions.

Recent Publications on Biological Invasions

Cohen, A. N. The exotic species threat to California's coastal resources, *Proc. California and the World Ocean '97 Conference*, March 24-27, 1997, San Diego CA (in press).

Cohen, A. N. The invasion of the estuaries. *Proc. 2nd International Spartina Conf.*, Mar. 20-22, 1997, Olympia WA (in press).

Cohen, A. N. and J. T. Carlton. Transoceanic transport mechanisms: The introduction of the Chinese mitten crab *Eriocheir sinensis* to California, *Pac. Sci.* 51(1): 1-11, 1997.

Cohen, A. N. Biological invasions of the San Francisco Bay and Delta, *Proc. Nat'l Forum on Nonindigenous Species Invasions in U. S. Marine and Fresh Waters*, U. S. Capitol Building, Washington DC, Mar. 22, 1996.

Cohen, A. N. and J. T. Carlton. *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta*. U. S. Fish and Wildlife Service, Washington DC, Dec. 1995.

Cohen, A. N., J. T. Carlton and M. C. Fountain. Introduction, dispersal and potential impacts of the green crab *Carcinus maenas* in San Francisco Bay, California, *Mar. Biol.* 122: 225-237, 1995.

VI. Compliance with Standard Terms and Conditions:

Nondiscrimination Compliance Statement attached.

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME

SAN FRANCISCO ESTUARY INSTITUTE

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME

Margaret R. Johnston

DATE EXECUTED

July 25, 1997

EXECUTED IN THE COUNTY OF

Contra Costa County

PROSPECTIVE CONTRACTOR'S SIGNATURE

PROSPECTIVE CONTRACTOR'S TITLE

Executive Director

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

San Francisco Estuary Institute