Elkhorn Slough National Estuarine Research Reserve

Final Management Plan 2007-2011

September 29, 2006

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Executive Summary

Overview

This document is the second edition of the management plan for the Elkhorn Slough National Estuarine Research Reserve (Elkhorn Sough NERR), and covers the period from 2007-2011. The plan provides an update to the *Elkhorn Slough National Estuarine Research Reserve Management Plan, 1985*—the first management plan developed for the Reserve.

The Elkhorn Slough NERR is an ecologically diverse 583 hectare (1,439 acre) protected area located on the eastern shore of the Elkhorn Slough, near the Monterey Bay in Central California. Elkhorn Slough is a seven-mile arm of the Monterey Bay located half way between the cities of Santa Cruz and Monterey. This arm bends as it extends inland, and at the "elbow" lies the Reserve.

The Elkhorn Slough NERR is protected for long-term research, water-quality monitoring, education and coastal stewardship. The Reserve also offers opportunities for public access and is home to an award-winning visitor's center. The property features several well-maintained hiking trails and has boardwalks, a wildlife viewing blind, and a fully-accessible scenic overlook.

The Elkhorn Slough NERR, is a component of the National Estuarine Research Reserve System (NERRS), a federal state partnership of protected research and education sites administered by the National Oceanic and Atmospheric Administration (NOAA) and the California Department of Fish and Game (CDFG). The NERRS was created in the legislation that established by the Coastal Zone Management Act (CZMA). As such the reserves are required by Federal regulation, 15 C.F.R. Part 921.13, to have a NOAA-approved management plan that is updated every five years. The *Elkhorn Slough NERR Management Plan 2007-2011* meets the Reserve's Federal obligation.

Within the plan we describe the Reserve's long-term conservation goals and detail the process involved in identifying those goals. We also map out the objectives and strategies that the Reserve will use over the next five years in order to move toward accomplishing our goals. Furthermore, the plan gives an overview of our research and monitoring, education, stewardship, Coastal Training, volunteer, and administration programs and describes our plans for public access, acquisition, and facilities.

This plan is a significant revision of the original management plan that was approved by the California Department of Fish and Game (CDFG) and the National Oceanic and Atmospheric Administration (NOAA) in 1985. In developing this plan the Reserve used a collaborative approach, which focused on integrating the Reserve's programs in order to better achieve conservation success.

Mission, Vision and Beliefs of the Elkhorn Slough NERR

The Elkhorn Slough NERR's Mission, Vision, and Beliefs are as follows:

Mission:
To improve the understanding and stewardship of Elkhorn Slough and its watershed.

Vision:
The Elkhorn Slough NERR is a hub of substantive research, education, and resource management which models:

- biodiversity through the protection of existing native habitat and the restoration of disturbed habitat through adaptive management practices
- quality, hands-on interaction with watershed habitats without significant negative impact on the environment
- inspiration of diverse audiences to make personal commitments to environmental stewardship
- objective and responsible information exchange, interaction, and learning
- broad-based community involvement
- sound, up-to-date, and fiscally responsible infrastructure
- high professional standards by staff and volunteers
- long-term strategic planning

Statement of Beliefs
The Elkhorn Slough NERR Believes that:

- Global environmental health depends on widespread commitment to stewardship, both individually and collectively

- As an integral part of a natural system, the Reserve should maintain a watershed perspective.

- Conservation best served when education, research, and resource management are interdependent and mutually supportive.

- Reserve education should reflect best educational practice.

- Everyone has the capacity to increase their knowledge and appreciation of the environment.

- Reserve research should adhere to the highest standards of scientific inquiry.

- Research should be widely accessible and results should be disseminated in a manner which is timely, clear, accurate, and unbiased.

- Research should guide resource management decisions.

- Optimal management of the Reserve contributes to long-term global environmental health.

Management Plan Planning Process

Most of this plan focuses on the Elkhorn Slough NERR's long-term conservation goals and what the Reserve will do over the next five years in order to move closer to achieving those goals.

In developing these watershed-specific conservation goals we combined Reserve-developed methodologies with tools developed by the disciplines of conservation planning and program design in a novel approach we hope will provide future direction to Reserve staff and their conservation partners. We first used extensive staff expertise and existing data to create a conservation assessment, which helped us to prioritize conservation targets. We then analyzed those targets to ascertain their predominate stresses and overall threats. Finally, we developed a comprehensive list of all of the actions needed to address stresses and threats and prioritized those actions which we felt could be achieved in the next 5 years.

ESNERR Conservation Goal #1
Protect and Restore Estuarine Habitats in the Watershed

The Elkhorn Slough NERR sits on the edge of a large estuary with habitats that include productive salt marshes, rich mudflats, and meandering tidal channels and creeks. Dozens of vascular algae and plant species, over 100 fish species, over 135 bird species, and over 550 invertebrate species have been reported from Elkhorn Slough's estuarine habitats (Caffrey et al. 2002).

While Elkhorn Slough today still hosts extensive estuarine habitats and diverse species, there is strong evidence that local biodiversity is threatened, and has already undergone significant changes in the past centuries (Caffrey et al. 2002). Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes which are essential to support and sustain Elkhorn Slough's estuarine habitats.

This has led to substantial changes in the extent and distribution of different estuarine habitat types. Major threats to estuarine habitats result from increased rates of tidal erosion, marsh drowning, and dikes. The accelerated rate of bank and channel erosion in Elkhorn Slough is causing tidal creeks to deepen and widen reducing functions for estuarine fish, salt marshes to collapse into the channel and die, and soft sediments that provide important habitat for invertebrates to be eroded from channel and mudflat habitats. Increases in the flooding of tidal waters on marshes are causing plants to "drown" in central areas of the marsh. Based on current knowledge, the accelerated rates of tidal erosion and marsh drowning are primarily due to the estuarine mouth modifications. Since the 1870s, approximately 30 percent of the salt marsh has been lost due to the construction of levees to drain wetlands for cattle grazing, railroad and road construction, and the creation of freshwater impoundments for duck hunting (Van Dyke and Wasson 2005). After a harbor was constructed at the mouth of Elkhorn Slough in 1947, 50 percent of the salt marsh was lost due to the marsh drowning and bank erosion and continues today at dramatic rates (Van Dyke and Wasson 2005). Tidal creek, mudflat, and channel habitats are also degraded by tidal erosion, which results in approximately two million cubic feet of sediment being exported from Elkhorn Slough

each year. Reserve staff are leading a large, collaborative effort, the Elkhorn Slough Tidal Wetland Project (TWP), with the assistance of many partners to develop specific recommendations to conserve and restore estuarine habitats and implement them.

Other habit modifications of the Elkhorn Slough come in the form of invasive species. About 60 non-native invertebrates have been documented at Elkhorn Slough, and they include some of the most common species encountered, such as the European Green Crab and the Japanese Mud Snail (Wasson et al. 2001). There are also common algal, plant, and fish invaders in Slough estuarine habitats. Between the 1930s and 1970s, the majority of these invaders probably arrived with shipments of non-native oysters that were cultured at the Slough. Since then, the main introduction route is via hull-fouling on small boats traveling to Moss Landing Harbor. Most of the species arriving in recent decades first became established in San Francisco Bay (to which they were introduced largely by commercial shipping), then spread via boat traffic as well as natural transport of larvae on currents up and down the coast (Wasson et al. 2001). Marine and estuarine invasions have been shown to cause local extinction of native competitors and prey organisms, alteration of community composition and food webs, change in physical habitat structure, and even alteration of flow of energy and materials through whole ecosystems (Grosholz 2002).

In order to protect and restore estuarine habitats in the watershed the Reserve will work toward the following objectives over the next five years:

- Restore and Enhance Estuarine Habitats with Restricted Tidal Flows
- Reduce Erosion in Subtidal Habitats and the Loss and Degradation of Intertidal Habitats
- Prevent new biological introductions into estuarine habitats
- Detect and eradicate new biological introductions into estuarine habitats
- Develop restoration strategies that help favor dominance by native assemblages

ESNERR Conservation Goal #2
Protect and Restore the Watershed's Key Freshwater Habitats

Freshwater wetlands occur where land surfaces are saturated or covered by freshwater for sufficient time that the resulting plant community has adaptations to survive these stressful conditions. In the Elkhorn Slough watershed, freshwater habitats occur as riparian corridors, wet meadows, freshwater marshes, and ponds.

Freshwater habitats provide important habitat for diverse communities of plants and animals, including sensitive species such as the Santa Cruz Long-toed Salamander (*Ambystoma macrodactylum croceum*), California Tiger Salamander (*Ambystoma californiense*), California Red-legged Frog (*Rana draytonii*), and the Southern Pacific Pond Turtle (*Actinemys marmorata pallida*). Unfortunately, freshwater habitats have experienced significant losses over the last 150 years. A network of shallow lakes and freshwater marshes that once extended from south of the city of Salinas to north of the city of Watsonville was drained in the late 1800s and early 1900s for agriculture (Gordon 1996). A series of small upland ponds just north and south of lower Moro Cojo Slough

was converted to agricultural and industrial land (Johnson and Rodgers 1854). Freshwater springs and seeps that were once common along the edges of Elkhorn Slough have been lost since the 1940s, presumably due to lowered groundwater levels resulting from agricultural and domestic pumping (Van Dyke and Wasson 2005).

Some freshwater habitats do remain in the watershed, but most face at least some level of ongoing threat. In many cases, exotic plants invade native plant communities, and introduced fish and amphibians prey upon threatened and endangered animals. In other cases, ponds, marshes and meadows are affected by excessive agricultural runoff which results in sediment accumulation, increased turbidity, and other pollutants. Furthermore, many of the watershed's ponds are man-made, created from former salt marshes or seasonal streams, or otherwise excavated to form sediment basins or stock ponds. Presumably the hydroperiod, vegetation, and sediment characteristics of these waterbodies are quite different than the original freshwater wetlands that have been lost. The subsequent changes have influenced the plant and animal assemblages that currently inhabit these sites.

In order to protect and restore the watershed's key freshwater habits the Reserve will work toward the following objectives over the next five years:

- Maintain and enhance key freshwater habitats
- Explore and act upon opportunities for watershed partnerships and outreach
- Conduct research to improve management strategies for local freshwater habitats
- Protect Reserve and key neighboring freshwater habitats from selected invaders

ESNERR Conservation Goal #3
Protect and Restore Maritime Chaparral is the Elkhorn Slough Watershed

Chaparral is perhaps California's most emblematic vegetation type, forming broad expanses across coastal and inland foothills and constituting about five percent of the state's land cover (Hanes 1988). Paradoxically, maritime chaparral, a manzanita-dominated association found only in relatively small patches near the coast, is one of our most uncommon and highly threatened vegetation communities. Significant stands of maritime chaparral remain in the Burton Mesa region of Santa Barbara County, near Morro Bay in San Luis Obispo County, and in the Monterey Bay area at former Fort Ord and on sandhills adjacent to Elkhorn Slough. Maritime chaparral is protected as environmentally sensitive habitat under the California Coastal Act and under Monterey County's Local Coastal Plan (Monterey 1982). Occurrences are mapped as a rare natural community by the California Department of Fish and Game in the California Natural Diversity Database (CNDDB).

Maritime chaparral patches in the Elkhorn Slough watershed occur within a matrix of coast live oak woodland, coastal sage scrub, and annual grassland as well as agricultural and rural residential development. Maritime chaparral is threatened by removal and fragmentation due to development, encroachment by invasive exotic species such as

pampas grass, iceplant, and blue gum eucalyptus, and gradual conversion to other habitat types, particularly live oak woodland.

Today, approximately 2800 acres of maritime chaparral remain in north Monterey County. Of this, 1700 acres (61%) are within the boundaries of the Elkhorn Slough watershed. Of the watershed's maritime chaparral, 350 acres (21%) are within conservation lands protected by ESF and The Nature Conservancy and 160 acres (9%) are within Manzanita County Park. The remaining 1190 acres (70%) are in either developed or as yet undeveloped parcels on privately owned land.

Because we only protect what we know and understand, the key to preserving remaining maritime chaparral is developing a network of watershed residents, educators, land managers, land-use decision makers, and scientists who are familiar with chaparral ecology and with policies and practices designed to protect and restore the habitat. This understanding will need to be developed in the visitor center and the classroom, in the laboratory and greenhouse, in the homes and gardens of watershed residents, and in the wild.

In order to protect and restore the watershed's maritime chaparral habits the Reserve will work toward the following objectives over the next five years:

- Preserve existing maritime chaparral in the Elkhorn Slough watershed
- Reduce loss of maritime chaparral due to habitat type conversion

ESNERR Conservation Goal #4
Protect and Restore the Watershed's Coastal Prairie and Coastal Scrub Habitats

Coastal prairie and northern coastal scrub are part of a complex and dynamic mosaic of upland habitats within the Elkhorn Slough watershed. Coastal prairie is a species-rich habitat that occurs within 100 kilometers of the coast. It hosts not only array of insects, amphibians, reptiles, birds, and mammals, but also a number of endangered annual forbs. This habitat can be defined, in part, by its native grass and forb species. Coastal prairie often coexists with, and frequently has a successional relationship with, northern coastal scrub (Ford and Hayes in press, Heady et al. 1988, Heady et al. 1992). Coastal scrub is an assemblage of evergreen shrubs, and within California, ecologists recognize northern and southern divisions. Northern coastal scrub occurs from Santa Barbara County north to the Oregon border. In the Elkhorn Slough watershed it is dominated by coyote brush. Co-dominants include California sagebrush, black sage, coffeeberry, bush monkeyflower, California blackberry, yellow bush lupine, and poison-oak. This habitat is important for a variety of small mammals and birds. The mosaic and herbaceous height characteristics of coastal prairie with northern coastal scrub are critical to the upland habitat quality for special-status species, including:

- Santa Cruz sunflower (federal and state listed endangered),
- artist's popcornflower (California Native Plant Society 1B: Rare, threatened or endangered in California and elsewhere 1B),
- peregrine falcon (state listed as endangered),
- northern harrier (species of special concern),

- Santa Cruz long-toed salamander (federally and state listed as endangered),
- California red-legged frog (federally listed as threatened), and
- California tiger salamander (species of special concern) (CalPIF 2004, Becker 1988, L. Ford pers. comm., Hobbs and Mooney 1986).

Unfortunately, both coastal prairie and coastal scrub face significant threats. Approximately 99% of California native grasslands have been lost over the last 200 years, making them one of the most critically endangered ecosystems in the U.S. (Noss et al. 1995). Loss of coastal scrub in some parts of California has also been severe. Up to 90 % of the historic acreage of southern coastal scrub has been lost to development (Noss et al., 1995). Northern coastal scrub is apparently more secure for now, but it too has declined by over 35% since 1950 (FRRAP 1988:Table 7-4; FRAP 2003), and faces the same sprawl as Southern California. Within the Elkhorn Slough watershed, coastal scrub assemblages often face threats from infestation by tall exotic biennials and perennials, such as poison hemlock, fennel, and jubata grass.

Despite dramatic losses locally and statewide, some remnant coastal prairie and intact coastal scrub persists in the Elkhorn Slough watershed and on the Elkhorn Slough NERR. The Reserve will give priority to identifying and preventing the establishment of new invasive exotic plants in these areas on the Reserve.

In order to protect and restore the watershed's coastal prairie and costal scrub habits the Reserve will work toward the following objectives over the next five years:

- Reduce abundance of selected non-native plant and animal species in Reserve coastal prairie and coastal scrub assemblages.
- Help build support for regional Coastal Prairie and Coastal Scrub projects.
- Implement research that informs regional restoration strategies

ESNERR Conservation Goal #5
Protect and Restore the Watershed's Coast Live Oak Habitats

Coast live oak (*Quercus agrifolia*) woodland is common in the Elkhorn Slough watershed and is often found growing on 15 to 50 percent slopes and loamy sands in the hills east of the Elkhorn Slough National Estuarine Research reserve (Elkhorn Slough NERR). On the Reserve, oak woodlands also frequently appear on the slopes of dissected terraces. Oak woodland can range from dense forests with closed canopies at moderately moist sites, to widely-spaced open woodland or savannah in drier areas. Oak understory vegetation is also variable. Where the canopy is closed, understory vegetation often includes shade-tolerant shrubs, ferns, and forbs. Where trees are scattered, the understory is commonly made up of grassland and occasional shrubs (Holland 1988). At Elkhorn Slough NERR, the overstory is made up exclusively of coast live oak, and common native understory species include poison oak (*Toxicodendron diversilobum*), sword fern (*Polystichum munitum*), California blackberry (*Rubus ursinus*), hedge nettle (*Stachys bullata*), snowberry, (*Symphoricarpos albus* var. *laevigatus*), coffeeberry (*Rhamnus californica* and *R. tomentella*), beeplant (*Scrophularia californica*) and miner's lettuce

(*Claytonia perfoliata*). Creeping wildrye (*Leymus triticoides*) and Santa Barbara sedge (*Carex barbarae*) also occur in open woodlands.

Coastal oak woodlands provide habitat for a variety of wildlife species, including many mammals and a wide range of birds. According to California Partners in Flight and the Point Reyes Bird Observatory (2002), oak woodlands have the richest wildlife species abundance of any habitat in California, and may rank among the top three habitat types in North America for bird richness. The California Wildlife Habitat Relationships System lists over 200 animals species that live in or otherwise use coastal oak woodlands in Monterey County. In the Elkhorn Slough watershed these include nesting white tailed kites (California Fully Protected) and golden eagles (California Species of Special Concern), Swainson's hawks (California Threatened), peregrine falcons (California Endangered), and seasonally, Santa Cruz long-toed salamanders (Federally and California Endangered).

It is unknown how many oaks in the Elkhorn Slough watershed have been lost over the last 150 years. Comparisons between mid-nineteenth century surveys and recent aerial photos hint at large-scale changes. When surveying the boundaries of Spanish land grants and township and range lines in the 1850s and 60s, the U.S. Surveyor General mapped many natural features, including oak trees. In the Elkhorn Slough watershed, oaks were therefore mapped on the boundaries of the San Cayetano, Los Carneros, and Bolsa Nueva y Moro Cojo ranchos, and along the public lands north of Hall Road, on the Springfield Terrace, and in the hills approximately 3.5 kilometers east of today's Elkhorn Slough NERR. Only half of the survey points shown as coast live oak in the 1800s are oak habitat today. Approximately 40% of the originally mapped oaks have since been converted to agricultural fields or grassland, while the other approximately 10% have since been replaced by non-native eucalyptus or pine trees (U.S. Survey General 1872, Foreman 1867, Terrell 1859, Day 1854, Freeman 1854).

In order to protect and restore the watershed's coast live oak habits the Reserve will work toward the following objectives over the next five years:

- Protect the watershed's coast live oak habitats from biological invaders.
- Investigate the habitat use of native oak vs. non-native eucalyptus groves.

ESNERR Conservation Goal #6
Reduce Pollution across the Elkhorn Slough Watershed

Estuaries often have particularly high levels of pollution relative to other coastal habitats, because human uses such as industry, agriculture, residential development, and harbors are often densely concentrated around them (Kennish 2002). In estuarine habitats of the Elkhorn Slough watershed, numerous contaminants from a variety of sources have been identified, and many more no doubt remain undetected. In this largely rural watershed, the main cause of water and sediment quality degradation appears to be agricultural non-point source pollution (Caffrey 2002, Phillips et al. 2002).

The Elkhorn Slough National Estuarine Research Reserve's (Elkhorn Slough NERR) water quality monitoring program has documented elevated nutrient levels in watershed

wetlands. For instance, in the South Harbor, Tembladero Slough, and old Salinas river channel, nitrates average over 50 mg/L (vs. safe drinking water standard of 10 mg/L), and the peak values at these sites are among the highest ever reported for estuarine ecosystems (Caffrey 2002). In the main channel of Elkhorn Slough, nitrate concentrations are lower, averaging 5 mg/L or less. However even in these areas strongly flushed by the tides, higher concentrations occur in the rainy season, partly due to subwatershed sources. This is shown through data generated for National Estuarine Research Reserve's System-wide water quality program, which sometimes detects much higher level of nutrients in Reserve wetlands on outgoing tides, attributable to local sources, than on incoming tides. Furthermore, an array of in-situ nitrate monitoring instruments has recently documented nitrate from Salinas River channel / Tembladero Slough sources traveling up the Slough, into and well past the Reserve (K. Johnson in prep; www.mbari.org/lobo).

In order to reduce pollution across the Elkhorn Slough Watershed the Reserve will work toward the following objectives over the next five years:

- Improve understanding of pollution levels, sources, and effects on coastal habitats.
- Generate and disseminate information on estuarine values and how they are affected by pollution.
- Decrease effects of agricultural run-off and erosion on the Reserve.

ESNERR Conservation Goal #7
Monitor Key Indicators of Coastal Ecosystem Health to Enhance Understanding of Spatial and Temporal Variation and Long-term Trends

Long-term monitoring programs – those carried out consistently for at least a decade, and ideally many decades – are vital for detecting spatial and temporal trends in ecosystems, and for distinguishing natural from anthropogenic perturbations. Long-term datasets improve our understanding of, and thus decision-making about, complex ecological processes that occur at large spatial and temporal scales (Vos et al. 2000).

In the Elkhorn watershed, the Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR) is ideally suited to designing and implementing long-term monitoring. There is strong institutional support at the local (Elkhorn Slough NERR) and national (National Estuarine Research Reserve System) level for carrying out high quality, consistent monitoring of key indicators of coastal health. The Reserve is committed to continuing its role as a leader in regional monitoring.

To improve the management of complex coastal ecosystems, it is important to use a combination of different indicators at multiple scales, from ecosystems to habitats to species (Noss 1990, Wilson 1994). Reserve monitoring programs fall into three main categories:

1. Water quality and weather monitoring to characterize overall ecosystem health

2. Habitat and land use change monitoring to track changes in the extent and distribution of different land cover classes, and

3. Biological monitoring of threatened species and characteristic estuarine and coastal communities.

In order to monitor key indicators of ecosystem health in the watershed the Reserve will work toward the following objective over the next five years:

- Collect, archive, and disseminate consistent, high caliber data on critical ecosystem characteristics.

The long-term monitoring programs are summarized in Tables 9.1 through 9.6.

ESNERR Conservation Goal #8
Educate the Community about the Watershed and Inspire Them to Consider Environmental Conservation When Making Decisions Affecting Elkhorn Slough and Its Watershed

The Reserve offers a mosaic of education programs that are designed to reach a variety of audiences through different venues using different delivery modes. Based on target audiences these programs can be grouped into four components:

1. Coastal Training Program – reaching local and regional decision makers though workshops, workgroups, independent scientific review, distribution of information, and networking with experts.

2. School Programs – current programs include: K-12 Teacher Professional Development, Reserve-based Field Experiences, Interactive Virtual Field Trips, Multicultural Outreach, K-12 and Non-formal Education Partnerships, and support of college and university courses, community service programs and student internships.

3. Public Education – centering on the visitor center and five miles of trails, offering guided tours, special events, and opportunities for outreach to neighbors in the Elkhorn Slough watershed.

4. Volunteer Program – trains a cadre of community volunteers to assist with the implementation of the other education programs and also serve to support the research, monitoring and restoration programs, and other aspects of the operation of the Reserve.

The challenge for the Reserve's environmental education program is to offer entry level experiences for all ages with opportunities to take "courses" of greater depth and increasing levels of involvement.

In order to educate the community about the watershed and inspire them to consider environmental conservation when making decisions affecting Elkhorn Slough and its watershed the Reserve will work toward the following objective over the next five years:

- Create and implement environmental education programs for school-aged children, visitors, our watershed neighbors, and decision makers.

ESNERR Conservation Goal #9
Maintain a Viable Base for ESNERR Programs: Organization, Budget, and Facilities

In order to successfully protect, restore, research, and educate, we must provide a strong organizational and infrastructure foundation upon which these activities can build. Important conservation goals can only be fully achieved when the staffs working on them have a productive and safe environment in which to work, as well as the resources and tools necessary to do their jobs. The rationale is simple: If an organization is plagued with unsafe or uncomfortable working conditions, low morale, bad communications, disorganization, too few funds, a poor public image, or inadequate facilities, it is less able to accomplish its mission.

In order to maintain a viable base for ESNERR programs the Reserve will work toward the following objective over the next five years:

- Maintain a productive, safe, and efficient ESNERR work environment.
- Maintain a visible and positive ESNERR image.
- Maintain, repair, and construct ESNERR facilities and infrastructure.

Program Overviews
Administration

People and funding are the basis of all Reserve programs. If either one of these elements is missing or is mismanaged, the program will fail and conservation goals will not be attained. Operating in a well-organized manner increases efficiency and productivity. Positive public relations help garner funding, partnerships, and community support which, in turn, promotes Elkhorn Slough watershed conservation.

The administration program's purpose is to provide human and fiscal resource management to the Reserve and to provide a framework of policies and processes necessary to support Reserve programs and operations.

Goals

- To provide well-trained staff to achieve the Reserve's conservation goals.
- To provide a stimulating, healthy work environment for all staff.
- To procure and responsibly manage funding to achieve the Reserve's conservation goals.
- To foster cooperation within and between CDFG, NOAA, and ESF.
- To facilitate the development and implementation of clear policies and procedures to guide the management of the Reserve.

- To operate the Reserve in a well-organized and efficient manner.
- To provide high quality public information about the Reserve.

Volunteer Program

Reserve volunteers assist with the work of stewardship, research, education, public outreach, maintenance, and administration. Their hours represent a significant contribution to Reserve programs. Moreover, the Reserve converts volunteer hours into a dollar value which is then used as in-kind match for grants. In 2005, the financial value of volunteer hours to the Reserve was over $100,000.

Some of the benefits of a volunteer program are less directly tangible than a dollar value represented by their hours worked. Well-trained and enthusiastic volunteers serve as important community ambassadors for conservation. It has been shown that volunteer programs are needed by society to provide a venue for like-minded people to get together and share their passion for a cause. Providing those opportunities, in the context of working toward important conservation goals, is part of what the Elkhorn Slough volunteer program can provide.

Purpose

The purpose of the volunteer program is to recruit, train, and support volunteers so they can effectively assist Reserve and ESF staff in carrying out their conservation goals. Our core belief is that knowledge of and appreciation for nature precedes and motivates conservation behavior.

Program Goals

- **Address the needs of volunteers**
  - In order to be productive and have a positive personal experience, volunteers must enjoy what they do and feel appreciated.

- **Maintain a well-organized and well-managed volunteer program**
  - Clear guidance must be given regarding issues such as policies, procedures, and minimum requirements for training and service. Accurate and up-to-date data bases of volunteer information, hours and type of service must be maintained.

- **Focus volunteer efforts on the highest priority needs of the Reserve and ESF**
  - Annual evaluation of work plans of both staff and volunteers is necessary to insure that the most important tasks are being given the greatest effort.

- **Maintain high quality volunteer output**
  - In order to insure that volunteers serve as appropriate and effective ambassadors for the Reserve and for watershed conservation, regular evaluation of their performance is necessary. Evaluation results will inform where training or feedback is needed and will guide future program planning.

Education Program

As environmental educators we are facing an increasingly complex challenge, an obligation of global significance, and an urgency that requires us to be thoughtful and strategic in our efforts. Some of these challenges include:

- The population of California is incredibly diverse, with over 50 different languages spoken in the public schools, (Jepsen 2005) and is expected to increase by 11.3 million to a total of 45 million people by the year 2020, (CDOF 2001). Likewise, the Monterey Bay Area will see a population increase of over 130,000 people by 2020 and another 156,000 people will arrive by 2050 (Figure 16.1) (State of California, Dept of Finance 2004). These people will be neighbors to the Elkhorn Slough and many will inevitably live in its watershed.

- California is also home to one third of "at risk species" identified in the United States. The state is considered to be one of the 25 most significant biological hotspots in the world (Stein 2000). There are twenty-one threatened or endangered species in the Elkhorn Slough and neighboring Pajaro and Salinas River watersheds.

- Our terrestrial activities are linked to the world's ocean through watersheds and estuaries and have had significant detrimental effects. Recent reports from the US Commission on Ocean Policy (2004) and the Pew Oceans Commission (2003) have made it abundantly clear that the ocean and coastal habitats are in dire need of increased study and protection.

The core effort of our education program must continue with even greater urgency as the population encroaches; people become more urbanized and divorced from nature; and social, political and economic forces converge in the next decade to determine what will be left of the natural systems in the watersheds of the central coast.

Purpose

The Reserve's education programs are designed to address different issues within different time frames. We strive to strategically define priorities and develop programs that address:

1. The most **immediate** threats to coastal habitats and the people (decision makers) who most need to understand the issues in order to make well informed decisions. This time frame includes targeted CTP workshops.

2. The issues on an **intermediate** time frame that require the building of a baseline of understanding among professionals in both private and public sectors, public servants (politicians) and the general public who can get involved in the community decision making process, (public hearings, planning commissions, general plan updates). The Reserve education program can help by defining specific research needs, and/or by defining

and interpreting existing research so people can be involved in discussions in the larger community pertinent to making well informed decisions. This time frame includes professional development, a second tier of CTP workshops, graduate level research, student internships, and collaborations with college level course instruction.

3. The **long-term** need of providing quality K-12 education programs to develop a culture of conservation that includes
    i. an awareness, appreciation for and understanding about nature
    ii. experience with scientific inquiry and appreciation for the strengths and limits of science
    iii. an understanding of career choices and the education required to work in these careers
    iv. an understanding of the decision making process, power structures in the community and a desire to be involved in shaping the local landscape.

    This time frame includes teacher professional development, curriculum development and field experiences for K-12 students.

Goals

To achieve ESNERR's conservation goals outlined in previous chapters, our programs must continually adapt to a rapidly changing world to meet high standards of excellence in content and presentation. The critical information and experiences we provide must be clearly defined, the audiences understood, and the two brought together in carefully choreographed workshops, forums, events and activities with the use of appropriate communication mediums and technologies.

We strive to develop flexible, responsive programs of clearly defined geographical scope, integrated with the activities/programs of local partners, anchored by the needs of the local community (both human and non-human) and tied to the goals of our state and federal partners/agencies. The education staff has acquired expertise in defining the process of developing and maintaining such adaptive programs through the development of the Coastal Training Program. As a national program, the CTP is able to access national resources and apply them to very specific local needs. The CTP operational model includes the following components, which guarantee program success:

- Ongoing market analysis that help identify key audiences and subjects not targeted by similar programs;
- Needs assessments that identify specific needs of target audiences;
- A carefully chosen advisory committee that ensures communication with key partners and networking with appropriate agencies and professionals in the

region;

- Strategic planning that provides vision while articulating the unique niche that the Reserve fills in the region;
- Short and long-term performance measures that help to track success and improve programs.

Aspects of this model are being applied to the other elements of the education program. (see Chapter X for details)

Research Program

To better fulfill our role as coastal stewards, we need to better understand the complex process and dynamics of our estuarine watershed and coastal biodiversity. We need to know more about the relative impacts of various potential threats and about the effectiveness of different restoration strategies. We need to better characterize the Slough's biodiversity to understand which estuarine species need our special support, because of the key role they play or because of their rarity. Applied conservation research, while becoming more common, still comprises a tiny minority of the investigations conducted by academic institutions. The Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR) thus plays a critical role in encouraging, supporting, and synthesizing applied conservation research by regional scientists. Furthermore, Reserve researchers themselves conduct original conservation research to address critical gaps in our understanding.

Purpose

In order for coastal managers to make informed decisions, they must possess credible, relevant information about the systems and species under their charge. History has shown us what can happen when human actions, often with the best of intentions, are taken without proper knowledge of the consequences. Research is necessary to help insure the *intended* consequences are realized and to help minimize the risk of *unintended* consequences of human activities.

Goals

According to the CZMA, a key goal of the Reserves is to "conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas."
In order to meet this overarching coastal program goal, we strive to..

- Detect short term variability and long term change in Elkhorn Slough and its watershed through various monitoring projects
- Produce unbiased, scientifically robust data as a result of short-term applied conservation research
- Disseminate data, reports, theses, research conclusions, and other relevant scientific information about Elkhorn Slough available
- Facilitate and encourage research to fill the highest-priority data gaps

- Encourage research by outside scientists
- Archive scientific information about Elkhorn Slough

Stewardship Program

California is a biological rich region, home to well over 4000 species of plants and almost 600 species of vertebrates (Myers et al 2000), but most of the state's natural ecosystems face serious anthropogenic threats. California has been designated a biodiversity hotspot, or an area where exceptional concentrations of endemic species are undergoing exceptional losses of habitat (Myers et al 2000). These losses occur in two basic ways. The first is through conversion, or the outright change of natural habitat into developed or agricultural areas. The second is through qualitative losses which involve changes or degradation in the structure, function, or composition of an ecosystem. At some level of degradation, an ecosystem ceases to be natural (Noss et al. 1995). Losses due to both conversion and degradation have been significant. California native grasslands have been reduced to about one percent of their original extent, both through land conversion and degradation by exotic species invasions. Other seriously threatened ecosystems include wetlands and riparian woodlands, which have been reduced to 10 percent or less of their original area (Noss et al. 1995). Predictably, many of the animal species dependent on these habitats have declined as well.

The Elkhorn Slough watershed shares many of the same human impact issues as other habitats across the state and the nation. For example, the Elkhorn Slough National Estuarine Research Reserve's (Elkhorn Slough NERR) grassland and oak woodland understories are, with few exceptions, highly degraded and invaded by exotic plants; its freshwater springs have been almost entirely lost due to groundwater overdraft; and 75% of its historical salt marshes have been lost through conversion, first to agricultural land, and later to mudflats and permanently subtidal lagoons. In order to preserve the natural habitats that remain, the Elkhorn Slough Reserve's stewardship program gives high priority to habitat protection within Reserve boundaries. In areas already degraded by past land uses, invasive species, or pollution, the stewardship program endeavors to sustainably recover or restore at least some of the lost aspects of local biodiversity and natural processes.

Purpose

The purpose of the Reserve's stewardship program is to protect and restore coastal habitats in the Elkhorn Slough watershed, with emphasis on the Elkhorn Slough NERR. The stewardship staff works collaboratively with the Reserve research and education staff to design and implement a number of projects including invasive species control, endangered species management, habitat mapping, ecological restoration, erosion control, community outreach, and applied research. CTP often provides information critical to scientifically-sound project design, and Reserve volunteers are frequently instrumental in project implementation. Through these actions, the stewardship program helps to protect and rehabilitate the diversity and integrity of native species and communities natural to the region. The main components of the stewardship program are briefly described below.

Goals

The Reserve's key stewardship goals are to:

- Protect intact, native habitats and sensitive species
- Restore degraded conservation targets
- Manage habitats that require ongoing manipulation
- Use restoration science and or adaptive management techniques that allow us to share, scientifically, with other land managers which techniques work, and which do not.

Operations and Facilities Program

It is difficult and sometimes even impossible to achieve many conservation goals without a healthy physical infrastructure in place. Buildings, roads, and parking areas must be built and maintained in order for basic activities to take place. Providing researcher and public access as well as interpretive services presents another suite of physical site needs and an increased responsibility to public health and safety.

Some operations and facilities activities overlap strongly with the Stewardship Program. For example, managing weeds is important for both improving native habitat and for fire protection.

Purpose

The purpose of the operations and facilities program is to provide a stable foundation of infrastructure upon which the Reserve's research, education, stewardship, and administration programs can succeed.

Goals

Elkhorn Slough NERR will strive to plan, construct, and operate facilities that:

- are well-maintained, attractive, safe, and fully-functional,
- comply with the requirements of the Americans with Disabilities Act,
- support multiple Reserve goals,
- minimize environmental impacts.

Chapter I.

Introduction

This document is the second edition of the management plan for the Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR), and covers the period from 2007-2011. This plan is a significant revision of the original management plan that was approved by the California Department of Fish and Game (CDFG) and the National Oceanic and Atmospheric Administration (NOAA) in 1985.

The first iteration of the management plan was developed after inclusion of the Elkhorn Slough NERR into the National Estuarine Research Reserve System (NERRS). During the development of the 1985 plan the Reserve was still in its infancy with most of its programs still just concepts on paper. However, over the last 20 years, through the hard work of many individuals, the Reserve has steadily evolved. Today the Elkhorn Slough NERR supports fully-functioning research, education, coastal training, and stewardship programs that are making significant contributions to the conservation of the estuary and its watershed. But the environmental threats facing the Reserve and the surrounding watershed remain great and there is still much work to be done.

A. Purpose and Scope of Management Plan

Federal regulations (*15 C.F.R. Part 921.13*) require each National Estuarine Research Reserve to have a federally-approved management plan that provides direction for the Reserve programs by identifying goals and objectives, management issues, strategies, and proposed actions for meeting established goals and objectives. Management plans provide the basis for evaluation of the reserve pursuant to Section 312 of the Coastal Zone Management Act (CZMA).

The *Elkhorn Slough NERR 2007-2011 Management Plan* provides an overview of the:

- environmental threats facing the Elkhorn Slough NERR and its watershed,
- long-term goals the Reserve has developed in order to mitigate those threats and achieve the Reserve's Mission,

- Reserve's objectives and strategies to move these goals forward over the next five years.

This management plan has been developed in accordance with the regulations of CDFG and NOAA, including all provisions for public involvement. It is consistent with the congressional intent of Section 315 of the CZMA, as amended.

B. Description, Mission, and Goals of the NERRS

The National Estuarine Reserve System was created by the Coastal Zone Management Act (CZMA) of 1972, as amended, 16 U.S.C. Section 1461, to augment the Federal Coastal Zone Management (CZM) Program. The CZM Program is dedicated to comprehensive, sustainable management of the nation's coasts.

The reserve system is a network of protected areas established to promote informed management of the Nation's estuaries and coastal habitats. The reserve system currently consists of 27 reserves in 22 states and territories, protecting over one million acres of estuarine lands and waters.

NERRS Mission

As stated in the NERRS regulations, 15 C.F.R. Part 921.1(a), the National Estuarine Research Reserve System mission is:

the establishment and management, through Federal-state cooperation, of a national system of Estuarine Research Reserves representative of the various regions and estuarine types in the United States. Estuarine Research Reserves are established to provide opportunities for long-term research, education, and interpretation.

Goals

Federal regulations, 15 C.F.R. Part 921.1(b), provide five specific goals for the reserve system:

(1) Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve resources;

(2) Address coastal management issues identified as significant through coordinated estuarine research within the System;

(3) Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;

(4) Promote Federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and

(5) Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

National Estuarine Research Reserve System Strategic Goals 2005 – 2010

The reserve system began a strategic planning process in 1994 in an effort to help NOAA achieve its environmental stewardship mission to "sustain healthy coasts." In conjunction with the strategic planning process, the Estuarine Reserves Division (ERD) and reserve staff have conducted a multi-year action planning process annually since 1996. The resulting three-year action plan provides an overall vision and direction for the reserve system. As part of this process, the reserve system developed a vision: Healthy estuaries and watersheds where coastal communities and ecosystems thrive; and mission: To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas. The following goals are outlined in the 2005-2010 Strategic Plan.

Goals:

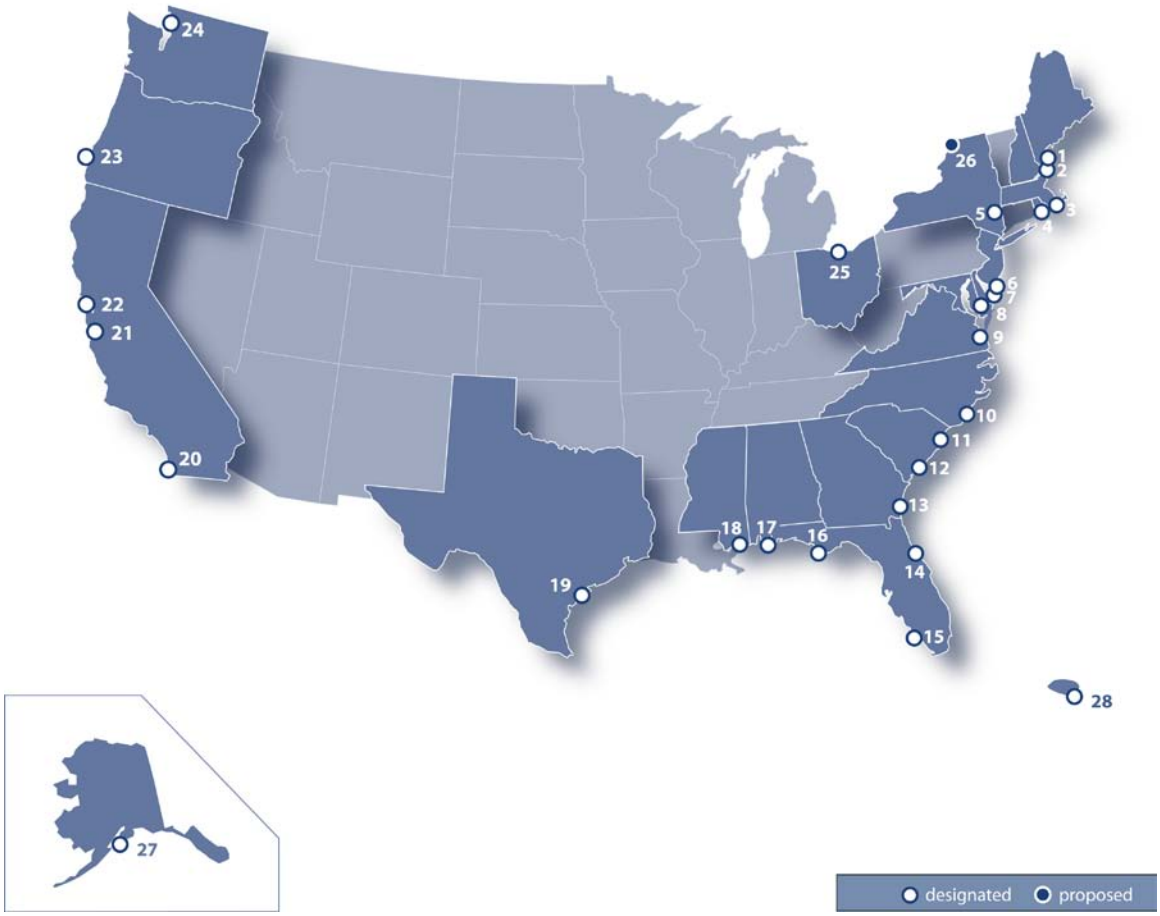
1. Strengthen the protection and management of representative estuarine ecosystems to advance estuarine conservation, research and education.

2. Increase the use of reserve science and sites to address priority coastal management issues.

3. Enhance peoples' ability and willingness to make informed decisions and take responsible actions that affect coastal communities and ecosystems.

Biogeographic Regions

NOAA has identified eleven distinct biogeographic regions and 29 subregions in the U.S., each of which contains several types of estuarine ecosystems (15 C.F.R. Part 921, Appendix I and II). When complete, the reserve system will contain examples of estuarine hydrologic and biological types characteristic of each biogeographic region. As of 2006, the reserve system includes 27 reserves and two reserves in the process of designation. The reserves are listed below by biogeographic region and subregion with their designation date denoted in parentheses (Figure 1.1).



Acadian – Southern Gulf of Maine
1. Wells Reserve, Maine (1984)
2. Great Bay Reserve, New Hampshire (1989)

Virginian - Southern New England
3. Waquoit Bay Reserve, Massachusetts (1988)
4. Narragansett Bay Reserve, Rhode Island (1980)
5. Hudson River Reserve, New York (1982)

Virginian – Middle Atlantic
6. Jacques Cousteau Reserve, New Jersey (1998)
7. Delaware Reserve (1993)

Virginian – Chesapeake Bay
8. Chesapeake Bay Reserve, Maryland (1985,1990)
9. Chesapeake Bay Reserve, Virginia (1991)

Carolinian – North Carolina
10. North Carolina Reserve (1985,1991)

Carolinian – South Atlantic
11.North Inlet-Winyah Bay Reserve, South Carolina (1992)
12. ACE Basin Reserve, South Carolina (1992)
13. Sapelo Island, Georgia (1976)

Carolinian – East Florida
14. Guana Tolomato Matanzas Reserve, Florida (1999)

West Indian – West Florida
15. Rookery Bay Reserve, Florida (1978)

Louisianan – Panhandle Coast
16. Apalachicola Reserve, Florida (1979)
17. Weeks Bay Reserve, Alabama (1986)

Louisianan – Mississippi Delta
18. Grand Bay Reserve, Mississippi (1999)

Louisianan – Western Gulf
19. Mission-Aransas Reserve, Texas (2006)

Californian – Southern California
20. Tijuana River Reserve, California (1982)

Californian – Central California
21. Elkhorn Slough Reserve, California (1979)

Californian – San Francisco Bay
22. San Francisco Bay, California (2003)

Columbian – Middle Pacific
23. South Slough Reserve, Oregon (1974)

Columbian – Puget Sound
24. Padilla Bay Reserve, Washington (1980)

Great Lakes – Lake Erie
25. Old Woman Creek, Ohio (1980)

Great Lakes – Lake Ontario
26. St. Lawrence River, New York (Proposed)

Fjord – Aleutian Islands
27. Kachemak Bay Reserve, Alaska (1999)

West Indian – Caribbean
28. Jobos Bay Reserve, Puerto Rico (1981)

Figure 1.1. Map of the reserves and represented bioregions in the National Estuarine Research Reserve System.

Reserve Designation and Operation

Under Federal law (16 U.S.C. Section 1461), a state can nominate an estuarine ecosystem for Research Reserve status so long as the site meets the following conditions:

1. The area is representative of its biogeographic region, is suitable for long-term research and contributes to the biogeographical and typological balance of the System;

2. The law of the coastal State provides long-term protection for the proposed Reserve's resources to ensure a stable environment for research;

3. Designation of the site as a Reserve will serve to enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation; and

4. The coastal State has complied with the requirements of any regulations issued by the Secretary of Commerce.

Reserve boundaries must include an adequate portion of the key land and water areas of the natural system to approximate an ecological unit and to ensure effective conservation.

If the proposed site is accepted into the reserve system, it is eligible for NOAA financial assistance on a cost-share basis with the state. The state exercises administrative and management control, consistent with its obligations to NOAA, as outlined in a memorandum of understanding. A reserve may apply to NOAA's ERD for funds to help support operations, research, monitoring, education/interpretation, stewardship, development projects, facility construction, and land acquisition.

National Estuarine Research Reserve System Administrative Framework

The Estuarine Reserves Division of the Office of Ocean and Coastal Resource Management (OCRM) administers the reserve system. The Division establishes

standards for designating and operating reserves, provides support for reserve operations and system-wide programming, undertakes projects that benefit the reserve system, and integrates information from individual reserves to support decision-making at the national level. As required by Federal regulation, 15 C.F.R. Part 921.40, OCRM periodically evaluates reserves for compliance with Federal requirements and with the individual reserve's Federally-approved management plan.

The Estuarine Reserves Division currently provides support for three system-wide programs: the System-Wide Monitoring Program, the Graduate Research Fellowship Program, and the Coastal Training Program. They also provide support for reserve initiatives on restoration science, invasive species, K-12 education, and reserve specific research, monitoring, education and resource stewardship initiatives and programs.

C. Description and Mission of the Elkhorn Slough NERR

The Elkhorn Slough NERR is an ecologically diverse 583 hectare (1,439 acre) protected area located on the eastern shore of the Elkhorn Slough, near the Monterey Bay in Central California (Figure 1.2). Elkhorn Slough is a seven-mile arm of the Monterey Bay located half way between the cities of Santa Cruz and Monterey. This arm bends as it extends inland, and at the "elbow" lies the Reserve.

As the primary terminus of the Elkhorn Slough watershed, the Reserve is part of a biologically rich system containing a diverse landscape of estuarine habitats, freshwater ponds, and hills containing native upland vegetation. These areas are interspersed with roads, working farms and residential housing.

Within the Reserve's boundaries there are lowland areas containing salt marsh, mudflats, and tidal lagoons, which flow into the slough's main channel. The Reserve's upland areas contain coastal prairie, maritime chaparral, oak woodland, pine and eucalyptus forest, and riparian/freshwater habitats.

Elkhorn Slough's tidal waters are part of the Monterey Bay National Marine Sanctuary, which is the largest of thirteen sanctuaries in the National Marine Sanctuary System. The

entire Elkhorn Slough estuary has also been designated a Globally Important Bird Area by the American Birding Conservancy, and a Western Hemisphere Shorebird Reserve by the Manomet Bird Observatory.

The Elkhorn Slough NERR represents the California Biogeographic Region and is protected for long-term research, water-quality monitoring, education and coastal stewardship. The Reserve also offers opportunities for public access and is home to an award-winning visitor's center. The property features several well-maintained hiking trails and has boardwalks, a wildlife viewing blind, and a fully-accessible scenic overlook.

The Reserve is owned and managed by CDFG and operates in partnership with NOAA and the local, non-profit Elkhorn Slough Foundation (ESF). At the State level, the Reserve is administered through DFG's Central Coast Regional Office (Region 3) located in Yountville.

ESNERR Mission

The mission of the Elkhorn Slough National Estuarine Research Reserve is to improve the understanding and stewardship of Elkhorn Slough and its watershed.

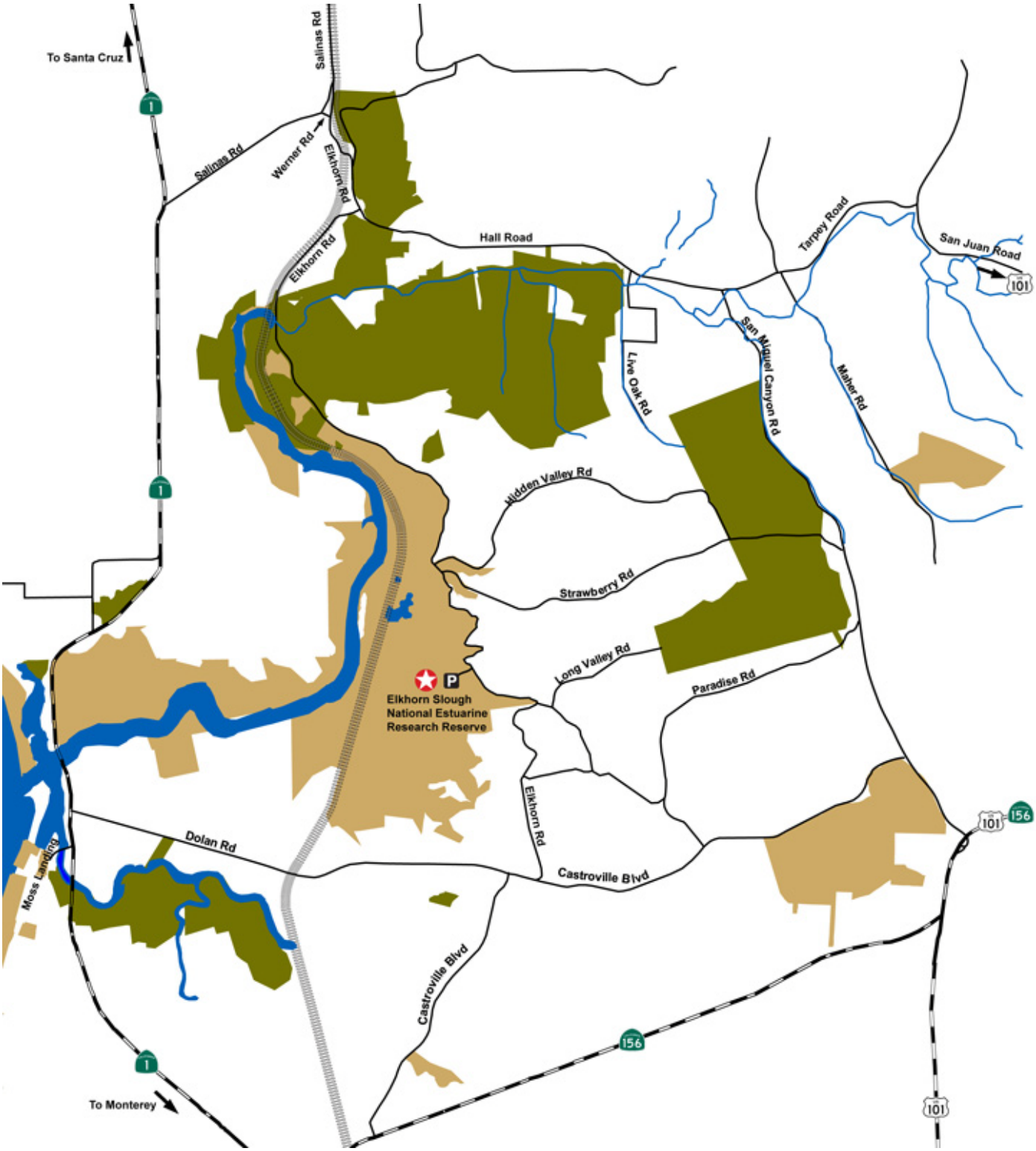


Figure 1.2. Map of the Elkhorn Slough in Central California.

D. Description and Mission of the CDFG

In 1870 the Board of Fish Commissioners was established "to provide for the restoration and preservation" of fish in California waters. This was the first wildlife conservation agency in the country. In 1878 the scope of the agency was expanded to include the management of game as well as fish and the agency's name was later changed to the California Department of Fish and Game.

Today, CDFG maintains native fish, wildlife, plant species and natural communities for their intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance in a sufficient amount and quality to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses.

CDFG Mission

The mission of the Department of Fish and Game is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

E. Description and Mission of the ESF

The Elkhorn Slough Foundation (ESF) is a nonprofit, member-supported organization working to conserve and restore Elkhorn Slough and its watershed. The Foundation works with ESNERR and other local, state, and national constituencies.

ESF was formed in 1982 primarily to support the work of the newly created Elkhorn Slough NERR. Its early successes included the creation of the volunteer, education and research programs at the Reserve and opening and expanding public access. Within a decade ESF took on a new role, when it began managing 800 acres of land owned by The Nature Conservancy. By the late 1990s ESF made the strategic decision to acquire, protect, and manage land itself.

In 1999, ESF adopted the Watershed Conservation Plan, developed with key partners including the Elkhorn Slough NERR. This plan remains the basis for ESF's Strategic Initiative. The plan calls for the balanced conservation of land and embraces the notion of a "working landscape." It calls for the protection of lands in four areas: the "Northern Crescent" of Elkhorn Slough, bordering on Carneros Creek, the Slough's primary source of fresh water; the "Southern Crescent" of the Slough, bordering on the Reserve; Moro Cojo Slough, which lies south of Elkhorn Slough; and the wetlands of the Springfield Terrace, west of the slough.

ESF currently manages more than 3,500 acres of conservation lands.

ESF Mission

The mission of the Elkhorn Slough Foundation is to conserve and restore Elkhorn Slough and its watershed.

F. National Focus on Estuarine Conservation

Estuaries—the vibrant coastal zones where rivers join with the sea—are uniquely productive natural systems. An estimated 95 percent of commercial fish and 85 percent of sport fish spend a portion of their lives in estuarine and coastal habitats (Pew Oceans Commission. 2003). But like so many natural environments, the nation's estuaries have fallen on hard times. Since the arrival of the Pilgrims, over half of our fresh and saltwater wetlands—more than 110 million acres—have been lost to development (Pew Oceans Commission. 2003). Within the estuaries that remain, human impacts are taking a toll. In 2001, 23 percent of the nation's estuarine areas were considered impaired for swimming, fishing, or supporting marine species (U.S. Commission on Ocean Policy. 2004).

The degradation of the nation's estuaries has come from multiple sources. Polluted runoff from the land has degraded estuarine habitats. A decline in fish stocks has weakened a complex web of marine life. Non-native species have been introduced, both

intentionally and accidentally, often resulting in significant economic costs, risks to human health, and ecological consequences that we are only beginning to comprehend.

Reversing human's impact on estuaries has taken on increased urgency in recent years, in part because things could get much worse. Experts predict that by 2025, 75 percent of our population will live within 50 miles of the coast (U.S. Commission on Ocean Policy. 2004).

On a national level, several groups have recently mapped strategies for protecting our oceans, coasts, and estuaries. Two of these groups, the United States Oceans Commission and the Pew Oceans Commission, have recommended several policy initiatives, some of which have already taken effect and many others that are being discussed on both the state and federal levels.

An initiative more specific to estuaries, the Estuary Restoration Act, was passed in 2000 and resulted in the creation of *A National Strategy to Restore Coastal and Estuarine Habitats* (RAE and NOAA. 2002). The Act makes a strong federal commitment and encourages public-private partnerships to restore habitat in America's estuaries. Specifically, the Act:

- Makes restoring America's estuaries a national priority.
- Creates the federal Estuary Habitat Restoration Council.
- Requires development of an Estuary Habitat Restoration Strategy.
- Sets a goal of restoring one million acres of estuarine habitat by 2010.
- Authorizes $275 million over five years for restoration projects.
- Requires enhanced monitoring, data sharing, and research capabilities.

G. Conservation of Elkhorn Slough

Elkhorn Slough has faced many of the same human impact issues as other estuaries across the nation. Over the past 150 years, human actions such as the diking and draining of wetlands, diversion of a river, and the construction of a railroad, boat harbor, roads, dams, and levees have seriously altered tidal, freshwater, and sediment processes in the

modern day Elkhorn Slough watershed. Hundreds of acres of salt marsh, channel, and tidal creek habitats have been lost or degraded as a result of these human modifications.

In addition to these local changes, at the state level California is home to one third of "at risk species" identified in the United States. The state is considered to be one of the 25 most significant biological hotspots in the world (Figure 1.3) (Stein 2000). There are twenty-one threatened or endangered species in the Elkhorn Slough and neighboring Pajaro and Salinas River watersheds (see Appendix 5).

Beginning in earnest in the 1970's a large citizen movement to protect Elkhorn Slough and its surrounding watershed began to take shape. This led the state to recommend that a management plan be developed for the Elkhorn Slough watershed and that both the Monterey Bay and Elkhorn Slough be considered for designation as national sanctuaries.

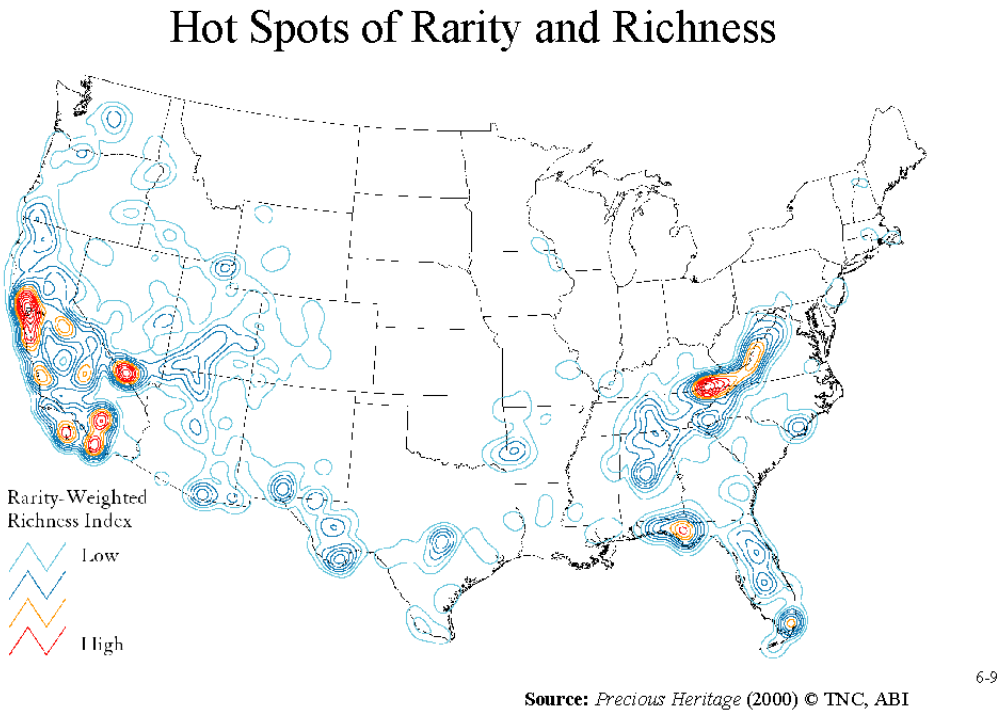


Figure 1.3 Map of biological hotspots found in the United States

In 1974, the California Coastal Commission, acting on recommendations from the public and local agencies, nominated Elkhorn Slough for designation as a federal estuarine sanctuary. In 1980, 405 hectares (1,000 acres) of Elkhorn Slough lands located on the old Elkhorn Dairy were purchased by the CDFG and the Elkhorn Slough Ecological Reserve was formed. With the site's Federal designation came the name Elkhorn Slough National Estuarine Sanctuary, and later the name was changed to the Elkhorn Slough NERR. Also, the CDFG purchased 283 hectares (700 acres) on the north side of the slough near its mouth and created the Moss Landing Wildlife Area.

In addition to the state-owned protected lands, during the last 20 years more than 3,000 hectares (7,000 acres) of key watershed habitats have been acquired and protected by ESF and The Nature Conservancy.

Today, an impressive variety of agencies, organizations, and individuals dedicate themselves, in whole or in part, to the conservation of Elkhorn Slough and its watershed.

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Estuary-Related Recommendations from the United States Oceans Commission& the Pew Oceans Commission:

U.S. Oceans Commission

Sound Science for Wise Decisions

- Double the nation's investment in ocean research, launch a new area of ocean exploration, and create the advanced technologies and modern infrastructure needed to support them.
- Implement the national Integrated Ocean Observing System and a national monitoring network.

Education—A Foundation for the Future

- Improve ocean-related education through coordinated and effective formal and informal efforts.

Specific Management Challenges

- Strengthen coastal and watershed management and the links between them.
- Set measurable goals for reducing water pollution, particularly from non-point sources, and strengthen incentives, technical assistance, enforcement, and other management tools to achieve those goals.
- Reform fisheries management by separating assessment and allocation, improving the Regional Fishery Management Council system, and exploring the use of dedicated access privileges.

Pew Oceans Commission

Preserving Our Coasts

- Develop an action plan to address non-point source pollution and protect water quality on a watershed basis.
- Identify and protect from development habitat critical for the functioning of coastal ecosystems.
- Institute effective mechanisms at all levels of government to manage development and minimize its impact on coastal ecosystems.
- Redirect government programs and subsidies away from harmful coastal development and toward beneficial activities, including restoration.

Science, Education, and Funding

- Develop and implement a comprehensive national ocean research and monitoring strategy.
- Double funding for basic ocean science and research.
- Improve the use of existing scientific information by creating a mechanism or institution that regularly provides independent scientific oversight of ocean and coastal management.
- Broaden ocean education and awareness through a commitment to teach and learn about our oceans, at all levels of society.

Elkhorn Slough NERR Mission, Vision, & Beliefs

MISSION
The mission of the Elkhorn Slough National Estuarine Research Reserve is to improve the understanding and stewardship of Elkhorn Slough and its watershed.

ESNERR VISION
ESNERR is a hub of substantive research, education, and resource management which models:

- biodiversity through the protection of existing native habitat and the restoration of disturbed habitat through adaptive management practices
- quality, hands-on interaction with watershed habitats without significant negative impact on the environment
- inspiration of diverse audiences to make personal commitments to environmental stewardship
- objective and responsible information exchange, interaction, and learning
- broad-based community involvement
- sound, up-to-date, and fiscally responsible infrastructure
- high professional standards by staff and volunteers
- long-term strategic planning

ESNERR STATEMENT OF BELIEFS
Global environmental health depends on widespread commitment to stewardship, both individually and collectively.

As an integral part of a natural system, the Reserve should maintain a watershed perspective.

Conservation best served when education, research, and resource management are interdependent and mutually supportive.

Reserve education should reflect best educational practice.

Everyone has the capacity to increase their knowledge and appreciation of the environment.

Reserve research should adhere to the highest standards of scientific inquiry.

Research should be widely accessible and results should be disseminated in a manner which is timely, clear, accurate, and unbiased.

Research should guide resource management decisions.

Optimal management of the Reserve contributes to long-term global environmental health.

Chapter II.

ESNERR Conservation Planning Process

To achieve long-term measurable conservation success in the Elkhorn Slough watershed, we combined Reserve-developed methodologies with tools developed by the disciplines of conservation planning and program design in a novel approach we hope will provide future direction to Reserve staff and their conservation partners. We first used extensive staff expertise and existing data to create a conservation assessment, which helped us to prioritize conservation targets. We then analyzed those targets to ascertain their predominant stresses and overall threats. Finally, we developed a comprehensive list of all of the actions needed to address stresses and threats and prioritized those actions which we felt could be achieved in the next 5 years. We plan on continuing this process, honing our conservation planning by collecting better information, and monitoring our performance in the coming years.

A. Conservation Assessment Framework

Conservation Action Planning

To assess the current environmental state of the Elkhorn Slough watershed, Elkhorn Slough NERR used a modified version of a conservation planning tool developed by the Nature Conservancy, referred to here as "Conservation Project Planning Workbook" (CPPW) (The Nature Conservancy 2005). The CPPW methodology provides a science-based approach for developing and evaluating the effectiveness of conservation strategies. The CPPW approach focuses on documenting and detailing the following components:

- **Systems**: Out of the entire list of all possibilities, define and prioritize fewer than 8 focal conservation targets, describing their key ecological attributes.
- **Stresses**: Identify the most serious types of impacts which threaten the conservation targets. Prioritize the stresses according to its severity and the geographic extent of its impact.

- **Sources of stress**: Clearly articulate the causes or agents of destruction or degradation. Rank these sources according to the ability to reverse it and its contribution to each stress.
- **Strategies**: List the full array of actions necessary to abate the threats or enhance the viability of the conservation targets. Determine who would be responsible for each, and how much time and money it would take to accomplish these tasks.
- **Success measures**: Define the specific thresholds that would determine success in protecting the systems. Detail the monitoring process for assessing progress in abating threats and improving the biodiversity health of a conservation area.

The logic underlying the CPPW framework is simple (Figure 2.1). It works by identifying priority conservation targets, which in the Reserve's case consist of ecosystems (all species associated with plant communities) and maintaining the long-term viability of these targets. The process focuses on the actions and resources that must be brought to bear to address the sources of the stresses to conservation priorities.

The Elkhorn Slough NERR used the first three steps of TNC's CPPW framework: prioritizing conservation targets (systems), describing each target's critical stresses and sources of those stresses, and ranking those identified stresses.

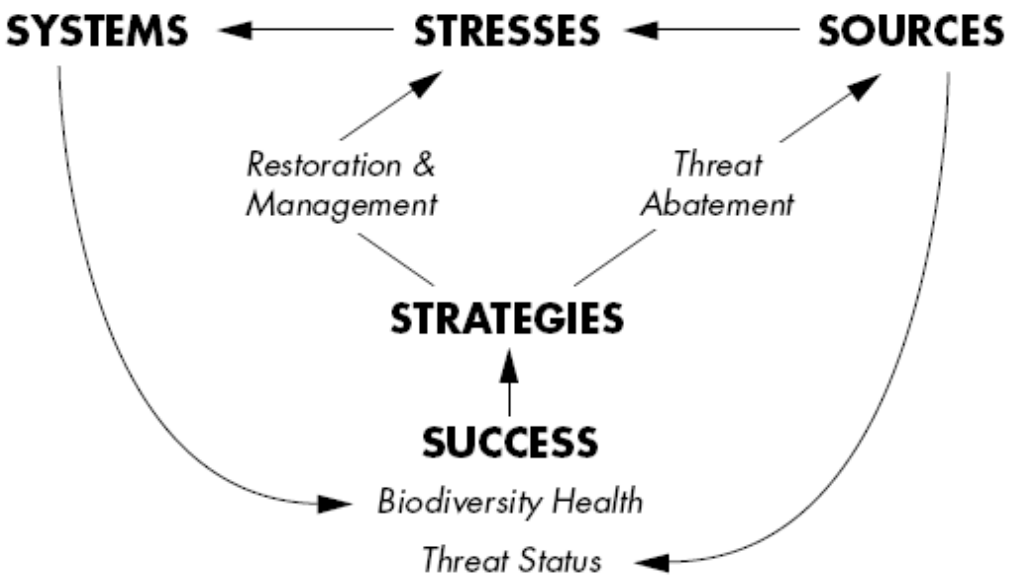

Figure 2.1. Framework for the Five S conservation planning tool (Low 2003).

After progressing through the first three steps of the CPPW process, the Elkhorn Slough NERR staff reanalyzed the targets by ranking each in terms of:

- estimated historical acreage loss,
- significance of the representation of the habitat in the watershed,
- number of listed species within the conservation target,
- overall urgency of addressing the conservation target in the near future,
- feasibility of restoration of the conservation target,
- the relative importance of the Reserve's niche in addressing the conservation target, and
- whether staff felt that addressing the conservation target was within the Reserve's Mission.

The purpose of this reanalysis was to rank the targets derived through the CPPW analysis because staff felt that financial and time resources were too limited to equally prioritize all targets. Staff also felt it important to corroborate the detailed, quantitative ('bottom up') CPPW approach with a more qualitative ('top down') approach – such a pairing of approaches has been suggested in the conservation literature (Hockings 2003).

Logic Models

In approaching the final two steps of the CPPW framework ('strategies' and measures of 'success'), the Elkhorn Slough NERR incorporated yet a third conservation planning approach, the logic model framework. The logic model framework is gaining popularity in program development throughout the United States (University of Wisconsin Extension 2006) and many in the NERR system are increasingly familiar with it because of training through NOAA's Coastal Services Center (Hinchcliff 2004). The logic model approach is designed to help clearly articulate long term goals and identify the suite of actions necessary to achieve those goals. The approach also requires identification of "SMART[1]" objectives for short, mid, and long term timeframes that would indicate progress towards the long term goal (Figure 2.2).

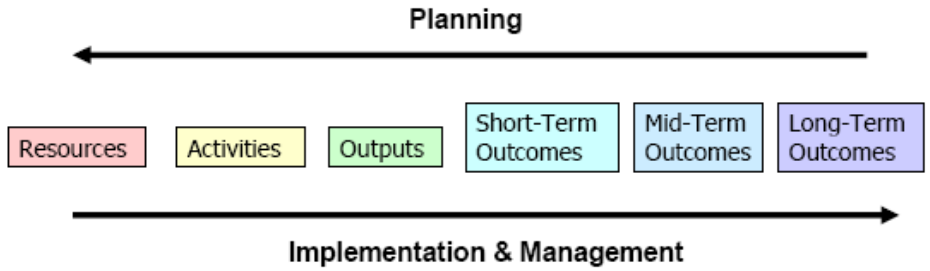

Figure 2.2: The essential elements of a typical program logic model, which is read from left to right using the terms "if" and "then" between boxes (e.g., if I have these *resources* then I will hold these *activities*; if I hold these *activities*, then I will get these *outputs*, etc.)

B. Description of Watershed Conservation Threats

Within the Elkhorn Slough watershed, we prioritized six of what we felt were the most threatened habitat types to include as the conservation targets as defined by the CPPW process. We avoided listing the suggested 8 top conservation targets because we felt that focusing on six would better focus limited conservation resources. Later in the planning

[1] SMART acronym: **S**pecific – Objectives should specify what they want to achieve; **M**easurable – You should be able to measure whether you are meeting the objectives or not; **A**chievable - Are the objectives you set, achievable and attainable?; **R**ealistic – Can you realistically achieve the objectives with the resources you have? **T**ime – When do you want to achieve the set objectives?

process, we further narrowed the conservation targets to five, grouping the riparian and freshwater wetlands into a single category. These are:

1. Tidal estuary
2. Coastal prairie/Coastal scrub
3. Maritime chaparral
4. Riparian/Freshwater wetlands
5. Coast live oak woodlands

We then identified the stresses affecting each of these systems (Table 2.1) and looked at the relative seriousness of the stress, which is a function of the following two factors:

- **Severity of damage.** What level of damage to the conservation target over at least some portion of the target occurrence can reasonably be expected within 10 years under current circumstances? Total destruction, serious or moderate degradation, or slight impairment?
- **Scope of damage.** What is the geographic scope of impact to the conservation target expected within 10 years under current circumstances? Is the stress pervasive throughout the target occurrences, or localized?

For each of the five conservation targets, we identified one or more stresses that ranked either "high" or "very high" in terms of severity and/or scope of the stress (Table 2.1). We also identified 3 of the most important sources of those stresses: agricultural activities, invasive species, and residential housing (Table 2.2).

C. ESNERR Conservation & Organizational Goals

Using the "high" and "very high" stresses identified during the TNC CPPW process, we developed a set of long-term conservation goals. The first six goals focus on protecting and enhancing native biodiversity and natural ecological processes in the watershed. Goals seven and eight are broader and support a more general understanding and appreciation of coastal ecosystems. The last goal is the Reserve's organizational goal and supports the long-term health of the Reserve's human and physical organization. This last goal is critical to achieving the aforementioned conservation goals.

The Reserve's long-term goals are:

Habitat-Specific Conservation Goals

1. Protect and restore the watershed's key estuarine habitats
2. Protect and restore the watershed's key freshwater wetland habitats
3. Protect and restore the watershed's key maritime chaparral habitats
4. Protect and restore the watershed's key coastal prairie habitats
5. Protect and restore the watershed's key coast live oak habitats

Broad Conservation Goals

6. Reduce pollution across watershed habitats
7. Monitor priority habitats and key species in the watershed and identify emerging threats
8. Educate the community and inspire them to consider environmental conservation when making decisions that affect Elkhorn Slough and its watershed

Human and Physical Organization Goal

9. Maintain a viable Elkhorn Slough NERR organization.

Table 2.1. Rank of stresses affecting priority conservation targets in the Elkhorn Slough watershed

Stresses - Altered Key Ecological Attributes	Severity	Scope	Overall Stress Rank
Tidal Estuary			
Erosion	High	Very High	High
Restriction of flow	High	High	High
Pollution	High	Very High	High
Biological invasions	High	Very High	High
Coastal Prairie/Coastal Scrub			
Biological invasions	High	Very High	High
Maritime Chaparral			
Altered fire regime	High	Very High	High
Habitat conversion	Very High	High	High
Biological invasions	High	Medium	Medium
Altered adjacent habitat	Medium	High	Medium
Erosion	Medium	Medium	Medium
Riparian			
Pollution	High	Very High	High
Altered adjacent habitat	High	High	High
Fluctuation of groundwater levels	High	Very High	High
Freshwater Wetlands			
Pollution	High	High	High
Groundwater	Very High	High	High
Altered sediment deposition processes	High	High	High
Biological invasions	High	Very High	High
Altered hydrologic regime	High	High	High
Coast Live Oak/Woodland			
Habitat conversion	Very High	Medium	Medium
Biological invasions	High	High	High
Erosion	Medium	Low	Low
Altered adjacent habitat	Medium	Medium	Medium

Table 2.2. Rank of threats (sources of ecological stresses) across six priority conservation targets of the Elkhorn Slough Watershed.

	Threats Across Systems Project-specific threats	Riparian	Tidal estuarine system	Freshwater Wetlands	Coastal Prairie/Coastal Scrub Complex	Central maritime chaparral	Coast live oak woodland	Overall Threat Rank
1	Agricultural activities	Very High	High	Very High	-	High	Medium	Very High
2	Residential housing	High	Medium	High	High	High	High	High
3	Invasive Species	Low	High	-	High	-	-	High
4	Water restriction devices: management for ecosystem services other than indigenous	Medium	High	-	-	-	-	Medium
5	Roads	High	-	Medium	-	-	-	Medium
6	Moss Landing Harbor	-	High	-	-	-	-	Medium
7	Altered Fire Regime	-	-	-	-	High	-	Medium
8	Mosquito abatement	-	-	High	-	-	-	Medium
9	Air nutrient loading from atmosphere and agriculture	Medium	Medium	-	Medium	-	-	Medium
10	Commercial and Industrial Development	Medium	Low	Medium	-	-	-	Medium
11	Increased public access to Slough	-	Medium	-	Medium	-	-	Medium
12	Introduced Genetic Material	-	-	-	Medium	Medium	-	Medium
13	Development of certain areas for ecosystem services	Low	-	-	Medium	-	-	Low
14	Removal of ungulate grazing - inappropriate grazing regimes	-	-	-	Medium	-	-	Low
15	Invasion of Baccharis	-	-	-	Medium	-	-	Low
16	Dumping	-	Low	Low	-	-	-	Low

D. Prioritization of Goals and Actions

We identified a comprehensive list of actions appropriate for the Elkhorn Slough NERR. These actions were paired with the aforementioned outputs and spanned research, education, stewardship and land acquisition. Reserve staff then worked to prioritize those actions that could reasonably be approached over the next five years with the resources available.

The prioritization process involved two steps. In the first, we prioritized the Reserve's long-term goals by scoring each for:

- Potential for conservation return versus investment,
- Number of endangered and threatened species within the target,
- Overall urgency of addressing the target in the near future,
- The relative importance of ESNERR staff expertise in addressing the target, and
- Whether staff felt that the target warranted ESNERR involvement because of NERRS mission.

Second, each program lead further prioritized by suggesting which of their program's actions could be achieved with the resources that program typically can engender.

The final product was a list of actions that will be worked on over the next five years and which are the focus of this management plan. Actions that were not prioritized because of lack of resources (winnowed from the second prioritization process, above) remain of great importance and are included in this management plan in hopes of acquiring additional resources. We will seek additional funding and work with our partners to strategize ways to complete any of the actions remaining from the logic models we developed so that all of the prioritized goals will be accomplished. To do this, we will be embarking on a science-based strategic planning process during the course of this management plan's timeframe.

E. Strategic Planning and Adaptive Management

The Elkhorn Slough NERR continues its conservation leadership through ongoing strategic planning that updates and populates the conservation planning tools we have developed through this management planning process. For each conservation goal, we have formed working groups that will meet periodically to improve and update the planning that has occurred thus far. For instance, we will develop measurable outcomes/measures of success and work with partners to better understand the other resources that can be expected to help achieve prioritized goals. The workgroups will also examine approaches to address the actual threats to priority conservation targets rather than the more symptomatic stresses. The information generated during these ongoing workgroup meetings will help to inform an adaptive management approach (Walters 1986; Gunderson, Holling et al. 1995) and prepare the Reserve to re-examine its work during the next management plan update.

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Chapter III. ESNERR Goal #1
Protect and Restore Estuarine Habitats in the Watershed

A. Introduction

Estuaries are coastal inlets where the fresh water of rivers and streams mixes with the salty water of the ocean. Estuarine habitats at Elkhorn Slough include productive salt marshes, rich mudflats, and meandering tidal channels and creeks. Dozens of vascular algae and plant species, over 100 fish species, over 135 bird species, and over 550 invertebrate species have been reported from Elkhorn Slough's estuarine habitats (Caffrey et al. 2002). Many of these are species that have broad aquatic distributions, but some are almost entirely restricted to estuarine or brackish conditions, and therefore of special conservation concern at Elkhorn Slough. These include species such as eelgrass, pickleweed, the native oyster, and the tidewater goby. The relative rarity of estuarine habitats along the Pacific coast makes Elkhorn Slough's role in supporting species dependent on estuarine habitats all the more essential.

While Elkhorn Slough today still hosts extensive estuarine habitats and diverse species, there is strong evidence that local biodiversity is threatened, and has already undergone significant changes in the past centuries (Caffrey et al. 2002). The modifications which have occurred at Elkhorn Slough are not isolated as they have occurred worldwide as a result of human use. Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes which are essential to support and sustain Elkhorn Slough's estuarine habitats. This has led to substantial changes in the extent and distribution of different estuarine habitat types (Figure 3.1). Major threats to estuarine habitats result from increased rates of tidal erosion, marsh drowning, and dikes. The accelerated rate of bank and channel erosion in Elkhorn Slough is causing tidal creeks to deepen and widen reducing functions for estuarine fish, salt marshes to collapse into the channel and die, and soft sediments that provide important habitat for invertebrates to be eroded from channel and mudflat habitats. Increases in the flooding of tidal waters on marshes are causing plants to "drown" in central areas of the marsh. Based on current knowledge, the accelerated rates of tidal erosion and marsh drowning are primarily due to the estuarine mouth modifications. The subsidence of marsh areas, the loss of riverine

sediment inputs, and sea level rise may also contribute to marsh drowning because marsh plants are sensitive to changes in both hydrodynamics and elevation. Diking causes tidal marsh loss through the conversion to different habitat types and degradation due to subsidence, loss of tidal connectivity, and decreased water quality conditions. Since the 1870s, approximately 30 percent of the salt marsh has been lost due to the construction of levees to drain wetlands for cattle grazing, railroad and road construction, and the creation of freshwater impoundments for duck hunting (Van Dyke and Wasson 2005). After a harbor was constructed at the mouth of Elkhorn Slough in 1947, 50 percent of the salt marsh was lost due to the marsh drowning and bank erosion and continues today at dramatic rates (Van Dyke and Wasson 2005). Tidal creek, mudflat, and channel habitats are also degraded by tidal erosion, which results in approximately two million cubic feet of sediment being exported from Elkhorn Slough each year. Reserve staff members are leading a large, collaborative effort, the Elkhorn Slough Tidal Wetland Project (TWP), with the assistance of many partners to develop specific recommendations to conserve and restore estuarine habitats and implement them. The first two objectives in this section describe these efforts.

A second major threat to the Slough's estuarine habitats is biological invasions by non-native species that arrived mostly with non-native cultured oysters and on fouled boat hulls. Over 80 non-native species have been documented in the Slough's estuarine habitats, and the most common, conspicuous invertebrates encountered on a low tide at Elkhorn Slough are invaders (Wasson et al. 2001). Some of these are having significant effects on native communities. The final three objectives in this section address the threat of invasions.

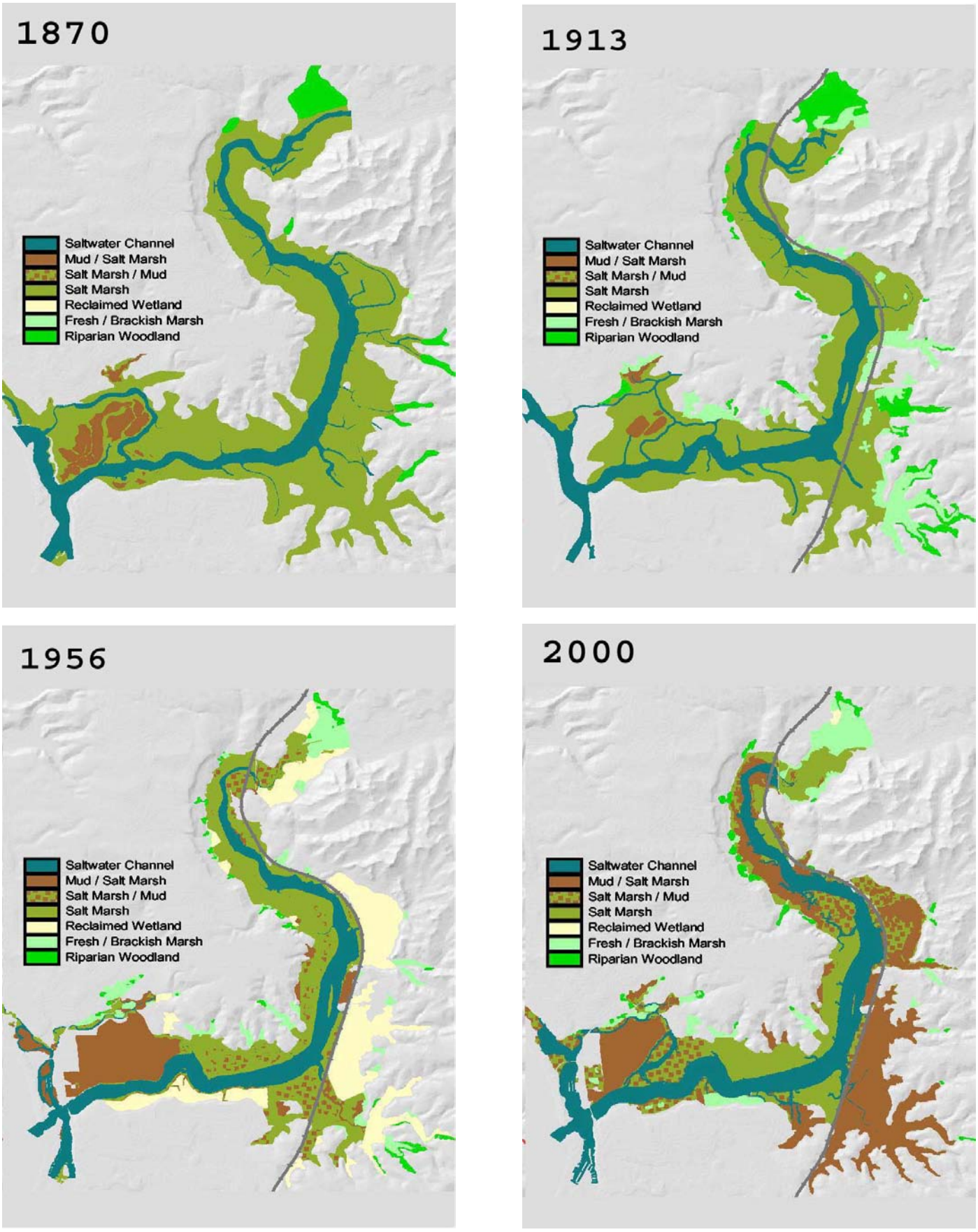

Figure 3.1. Changes to tidal habitat composition in Elkhorn Slough from 1870 to 2000 based on map and aerial photograph interpretations (Van Dyke and Wasson 2005).

A third main threat to estuarine habitats at Elkhorn Slough is non-point source pollution, including substantial agricultural run-off. Remarkably high nutrient and pesticide concentrations have been documented in the Slough's estuarine habitats. Few studies have directly addressed the ecological impacts of pollution at Elkhorn Slough, but based on published studies elsewhere, it is possible that changes in water quality have increased the abundance of nutrient-limited producers (e.g., macroalgae such as sea lettuce) and pollution-tolerant animals, while decreasing the abundance of pollution-intolerant species. This threat is addressed under Goal 6 in Chapter VIII of this plan.

Other possible threats to estuarine habitats at Elkhorn Slough include public access impacts, cattle trampling in marshes, and commercial activities such as a wrecking yard, and the Moss Landing Power Plant that takes in large volumes of water in the Moss Landing Harbor area for its cooling system. The role of these factors on the entire estuarine ecosystem has not been thoroughly characterized, and may be minor relative to the three major threats described above, but Reserve staff continues to track the development and impacts of these potential threats. In the coming decade, however, the majority of Reserve staff efforts with regard to estuarine habitats will be focused on the three strategies described below.

Estuarine Habitats facing Restricted Tidal Circulation

In 1872, the Southern Pacific Railroad was extended through the tidal wetlands of Elkhorn Slough, creating a large levee between marshes and tidal creeks on the east and west sides of the main channel. Local landowners built additional levees and dikes so that the impounded areas could be used for duck ponds (1930s), cattle grazing (1940s-1950s), and roads. By the 1960s, approximately 900 acres (30 percent of all tidal marsh areas) in Elkhorn Slough were isolated from the Slough and converted for human uses through diking and draining. The construction of dikes caused the marsh surface to subside which occurs as a result of several processes including drying out of soils, soil compaction and organic matter decomposition, loss of sediment imported with regular tidal flooding, and changes to water movement and storage (Cahoon et al. 1999). In areas where full or muted tidal flow has been returned to these subsided wetlands, mudflats and

lagoons have replaced historic salt marsh because of a decrease in elevation of several feet. As a result of past tidal restriction, restoration projects must address the subsidence of marsh elevations. At the same time, land use and freshwater input changes (i.e. diversion of the Salinas River) have reduced the input of riverine sediments normally entering the Slough and building marsh elevations. In addition, a number of estuarine wetlands are behind water control structures or levees which restrict tidal exchange and can reduce water quality due to hypersalinity.

In 1983, tidal flow was returned to approximately 415 acres of estuarine habitats in Elkhorn Slough, known as the Parsons Slough/South Marsh Complex, through both intentional (tidal restoration) and unintentional (winter storms) means. This area continues to be threatened from accelerated rates of tidal erosion and the loss of marsh elevations from subsidence. The Parsons Slough/South Marsh Complex currently supports mostly mudflat and subtidal habitat. There is an opportunity to restore the original complex network of salt marsh and tidal creeks by manipulating marsh elevations. This area may benefit from the installation of a structure to reduce tidal velocities (i.e. culverts, tide gates, earthen or rock levees, or sill) and sediment additions. Although structures are not a preferred restoration technique due to the high-level of maintenance required over time, the options are limited in this high energy system and all efforts will be made to make them adaptable. If large-scale restoration efforts take place (see strategy 2), long-term activities could include the removal of structures and levees that separate estuarine habitats, but in the short-term, the resulting hydrological change could accelerate tidal marsh loss in the rest of Elkhorn Slough.

A phased approach will be taken to reduce the loss of high quality estuarine habitats, restore estuarine habitats that have been lost and the natural processes that support them. These recommended restoration and enhancement activities will be revised and summarized in detail in the final *Elkhorn Slough Tidal Wetland Plan* that will be completed and publicly available in 2007.

Estuarine Habitats facing Tidal Erosion and Marsh Drowning

Since 1947, the primary cause of salt marsh loss in Elkhorn Slough has been drowning of the marsh in central areas due to increased tidal inundation and subsidence and tidal (bank and channel) erosion along the edges of marshes. The modification of the Elkhorn Slough mouth for the creation of a harbor permanently fixed a deeper opening to Monterey Bay, and is the main cause of subtidal erosion and more recent marsh loss/conversion. Contributing factors may include the decreases in sediment supply due to the diversion of the Salinas River, dike/levee failure and removal, the presence of the Monterey Canyon directly in line with the Slough's modified mouth, sea level rise (Cayan et al. 2005), subsidence of marsh areas (could be due to groundwater overdraft, tectonic activities, etc.), wave action, and other biogeochemical processes.

The Elkhorn Slough estuary, containing California's second largest tract of salt marsh, is currently facing unprecedented rates of tidal wetland loss and degradation. Due to human modifications, the ecosystem has become unbalanced and is experiencing accelerated rates of marsh drowning and tidal erosion. This has resulted in a 50 percent loss of tidal marsh through "drowning" of the vegetation in central areas and bank erosion which causes the marsh to collapse into the channel along the edges. Tidal creeks have eroded deepened and widened approximately five times (from an average width of eight feet to forty feet) reducing habitat use by estuarine fish species. Based on a number of meetings with a science panel over the past two years, there is agreement that the estuary is not in a stable state. In fact, almost two million cubic feet of sediment is exported from the Slough each year through habitat loss and degradation. These trends are predicted to continue in the near future if no management actions are taken.

In order to reduce the rapid tidal salt marsh loss and the loss of sediments from channel and tidal creek habitats, the Reserve will continue to lead the Elkhorn Slough Tidal Wetland Project. In the next few years, we will explore the feasibility of different restoration and conservation alternatives with the help of estuarine modeling, tidal hydrology/geomorphology, and habitat restoration experts. We will conduct targeted research to address the key uncertainties about the mechanisms of marsh loss. We also plan to provide community outreach to through meetings and written materials so that

they better understand the complex threats and the possible large-scale conservation and restoration actions that may be proposed. Potential large-scale alternatives could include the modification of the dimensions and/or location of the Elkhorn Slough's mouth to replicate past conditions and the addition of sediment to marsh areas to address elevation issues.

Elkhorn Slough Biological Invaders

Estuaries are by far the most highly invaded coastal habitat types (Wasson et al. 2005). About 60 non-native invertebrates have been documented at Elkhorn Slough, and they include some of the most common species encountered, such as the European Green Crab and the Japanese Mud Snail (Wasson et al. 2001). There are also common algal, plant, and fish invaders in Slough estuarine habitats. Between the 1930s and 1970s, the majority of these invaders probably arrived with shipments of non-native oysters that were cultured at the Slough. Since then, the main introduction route is via hull-fouling on small boats traveling to Moss Landing Harbor. Most of the species arriving in recent decades first became established in San Francisco Bay (to which they were introduced largely by commercial shipping), then spread via boat traffic as well as natural transport of larvae on currents up and down the coast (Wasson et al. 2001). Marine and estuarine invasions have been shown to cause local extinction of native competitors and prey organisms, alteration of community composition and food webs, change in physical habitat structure, and even alteration of flow of energy and materials through whole ecosystems (Grosholz 2002).

In addition to aquatic invaders, non-native upland species have invaded Slough habitats. More than 30 terrestrial non-native plants have been found in the high marsh in the watershed, and these account for about 15% of cover in this rich, narrow transition zone to the upland (K. Wasson and A. Woolfolk, unpublished data). In some places, non-native species such as poison hemlock and ice plant form a virtual monoculture, accounting for the majority of cover in the marsh upland ecotone.

Once invaders become widespread and abundant, they are extremely difficult, if not impossible, to eradicate. However, rapid responses to some recent invasions have resulted in successful eradication or imminent eradication demonstrating the critical need for monitoring and early detection of invaders (Bax 1999, Culver and Kuris 2000, Miller et al. 2004). Management efforts thus should focus on 1) prevention of new introductions, 2) early detection and eradication of new introductions before establishment and spread, and 3) restoration strategies that help favor dominance by native assemblages rather than established non-natives. The Reserve's actions fall into these three areas, as described below.

B. ESNERR Objectives & Strategies

The Tidal Wetland Planning (TWP) team consists of staff from the Reserve's Research, Stewardship, Education, and CTP Programs

Objective 1. Restore and Enhance Estuarine Habitats with Restricted Tidal Flows.
Objective 2. Reduce Erosion in Subtidal Habitats and the Loss and Degradation of Intertidal Habitats.

Strategies (for Objectives 1 & 2)**:**

1. The TWP Team will complete the Elkhorn Slough Tidal Wetland Plan which outlines restoration strategies for estuarine habitats. In order to accomplish this we will:
    i. hold meetings with partners and experts to develop project goals, objectives, and tasks that will support decisions about management and restoration strategies.
    ii. write, revise, and review sections of the *Elkhorn Slough Tidal Wetland Plan*.
    iii. continue to involve a technical advisory group to plan and guide project research and monitoring efforts.

2. The TWP team will obtain funding and permits and develop designs to implement research, restoration, and monitoring projects recommended in the Elkhorn Slough Tidal Wetland Plan. The Reserve will sustain collaborative efforts for the implementation of estuarine restoration projects. In order to accomplish this we will:

i. identify lead agencies, obtain funding, and oversee contractors that will complete preliminary restoration designs, model potential results, and obtain permits for restoration projects. Preliminary designs and the permitting process may be completed for smaller-scale projects.

ii. hold meetings with partners and technical experts to guide the development of restoration designs, modeling, research, and monitoring activities.

iii. conduct research studies, restoration pilot projects, and monitoring activities of estuarine habitats. Monitoring projects will include support for the installation of tide stations to evaluate tidal inundation patterns and surface elevation tables (SET) and feldspar soil horizon markers to determine the rates of sediment accumulation/erosion and vertical accretion in tidal wetlands. Research projects include the evaluation of how ecological communities respond to different levels of tidal exchange and a comparison of key ecological indicators as they are affected by potential large-scale restoration projects.

iv. support and oversee contracts for research studies, restoration pilot projects, and monitoring activities of estuarine habitats. Monitoring projects will include the installation of tide stations and surface elevation tables (SET). Projects could also include (depending on funding) studies to evaluate the feasibility of sediment addition strategies, determine marsh sediment characteristics, estimate the overall sediment budget of Elkhorn Slough, investigate the role of macroalgae cover and marsh loss, and evaluate historical habitat and

salinity conditions. A technical advisory group will be used to help develop and prioritize research and monitoring goals.

v. identify and if feasible, begin the implementation of restoration and enhancement activities for tidal habitats owned and managed by the Reserve including North Marsh, Estrada Marsh, South Marsh, and Parsons Slough. Potential actions may include the maintenance or improvement of water control structures to reduce hypersalinity issues, the installation of water control structures to reduce tidal erosion, or the addition of sediment to raise the elevation of subsided wetland areas to support marsh growth.

vi. obtain continued funding for an Elkhorn Slough Tidal Wetland Project Coordinator position and support for the involvement of partners, experts, and stakeholders.

vii. hold meetings to integrate ESNERR program activities.

3. The TWP team will hold meetings, workshops, generate and disseminate outreach materials, and explore land acquisition to obtain support for estuarine restoration and protection projects. In order to accomplish this we will:

i. hold meetings with key stakeholders and organizations to describe the estuarine habitat threats from tidal erosion and marsh drowning.

4. The CTP Staff will hold Coastal Training Program workshops at Elkhorn Slough about tidal restoration efforts that have already been implemented in other parts of the country.

5. The TWP team will create and disseminate outreach materials (newspaper articles, brochures, etc.) to the general public about threats to estuarine habitats and restoration projects.

Objective 3. Prevent new biological introductions into the Elkhorn Slough

Strategies:

1. The Research team will continue and expand current efforts to educate the public about the value of native estuarine diversity, and explain measures that can be taken by individuals to prevent invasions. This action will build support for regional prevention policy as well as directly reduce the chance of introductions of non-natives by individuals through mechanisms such as release of live bait or aquarium organisms.

2. The Research team will collaborate with regional policy development, by supporting various agencies with requests for information and participation in meetings aimed at developing policy (such as ballast water discharge protocols or hull-cleaning protocols) that decrease introductions at a broad geographic scale.

Objective 4. Detect and eradicate new biological introductions into the Elkhorn Slough

Strategies:

1. The Research team will continue early detection program by continuing to disseminate booklets (available online from www.elkhornslough.org/invader.htm) describing two dozen "least wanted" species that have not yet arrived in Elkhorn Slough, yet are likely to have major ecological impacts if they become established.

2. The Research team will continue annual rapid assessments of estuarine habitats, surveying for plants, algae and invertebrates in Elkhorn Slough to detect changes in native biodiversity and established non-natives, as well as to detect arrival of new species.

3. The Research team will support regional partners, especially Monterey Bay National Marine Sanctuary and California Department of Fish and

Game, in efforts to develop rapid response protocols that identify in advance methods, funding, permitting, and lead agencies that would be appropriate for eradication of new invaders immediately after detection.

Objective 5. Develop restoration strategies that help favor dominance by native assemblages.

Strategies:

1. The Research team will encourage and support research predicting success and ecological impacts of key regional invaders, especially by Graduate Research Fellows.

2. The Research team will develop restoration strategies that favor native over non-native biodiversity. In order to accomplish this we will:
    i. conduct literature surveys, attend workshops, and carry out field experiments to identify the biological and physical conditions that favor native estuarine assemblages, and particularly two former estuarine dominants that are now rare, native oysters and eelgrass.

3. The Research staff will complete an on-going investigation into the role of tidal restriction and cattle trampling on ecotone invasion by non-native plants, and explore the feasibility of restoration strategies for this fragile zone.

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Chapter IV. ESNERR Goal #2
Protect and restore the watershed's key freshwater habitats

A. Introduction

Freshwater wetlands occur where land surfaces are saturated or covered by freshwater for sufficient time that the resulting plant community has adaptations to survive these stressful conditions. In the Elkhorn Slough watershed, freshwater habitats occur as riparian corridors, wet meadows, freshwater marshes, and ponds. Riparian habitats are plant assemblages associated with streambanks. Within the watershed, riparian vegetation is dominated by willow (*Salix*) and is found primarily along Carneros Creek. Wet meadows occur in areas without standing water, but where soils are seasonally saturated and hydric. They sometimes occur as transitional areas between upland grasslands and freshwater marshes, and commonly include sedge (*Carex*), oatgrass (*Danthonia*), hairgrass (*Deschampsia*), barley (*Hordeum*), rush (*Juncus*), buttercup (*Ranunculus*), and bulrush (*Scirpus*) (Ratliff 1988). Freshwater marsh refers to emergent vegetation growing in at least semi-permanent shallow freshwater. The most frequently dominant freshwater marsh species are bulrush (*Scirpus*) and cattail (*Typha*) (Kramer 1988). Open freshwater ponds also occur in the watershed, and include both natural features, such as Werner Lake and McClusky Slough, artificially created agricultural ponds, and artificial impoundments in former estuarine habitats, including the Reserve's Rookery Pond and Cattail Swale. Also present, but not as well-documented in the watershed, are freshwater seeps and vernal pools.

Freshwater habitats provide important habitat for diverse communities of plants and animals, including sensitive species such as the Santa Cruz Long-toed Salamander (*Ambystoma macrodactylum croceum*), California Tiger Salamander (*Ambystoma californiense*), California Red-legged Frog (*Rana draytonii*), and the Southwestern Pond Turtle (*Actinemys marmorata pallida*). Unfortunately, freshwater habitats have experienced significant losses over the last 150 years. A network of shallow lakes and freshwater marshes that once extended from south of the city of Salinas to north of the city of Watsonville was drained in the late 1800s and early 1900s for agriculture (Gordon

1996). A series of small upland ponds just north and south of lower Moro Cojo Slough was converted to agricultural and industrial land (Johnson and Rodgers 1854). Freshwater springs and seeps that were once common along the edges of Elkhorn Slough have been lost since the 1940s, presumably due to lowered groundwater levels resulting from agricultural and domestic pumping (Van Dyke and Wasson 2005).

Some freshwater habitats do remain in the watershed, but most face at least some level of ongoing threat. In many cases, exotic plants invade native plant communities, and introduced fishes and amphibians prey upon threatened and endangered animals. In other cases, ponds, marshes and meadows are affected by excessive agricultural runoff which results in sediment accumulation, increased turbidity, and other pollutants. Furthermore, many of the watershed's ponds are man-made, created from former salt marshes or seasonal streams, or otherwise excavated to form sediment basins or stock ponds. Presumably the hydroperiod, vegetation, and sediment characteristics of these waterbodies are quite different than the original freshwater wetlands that have been lost. The subsequent changes have influenced the plant and animal assemblages that currently inhabit these sites.

Key Freshwater Habitats

Although many freshwater springs, wet meadows, marshes, and shallow lakes have been lost in north Monterey County over the last 150 years, some of these habitats, either natural or artificial, do persist in the Elkhorn Slough watershed. Today, natural freshwater meadow habitat can be found in on the valley floor of the Elkhorn Slough Foundation's (ESF) and the Elkhorn Slough National Estuarine Research Reserve's (Elkhorn Slough NERR) Long Valley and in areas of the ESF's Porter Ranch. Natural freshwater marsh remains in portions of south Strawberry Marsh, at the confluence of Porter Marsh and Corncob Canyon Creek, in the lowest reaches of Carneros Creek, and in portions of McClusky Slough. Natural ponds remain at McClusky Slough and in a string of ponds extending from Werner Lake to several spots along San Miguel Canyon Road and off San Juan Road. Artificial ponds are scattered throughout the watershed. Often, these were constructed as impoundments in natural drainages, or created from

diked salt marsh to form duck hunting ponds. On the Reserve, eighteen plumbed wildlife watering devices ('guzzlers') were installed in the 1980s to provide water for a variety of wildlife. Other artificial freshwater ponds on the Reserve include Upper and Lower Cattail Swale, Rookery Ponds 1, 2, and 3, Upper and Lower Barn Ponds, and the Five-fingers Pond. These features provide freshwater habitat, but many rely on piped-in well water, have unnatural hydroperiods, or have been severely degraded by pollution and infilling by accelerated rates of agricultural sediments from some surrounding fields. Altering these systems can shift the community composition of plants, vertebrates, and invertebrates (Wellborn et al. 1996, Relyea and Mills 2001, Knutson et al. 2004, Zedler and Kercher 2004, Whiles and Goldowitz 2005). Thus, although some of these altered habitats may provide critical habitat for rare species, others are actually sinks (habitats where local reproduction is insufficient to balance local mortality) for some native species due to the presence of introduced predators. A clear example of this is the presence of the introduced American Bullfrog (*Rana catesbeiana*) that occurs throughout the watershed primarily at long-lived or permanent wetlands. This species is known to have significant impacts on native Ranid species (Kiesecker et al. 2001, Kats and Ferrer 2003) and has been observed eating red-legged frogs in the Elkhorn Slough watershed.

Today, remaining freshwater habitats play an important role in maintaining sensitive animal species, providing clean water, and supporting important plant communities. The Agriculture and Land-Based Training Association (ALBA) and ESF are working to restore Carneros Creek. ESF and Elkhorn Slough NERR are actively experimenting with apparently successful management of wet meadows and vernal pools, and artificial ponds on the Elkhorn Slough NERR provide important breeding habitat for California Red-legged Frogs (CRLF) and Santa Cruz Long-toed Salamanders (SCLTS). But, the Reserve's man-made ponds may not be sustainable over the long term. Most ponds on the Reserve were created from converted salt marsh and transitional wetlands that could be restored to their natural habitat in the future. In the long term, the Elkhorn Slough NERR should collaborate with other organizations and private landowners to restore natural ponds, which still exist in the watershed but need enhancement and restoration to provide adequate habitat for breeding amphibians. Therefore, in order to best support the

protection and enhancement of local freshwater habitats in both the short- and long-term, Reserve efforts will focus on 1) stewardship of all Reserve freshwater habitats, 2) watershed partnerships and outreach, and 3) research.

Invasive Species

Invasive species have been a significant factor in the decline of federally listed amphibians (USFWS 2002). Introduced bullfrogs and predatory fish prey on CRLF, SCLTS, and California Tiger Salamanders (USFWS 2002 and 1999). Non-native tiger salamanders (*Ambystoma tigrinum*), formerly legally used as bait and illegally introduced into Monterey County waterbodies, are a significant threat to the endangered California Tiger Salamander. Non-native tiger salamanders compete with and hybridize with the native species (Riley et al. 2003). Chytrid fungus, a pathogen that researchers suspect is non-native to North America, has been linked to the mortality of many amphibian species worldwide. The chytrid fungus attacks amphibian body parts containing keratin (larval mouth parts, frog skin and nervous system), but its role in CRLF declines is currently unknown. Non-native plants, such as French broom, jubata grass, and eucalyptus have been implicated in the degradation of SCLTS habitat (USFWS 1999), while Cape ivy has been shown to impact wetland flood control functions, and may leach potent alkaloids into nearby water bodies (Cal-IPC 2006). While the exact role of plant invasions in amphibian declines is unknown, exotic weeds can certainly change the structure, function, and diversity of freshwater plant assemblages.

Several other invasive species that threaten freshwater habitats in California have not been found in the Elkhorn Slough watershed yet, but have the potential to spread into the region. These include exotic plants such as water hyacinth and hydrilla, and at least one non-native invertebrate. The New Zealand mud snail is a very small exotic freshwater snail that was first discovered in California in 2000. It has the potential to alter primary production and decrease native invertebrate abundance in freshwater habitats, and it appears to be expanding its range rapidly, primarily through human activities on aquatic gear, including shoes and boats.

A central principle of invasive species management is that small infestations can be eradicated, but large infestations can usually only be controlled. In order to be most effective, Reserve non-native management efforts will focus on 1) prevention of new introductions, 2) early detection and eradication of new introductions before establishment and spread, and 3) exotic species control strategies that help favor dominance by native assemblages.

B. ESNERR Objectives and Strategies

Staff from the Reserve's Stewardship, Education, and Research Programs are involved in the following objectives and strategies

Objective 1: Maintain and enhance key freshwater habitats on the Elkhorn Slough Reserve.

Strategies:

1. Maintain guzzlers so that they continue to provide habitat for CRLF, breeding tree frogs, birds, reptiles and mammals. Stewardship staff and volunteers will continue to:
    i. maintain open water using vegetation control
    ii. maintain plumbing infrastructure

2. The Stewardship staff will maintain infrastructure and seasonal water levels in order to promote successful CRLF and SCLTS breeding in the short-term. In order to accomplish this we will:
    i. maintain key structures (canal gates, flashboards, plumbing) at artificial ponds in the short-term
    ii. supplement water levels in two artificial, plumbed ponds when necessary for successful CRLF breeding in the short-term. CRLF tadpoles need standing water through August in order to metamorphose into adult frogs. In dry years, Rookery Ponds 2 and 3 may dry down by early summer. When necessary, and until other natural freshwater habitats are restored, subsidize these ponds (using existing irrigation infrastructure) through August.

iii. allow Rookery Ponds 2 and 3 to dry down naturally in September, to kill potentially-present bullfrog tadpoles, which need long-lived or permanent water to successfully metamorphose.

Objective 2: Explore and act upon opportunities for watershed partnerships and outreach.

Strategies:

1. The Stewardship staff will explore partnerships to restore natural ponds on private lands. If we successfully establish these partnerships, we will then seek funding to pursue restoration of historical freshwater habitat.

2. Dependent on the addition of the Community Outreach Coordinator, the Education staff will educate public about the importance of maintaining natural ponds on private land. In order to accomplish this we will:

i. work with local partners, public landowners, private landowners, conservation groups, planning interests, and stakeholders in developing a community outreach plan that will include a component on freshwater ponds.

Objective 3: Conduct research to improve management strategies for local freshwater habitats.

Strategies:

1. The Research team will create a GIS layer of historical distribution of freshwater and riparian areas.

2. The Research team will monitor water quality in selected freshwater habitats. In order to accomplish this we will:

i. continue monthly 24-station water quality monitoring program, which includes local freshwater sites.

ii. post summaries of data annually on the Elkhorn Slough NERR website, and make the database available upon request.

3. The Research team will investigate the characteristics of freshwater habitats in the watershed, and their use by threatened amphibians. In order to accomplish this we will:
    i. continue annual monitoring of about 40 freshwater habitats in the watershed,
    ii. analyze data in order to determine if presence and breeding success of native amphibians is linked to conditions such as hydroperiod, invasive predators, disease, and water quality.

4. The Research team will support research on amphibian metapopulation dynamics. In order to accomplish this we will:
    i. mentor and provide assistance to a graduate student researcher in her studies of red-legged frog movements and habitat usage. She will also investigate population-level effects of invasive bullfrog presence on survival and behavior of the red-legged frog. This research will provide critical information on CRLF metapopulation dynamics, instrumental for improved management of watershed populations.
    ii. collaborate with other interested researchers to study ecology and conservation related questions pertaining to SCLTS and California Tiger Salamanders.

Objective 4: Protect Reserve and key neighboring freshwater habitats from selected invaders.

Strategies:

1. The Stewardship team will prevent new introductions by taking precautions against spreading exotic species and pathogens (e.g., chytrid fungus) among freshwater sites. In order to accomplish this we will continue to ensure that both Reserve staff and visiting scientists appropriately clean boots and other gear between ponds.

2. The Stewardship team will detect and eradicate newly introduced exotic species. In order to accomplish this we will:

i. update Elkhorn Slough NERR's in-house "least wanted" plant cards to include likely freshwater plant invaders (these cards are separate from the published "Early Detection for Aquatic Invaders" booklet developed by the Reserve's research program for regional detection of marine and estuarine invaders). These cards identify the California Invasive Plant Council's (Cal-IPC) high priority weeds that are not yet found on the Reserve but have the potential to spread into the area. Least-wanted cards have helped Reserve stewards detect and rapidly control five new upland weeds since 2000.

ii. distribute "least wanted" cards to staff and volunteers

3. The Stewardship team will detect and remove bullfrogs from Reserve ponds. In order to accomplish this we will:

i. conduct annual surveys to determine whether bullfrogs are present at any Reserve ponds

ii. if bullfrogs are found, removal of all individuals will be attempted. If bullfrog tadpoles are discovered in any ponds, the ponds will be allowed to dry by the end of August to ensure the failure of this life stage.

4. The Stewardship team will develop and implement exotic control strategies that help favor dominance by native assemblages. In order to accomplish this we will:

i. continue to remove Cal-IPC's high priority weeds, including cape ivy, French broom, Himalayan blackberry, and jubata grass from freshwater habitats (including the edges of ponds, and in riparian woodlands and wet meadows).

ii. attempt to control a suite of "moderate" priority weeds that we have identified as having severe impacts locally. These include eucalyptus saplings and mature outlying trees, velvet grass, some patches of poison hemlock, and harding grass.

iii. plant, where necessary, native plants in removal areas to prevent re-infestation by non-native plants.

iv. decrease the abundance of non-native fish in Elkhorn Slough NERR ponds and guzzlers when and where practical.

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Chapter V. ESNERR Goal #3
Protect and Restore Maritime Chaparral in the Elkhorn Slough Watershed

A. Introduction

Chaparral is perhaps California's most emblematic vegetation type, forming broad expanses across coastal and inland foothills and constituting about five percent of the state's land cover (Hanes 1988). Ironically, maritime chaparral, a manzanita-dominated association found only in relatively small patches near the coast, is one of our most uncommon and highly threatened vegetation communities. Significant stands of maritime chaparral remain in the Burton Mesa region of Santa Barbara County, near Morro Bay in San Luis Obispo County, and in the Monterey Bay area at former Fort Ord and on sandhills adjacent to Elkhorn Slough. Maritime chaparral is naturally uncommon due to its unusual habitat requirements: sand or similar extremely well drained and nutrient deficient soils, and within the zone of frequent fog along the immediate coast. Maritime chaparral is protected as environmentally sensitive habitat under the California Coastal Act and under Monterey County's Local Coastal Plan (Monterey 1982). Occurrences are mapped as a rare natural community by the California Department of Fish and Game in the California Natural Diversity Database (CNDDB).

Conservation biologist's understanding of maritime chaparral and its associated rare plants is largely due to the pioneering work of Jim Griffin in the 1970s (Griffin 1978). Maritime chaparral stands are dominated by manzanita shrubs, typically a member of the burl-forming woollyleaf manzanita group in association with one or more of 30 rare non-burl-forming manzanita species that are endemic to restricted regions along the coast. In the Elkhorn Slough watershed, locally endemic Pajaro manzanita shares dominance with another central Monterey Bay area endemic, Hooker's manzanita, and with the more widely distributed brittleleaf manzanita. Several other shrubs, including chamise and toyon, contribute to a dense chaparral canopy. Two federally listed species, threatened Monterey spineflower and endangered Yadon's piperia, are closely associated with Elkhorn Slough's maritime chaparral.

Maritime chaparral patches in the Elkhorn Slough watershed occur within a matrix of coast live oak woodland, coastal sage scrub, and annual grassland as well as agricultural and rural residential development. Maritime chaparral is threatened by removal and fragmentation due to development, encroachment by invasive exotic species such as pampas grass, iceplant, and blue gum eucalyptus, and gradual conversion to other habitat types, particularly live oak woodland.

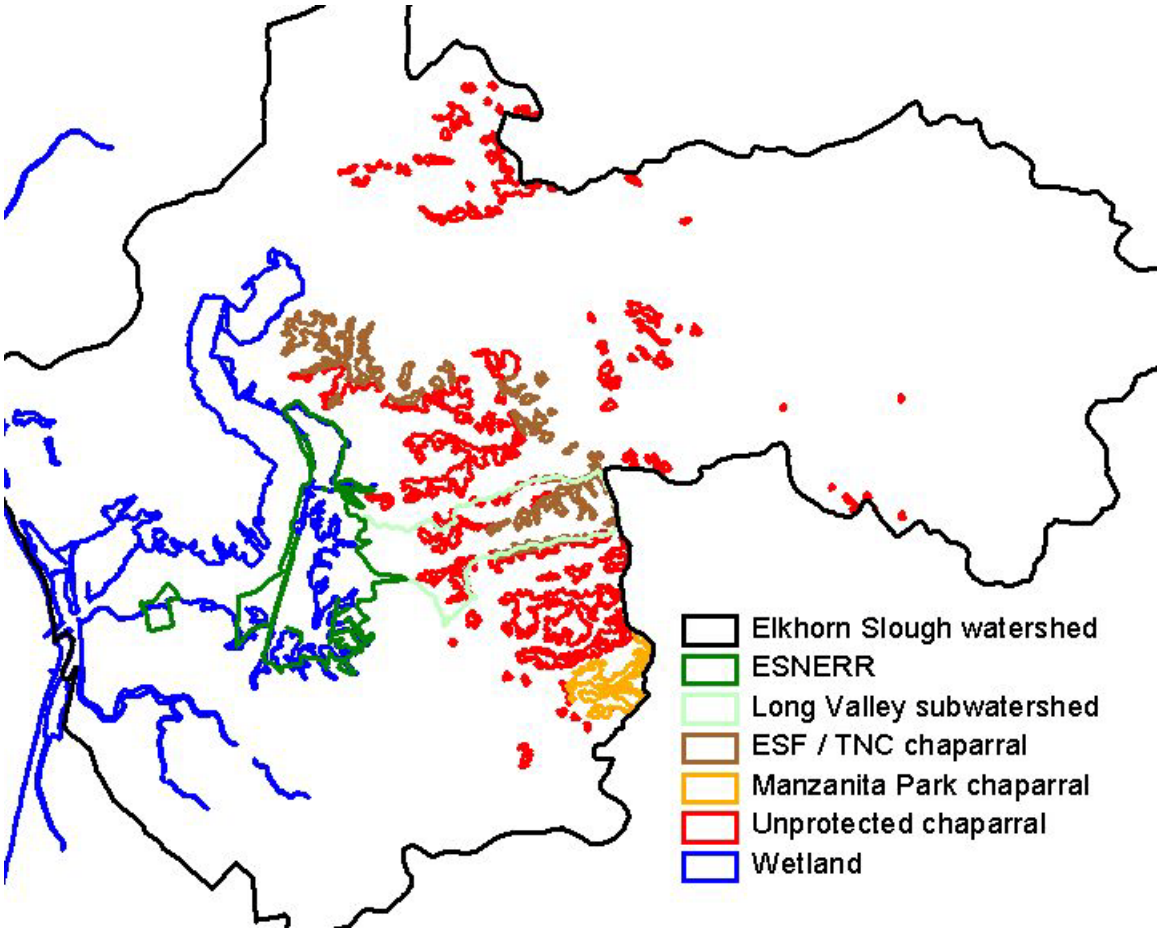

Figure 5.1: Map of the Elkhorn Slough watershed and maritime chaparral stands.

Preserving Existing Maritime Chaparral

The limited range of maritime chaparral coincides with some of California's most desirable (and expensive) specialty croplands and coastal homesites. Prior to the 1970s, chaparral was generally considered undesirable "scrubland" suitable for clearing and conversion to agricultural use. More recently, maritime chaparral habitat has suffered from removal and fragmentation as a result of residential subdivision. As much as one third of pre-settlement chaparral acreage has been eliminated in north Monterey County,

chiefly on lower slopes and plateaus. Much of the region's remaining maritime chaparral is concentrated along a network of narrow ridgelines.

With certification of the North Monterey County Local Coastal Program (LCP) in 1982, maritime chaparral was afforded protection as environmentally sensitive habitat. The Coastal Act's environmentally sensitive habitat policies specify that:

> Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

However, the specific policy enacted in the North Monterey County LCP is somewhat less restrictive:

> Maritime chaparral is an uncommon, highly localized and variable plant community that has been reduced in North County by residential and agricultural development. Further conversion of maritime chaparral habitat to agricultural uses is highly discouraged. Where new residential development is proposed in chaparral areas, it shall be sited and designed to protect the maximum amount of maritime chaparral. All chaparral on land exceeding 25 percent slope should be left undisturbed to prevent potential erosion impacts as well as to protect the habitat itself.

A stronger LCP policy applies specifically to the 1200 acre Long Valley subwatershed immediately adjacent to Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR):

> Preservation of both the natural habitat and watershed shall be of the utmost priority. Maritime Chaparral and stands of Monterey Pine, Coast Live Oak, Madrone, and Manzanita shall be protected to the maximum extent feasible.

In 1999 ESF in partnership with The Nature Conservancy adopted an *Elkhorn Slough Watershed Conservation Plan*, which was subsequently endorsed by the California Coastal Conservancy and the California Coastal Commission. A key goal of the plan, which ESF is actively implementing, is to "permanently protect the watershed's best

stands of connected maritime chaparral" through land ownership or acquisition of conservation easements.

Today, approximately 2800 acres of maritime chaparral remain in north Monterey County (Figure 5.1). Of this, 1700 acres (61%) are within the boundaries of the Elkhorn Slough watershed. Of the watershed's maritime chaparral, 350 acres (21%) are within conservation lands protected by ESF and The Nature Conservancy and 160 acres (9%) are within Manzanita County Park. The remaining 1190 acres (70%) are in either developed or as yet undeveloped parcels on privately owned land.

The key to preserving remaining maritime chaparral is developing a network of watershed residents, educators, land managers, land-use decision makers, and scientists who are familiar with chaparral ecology and with policies and practices designed to protect and restore the habitat. This understanding will need to be developed in the visitor center and the classroom, in the laboratory and greenhouse, in the homes and gardens of watershed residents, and in the wild.

Reducing Loss of Maritime Chaparral Due to Habitat Conversion

Dense chaparral covered much of California's central coast uplands at the end of the nineteenth century (Cooper 1922). During the decades since, annual grasslands, scrub, and live oak woodlands have gradually invaded or replaced many of these chaparral stands, although exact acreages and the underlying causes are not well understood.

Chaparral species exhibit a variety of adaptations to natural disturbance, including burls that resprout and refractory seeds that germinate in the aftermath of fire. Under a moderate fire return cycle, burned chaparral will be replaced by essentially the same mix of species. If fire cycles are frequent, a sufficient seed bank of chaparral shrubs may not accumulate and early successional species such as California lilac, coyote brush, or black sage will be favored (Davis et al. 1988). Too frequent fire or intense grazing pressure can lead to habitat type conversion, permanently replacing chaparral with coastal scrub vegetation or even annual grasslands (Odion and Tyler 2002; Keeley 2005). Conversely,

infrequent fire return intervals can alter chaparral species composition by favoring crown sprouting species including toyon and coast live oak (Keeley 1992). Numerous studies throughout the central coast region have demonstrated that gradual conversion from maritime chaparral to coast live oak woodland is occurring in the long absence of fire (e.g. Wells 1962; Davis 1972; Griffin 1978; Callaway and Davis 1993; Mensing 1998).

There is considerable controversy over what constitutes a "moderate" or historic fire cycle on the cool and foggy central California coast where rates of lightning-caused ignition are among the lowest in California (Greenlee and Langenheim 1990). Similarly, we lack a clear historic baseline due to disagreements over the relative contributions of grazing by prehistoric herbivores, Native American burning practices, European cattle ranching, and more recent fire suppression practices on the trajectory of habitat type conversion from shrublands to grassland or woodland. The majority of maritime chaparral stands in the Elkhorn Slough watershed have not burned for at least 75 years (Davis 1972). As a result, the density and height of the chaparral shrub layer have increased dramatically and the species composition has shifted from a mix of successional stages to overwhelming dominance by a few long-lived species. At the same time, the size of individual chaparral patches has decreased as oak woodlands gradually invade their perimeters. Within the chaparral canopy, recruitment by new chaparral shrubs is extremely uncommon, while seedlings and saplings of coast live oak are increasingly abundant (Van Dyke et al. 2001).

Three decades ago, gaps in the chaparral canopy were widespread, providing sites for the establishment of shrub seedlings and supporting a diversity of herbs and subshrubs including rare species such as Eastwood's ericameria, Gairdner's yampah, federally threatened Monterey spineflower, and federally endangered Yadon's piperia. Today, gaps are uncommon, resulting in significantly reduced species diversity (Van Dyke et al. 2001).

Even as maritime chaparral is protected from development, type conversion remains an ongoing threat to the habitat. The introduction of prescribed burning and other

management practices may be needed in the coming years to minimize the conversion of maritime chaparral to other habitat types and to prevent the loss of rare and endemic species. In preparation, we will initiate a program of applied habitat restoration science, sensitive species recovery planning, and community and decision-maker education.

B. Elkhorn Slough NERR Objectives and Strategies

Staff from the Reserve's Education, Coastal Training, and Research Programs are involved in the following objectives and strategies

Objective 1: Preserve existing maritime chaparral in the Elkhorn Slough watershed.

Strategies:

1. The Education staff will include maritime chaparral conservation as a component of the Elkhorn Slough NERR education and training programs. In order to accomplish this we will:
    i. develop maritime chaparral interpretation materials and activities that focus on:
        1. Maritime chaparral distribution, species, and ecology,
        2. Maritime chaparral-associated rare and endemic species protection,
        3. Responsible building and landscaping and compatible use of native plants,
        4. Invasive species control.

2. The Education staff will seek funding to initiate maritime chaparral community education. If successful, we will:
    i. develop outreach materials that focus on landscaping and invasive species control.
    ii. develop outreach and incentive programs that help landowners in primarily residential areas manage maritime chaparral areas wisely.

iii. develop information on the establishment and maintenance of conservation easements.

3. The CTP Staff will continue their decision-maker workshop series on the ecology, conservation, and restoration of maritime chaparral. In order to accomplish this we will:

i. continue to revisit and update the Ecology and Conservation and Restoration and Management topics.

ii. initiate new maritime chaparral topics including:

1. The design and management of easements for maritime chaparral conservation,
2. The development and implementation of conservation banking to protect maritime chaparral habitat.

4. The Research and Stewardship staff will support maritime chaparral habitat studies and restoration projects. In order to accomplish this we will:

i. encourage and support research by students, interns, or research fellows to:

1. Map currently dedicated conservation easements, document their past and present condition, and evaluate their ecological value,
2. Design recommended baseline characterization and monitoring programs for newly-dedicated conservation easements,
3. Evaluate the potential for a maritime chaparral conservation banking program in the watershed and,
4. Investigate habitat restoration strategies on Elkhorn Slough Foundation and other chaparral lands in the watershed.

Objective 2: Reduce loss of maritime chaparral due to habitat type conversion.

Strategies:

1. The Research and Education staff will increase understanding of chaparral fire ecology, wildland fire issues, and the use of prescribed burning. In order to accomplish this we will:
    i. collaborate with community partners to raise awareness of chaparral fire issues.
    ii. partner with interested community organizations to increase understanding of the issues associated with living at the chaparral wildland interface and the potential benefits of a prescribed burning program.

2. The CTP staff will host a decision-maker workshop on chaparral fire ecology and the use of prescribed fire for habitat maintenance and restoration. In order to accomplish this we will:
    i. bring together fire ecologists, wildland fire practitioners, fire protection agency staff, and land managers for a workshop to advance the theory and practice of disturbance-based maritime chaparral conservation and restoration.

3. The Research staff will support development and implementation of recovery plans for maritime chaparral habitat and associated sensitive species. In partnership with ESF we will:
    i. monitor and map occurrences of sensitive species in the watershed.
    ii. participate in the development of threatened and endangered species listing and recovery plans.

4. The Research staff will initiate research on maritime chaparral response to modified disturbance regimes.

5. The Research staff will map historic chaparral habitat changes and disturbance history.

6. The Research staff will develop a historical ecological analysis of long-term habitat change across the watershed's chaparral lands.

7. The Research staff will initiate a maritime chaparral restoration science research project. In partnership with ESF we will:

i. initiate long-term manipulative field studies to address some of the following questions:

1. Can degraded former maritime chaparral sites be restored? Are some settings (e.g. disturbance or land use history or adjacency to intact habitat) more conducive to restoration?
2. Can oak woodland invasion be reduced by these treatments?
3. Can invasion by exotic species such as pampas grass and iceplant be managed by these treatments?

Table 5.1: Common and scientific names used in this chapter (* indicates non-native species)

Common Name	**Scientific Name**
chamise	*Adenostoma fasciculatum*
Hooker's manzanita	*Arctostaphylos hookeri ssp. hookeri*
Pajaro manzanita	*Arctostaphylos pajaroensis*
woollyleaf manzanita	*Arctostaphylos tomentosa*
brittleleaf manzanita	*Arctostaphylos tomentosa ssp. crustacea*
coyote brush	*Baccharis pilularis*
*iceplant	*Carpobrotus edulis*
California lilac	*Ceanothus spp.*
Monterey ceanothus	*Ceanothus cuneatus var. rigidus*
Monterey spineflower	*Chorizanthe pungens var. pungens*
*pampas grass	*Cortaderia jubata*
Eastwood's ericameria	*Ericameria fasciculata*
*blue gum eucalyptus	*Eucalyptus globulus*
toyon	*Heteromeles arbutifolia*
Gairdner's yampah	*Perideridia gairdneri spp. gairdneri*
Yadon's piperia	*Piperia yadonii*
coast live oak	*Quercus agrifolia*
black sage	*Salvia mellifera*

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VI. Elkhorn Slough NERR Goal #4
Protect and Restore the Watershed's Key Coastal Prairie and Coastal Scrub Habitats

A. Introduction

Coastal prairie and northern coastal scrub are part of a complex and dynamic mosaic of upland habitats within the Elkhorn Slough watershed. Coastal prairie is a species-rich habitat that occurs within 100 kilometers of the coast. It hosts not only array of insects, amphibians, reptiles, birds, and mammals, but also a number of endangered annual forbs. This habitat can be defined, in part, by its native grass and forb species (Table 6.1). Coastal prairie often coexists with, and frequently has a successional relationship with, northern coastal scrub (Ford and Hayes in press, Heady et al. 1988, Heady et al. 1992). Coastal scrub is an assemblage of evergreen shrubs, and within California, ecologists recognize northern and southern divisions. Northern coastal scrub occurs from Santa Barbara County north to the Oregon border. In the Elkhorn Slough watershed, it is dominated by coyote brush. Co-dominants include California sagebrush, black sage, coffeeberry, bush monkeyflower, California blackberry, and poison-oak. This habitat is important for a variety of small mammals and birds. The mosaic and herbaceous height characteristics of coastal prairie with northern coastal scrub are critical to the upland habitat quality for special-status species, including:

- Santa Cruz sunflower (Federally Threatened, State Endangered, and California Native Plant Society (CNPS) 1B (Rare, threatened or endangered in California and elsewhere),
- artist's popcornflower (CNPS 1B),
- water sack clover (CNPS 1B),
- Smith's blue butterfly (**need status)
- burrowing owl (wintering population – CDFG California Special Concern Species)
- great blue heron (**need status)
- short-eared owl (**need status)
- Monterey vagrant shrew? (**need status)
- Salinas pocket mouse? (**need status)

- American badger (CDFG California Special Concern Species),
- grasshopper sparrow (**need status)
- golden eagle (**need status)
- American peregrine falcon (**need status)
- White tailed kite (**need status)
- northern harrier (nesting - CDFG California Special Concern Species),
- Santa Cruz long-toed salamander (Federally and State Endangered, CDFG Fully Protected),
- California red-legged frog (Federally Threatened and CDFG California Special Concern Species), and
- California tiger salamander (Federally Threatened and CDFG California Special Concern Species) (CalPIF 2004, Becker 1988, L. Ford pers. comm., Hobbs and Mooney 1986).

Unfortunately, both coastal prairie and coastal scrub face significant threats. Approximately 99% of California native grasslands have been lost over the last 200 years, making them one of the most critically endangered ecosystems in the U.S. (Noss et al. 1995). Loss of coastal scrub in some parts of California has also been severe. Up to 90 % of the historic acreage of southern coastal scrub has been lost to development (Noss et al., 1995). Northern coastal scrub is apparently more secure for now, but it too has declined by over 35% since 1950 (FRRAP 1988:Table 7-4; FRAP 2003), and faces the same sprawl as Southern California. Within the Elkhorn Slough watershed, coastal scrub assemblages often face threats from infestation by tall exotic biennials and perennials, such as poison hemlock, fennel, and jubata grass.

Table 6.1. Definitive coastal prairie plants. Adapted from Stromberg et al. 2001.

Native Coastal Prairie Grasses and Rushes	
Common Name	Species Name
California oat grass	*Danthonia californica*
Purple needlegrass	*Nassella pulchra*
Brown-headed rush	*Juncus phaeocephalus*
Tufted hairgrass	*Deschampsia cespitosa*
Blue wildrye	*Elymus glaucus*
Toad rush	*Juncus bufonius*

Nodding needlegrass	*Nassella cernua*
Meadow barley	*Hordeum brachyantherum*
California brome	*Bromus carinatus*
Salt grass	*Distichlis spicata*
Creeping wildrye	*Leymus triticoides*
Foothill needlegrass	*Nassella lepida*
Native Coastal Prairie Forbs and Shrubs	
Coyote brush	*Baccharis pilularis*
California plantain	*Plantago erecta*
Small tarweed	*Madia exigua*
Buttercup	*Ranunculus californicus*
Johnny jump-up	*Viola pedunculata*
Checker mallow	*Sidalcea malviflora*
Sun cup	*Camissonia ovata*
California acaena	*Acaena pinnatifida californica*
Coastal eryngo	*Eryngium armatum*
Soap plant	*Chlorogalum pomeridianum*
Everlasting	*Gnaphalium purpureum*
American carrot	*Daucus pusillus*
Blue-eyed grass	*Sisyrinchium bellum*

Most of the coastal prairie that once existed in the lower Salinas Valley and in northern Monterey County has been converted to agricultural fields, although some has been urbanized as well. Much of the remaining prairie has been impacted by large-scale community shifts from indigenous grasses and forbs to exotic, mostly European, species. This transformation, beginning in the 1700s, coincided with the loss of native herbivores and Native American burning regimes, as well as the concurrent introduction of highly-competitive exotic plants and over-grazing by domestic livestock. The role that each factor played in the conversion remains uncertain.

Regardless of the mechanisms, these losses have obscured the past distribution and composition of historical prairie. The earliest explorers to the Monterey region visited the area in late fall, and they described local grasslands in only the broadest terms. They found 1) that large areas of the lower Salinas Valley grasslands were home to "vast numbers of [pronghorn] antelopes" and were burned by Native Americans, 2) "swampy plains," and tule elk between the Elkhorn Slough-Moro Cojo-Tembladero Slough estuarine wetlands, 3) "good grasses" on knolls east of previously wide-spread freshwater wetlands, and 4) "hills of pure earth and grass, with some live oaks," in a valley just east of today's Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR) (Brown 2002, Palou 1930). Early naturalists in the late 1700s collected native annual and

tufted hairgrass, giant wildrye, buttercup, yarrow, several rushes, and hairy wood-sorrel in the Monterey Bay area; but did not otherwise describe local grasslands (Eastwood 1924, Presl 1830). Detailed accounts of Monterey area grasslands did not appear until the mid-1800s, and by this period many changes had taken place. Several European exotic forbs were common throughout the central California coast, and cattle were abundant (Hooker 1841, Hartweg 1846). Nonetheless, many native wildflowers were evident during springtime. In 1846, John Fremont (Jackson and Spense 1973) wrote:

> "Over the face of the country between Santa Cruz and Monterey, and around the plains of San Juan, the grass which had been eaten down by the large herds of cattle, was now everywhere springing up and flowers began to show their bloom. In the valleys of the mountains bordering the Salinas plains wild oats [non-native *Avena* sp.] were three feet high and well headed. . ."

Today, even the best prairie assemblages are highly invaded, and non-native grasses and exotic forbs often dominate remnant native patches (Stromberg et al. 2001).

Unfortunately, changes to historical coastal scrub in north Monterey County are not well documented. Early explorers in the region did not describe shrubs in detail, and did not clearly distinguish between coastal scrub and chaparral. Botanists' records only hint at the past distribution and composition of coastal scrub assemblages. In the early 1790s, a Scottish naturalist described scattered pockets of "Pasture & Thickets of Brush-wood" near Point Pinos, which included various shrubs that he could not identify, several species of Artemisia, and "a great variety" of birds. In 1854, the U.S. Surveyor General described "oak scrub and sage" near the eastern reaches of Long Valley, and mapped patches of unnamed bushes (apparently distinct from chaparral) in Hidden Valley (Freeman 1854). Today, many of these areas appear to have been replaced by oak or eucalyptus woodland. In 1906, the Los Angeles Times reported that the hills of the Empire Gun Club, today part of the Elkhorn Slough NERR, were "covered with scrub"

where “quail multiply and thrive” (Los Angeles Times 1906). Aerials from the 1930’s suggest that this scrub was later cleared for agriculture; but today, coyote brush and other associated scrub species have returned naturally to at least some of these slopes. However, many of these patches appear to be threatened by encroaching fennel, poison hemlock, and jubata grass.

Despite dramatic losses locally and statewide, some remnant coastal prairie and intact coastal scrub persists in the Elkhorn Slough watershed and on the Elkhorn Slough NERR. The Reserve will give priority to identifying and preventing the establishment of new invasive exotic plants in these areas on the Reserve.

The Elkhorn Slough NERR will also work to restore degraded grassland and scrub assemblages. Using historical ecology, we will identify areas best-suited for grassland and scrub restoration, and develop a target mosaic of the two related habitats. In areas deemed best for coastal scrub, we will reduce non-native plant cover, and where necessary, replant native scrub species. In areas best-suited for prairie, we will test the effectiveness of potential grassland restoration strategies. Coastal prairie restoration is an evolving science, and research is still needed. Grasslands with cattle grazing have been shown to have higher native annual forb richness and cover relative to ungrazed sites (Hayes and Holl 2003a), and the removal of cattle from prairie has been shown to lead to decreases in native California oat grass (Hatch et al. 1999). Grazing can also prevent the conversion of grasslands to coastal scrub. This argues against the removal of cattle from currently grazed prairies, but it is still unknown if the reintroduction of cattle to currently ungrazed, degraded grasslands can restore native grasses and forbs. Reintroducing clipping alone has been unsuccessful at restoring forbs at three coastal prairie sites (Hayes and Holl 2003b). This and other recent research suggests that the reintroduction of native grassland seeds or seedlings may also be necessary to help restore populations of native grassland species in areas that are currently dominated by exotic species (Corbin and D’Antonio 2004, Seabloom et al. 2003), but, again, more research is needed. We will implement a well-replicated experiment, comparing alternative strategies (grazing, mowing, and seed additions) in a robust design. The Reserve will monitor

appropriate indicators, ideally with collaboration from academic researchers. The eventual result will be a published manuscript that will help guide the Reserve's own work and help coastal prairie managers elsewhere better manage their lands.

Finally the Reserve will work other decision-makers and land managers to build support for regional grassland and scrub management and restoration, both through education and collaborative management efforts.

B. ESNERR Objectives and Strategies

Staff from the Reserve's Stewardship, Coastal Training, Education, and Research Programs are involved in the following objectives and strategies

Objective 1: Reduce abundance of selected non-native plant and animal species in Reserve coastal prairie and coastal scrub assemblages.

Strategies:

5. The Stewardship staff will control prioritized weeds through mechanical and chemical means in grassland and coastal scrub habitats. In order to accomplish this we will:

i. continue to control the California Invasive Plant Councils "high" priority weeds in Reserve grasslands and scrub habitats. These exotic species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment (Cal-IPC 2006). Target species to remove are iceplant (*Carpobrotus edulis*), jubata grass (*Cortaderia jubata*), veldt grass (*Ehrharta calycina*), fennel (*Foeniculum vulgare*), and French broom (*Genista monspessulana*).

ii. control outlying patches of harding grass (*Phalaris aquatica*), a Cal-IPC "moderate" priority weed that we have determined to have severe impact on Reserve coastal prairies.

iii. continue to work with school groups and community volunteers to remove non-native poison hemlock and replant with native coastal scrub species in a small-scale restoration project.

6. The Stewardship staff will establish a Reserve trapping program. Part of this program will include:

i. trapping feral cats, to decrease the number of native birds and mammals preyed upon in Reserve grasslands. This will protect quail, which are important dispersal agents of native grassland seeds and may be important to restoring the Reserve's grasslands (Leopold 1985).

Objective 2: Help build support for regional Coastal Prairie and Coastal Scrub projects.

Strategies:

1. The CTP staff will continue to sponsor and partner with educational efforts to inform regional decision-makers about grassland ecology, restoration, monitoring, and management strategies.

2. Dependent on the addition of the Community Outreach Coordinator, the Education staff will create a community education plan and use restoration on the Reserve as a model. In order to accomplish this we will:

i. use restoration projects on the Reserve to educate neighbors about coastal prairie and coastal scrub habitats. This would include opportunities for community members and groups from neighboring schools to assist with the restoration projects as well as educational tours of the sites. This will be part of a larger

strategic plan for community outreach in the Elkhorn Slough watershed that will be developed with local partners and community members (see Goal 8, Chapter X for more details).

3. The Stewardship staff will collaborate on strategies to protect, enhance and restore grasslands in the lower watershed. We will:

i. build stronger relationships with organizations and stakeholders involved in management of Elkhorn Slough watershed grasslands.

ii. work together to design restoration experiments.

Objective 3: Implement research that informs regional restoration strategies.

Strategies:

1. The Stewardship staff will create a GIS map of historical and current coastal prairie and coastal scrub in the watershed. This will help prioritize areas for weed control and restoration activities.

2. The Stewardship and Research staff will test the effectiveness of grazing, mowing, and seed addition in a well-replicated, large-scale coastal prairie experiment.

3. The Research staff will examine habitat use of native vs. non-native grassland species. We will:

i. compare arthropod assemblages in native and non-native grass and scrub species to determine how habitat value differs.

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Chapter VII. ESNERR Goal #5
Protect and Restore Key Coast Live Oak Habitats

A. Introduction

Coast live oak (*Quercus agrifolia*) woodland is common in the Elkhorn Slough watershed and is often found growing on 15 to 50 percent slopes and loamy sands in the hills east of the Elkhorn Slough National Estuarine Research reserve (Elkhorn Slough NERR). On the Reserve, oak woodlands also frequently appear on the slopes of dissected terraces. Oak woodland can range from dense forests with closed canopies at moderately moist sites, to widely-spaced open woodland or savannah in drier areas. Oak understory vegetation is also variable. Where the canopy is closed, understory vegetation often includes shade-tolerant shrubs, ferns, and forbs. Where trees are scattered, the understory is commonly made up of grassland and occasional shrubs (Holland 1988). At Elkhorn Slough NERR, the overstory is made up exclusively of coast live oak, and common native understory species include poison oak (*Toxicodendron diversilobum*), sword fern (*Polystichum munitum*), California blackberry (*Rubus ursinus*), hedge nettle (*Stachys bullata*), snowberry, (*Symphoricarpos albus* var. *laevigatus*), coffeeberry (*Rhamnus californica* and *R. tomentella*), beeplant (*Scrophularia californica*) and miner's lettuce (*Claytonia perfoliata*). Creeping wildrye (*Leymus triticoides*) and Santa Barbara sedge (*Carex barbarae*) also occur in open woodlands.

Coastal oak woodlands provide habitat for a variety of wildlife species, including many mammals and a wide range of birds. According to California Partners in Flight and the Point Reyes Bird Observatory (2002), oak woodlands have the richest wildlife species abundance of any habitat in California, and may rank among the top three habitat types in North America for bird richness. The California Wildlife Habitat Relationships System lists over 200 animal species that live in or otherwise use coastal oak woodlands in Monterey County. In the Elkhorn Slough watershed these include nesting white tailed kites (CDFG Fully Protected) and golden eagles (CDFG Special Concern Species), and seasonally, Santa Cruz long-toed salamanders (Federally and State Endangered).

It is unknown how many oaks in the Elkhorn Slough watershed have been lost over the last 150 years. Comparisons between mid-nineteenth century surveys and recent aerial photos hint at large-scale changes. When surveying the boundaries of Spanish land grants and township and range lines in the 1850s and 60s, the U.S. Surveyor General mapped many natural features, including oak trees. In the Elkhorn Slough watershed, oaks were therefore mapped on the boundaries of the San Cayetano, Los Carneros, and Bolsa Nueva y Moro Cojo ranchos, and along the public lands north of Hall Road, on the Springfield Terrace, and in the hills approximately 3.5 kilometers east of today's Elkhorn Slough NERR. Only half of the survey points shown as coast live oak in the 1800s are oak habitat today. Approximately 40% of the originally mapped oaks have since been converted to agricultural fields or grassland, while the other approximately 10% have since been replaced by non-native eucalyptus or pine trees (U.S. Survey General 1872, Foreman 1867, Terrell 1859, Day 1854, Freeman 1854). Many of these woodlands were undoubtedly cut down for firewood (Fig. 7.1) or otherwise cleared for crops and buildings. Today residential development threatens to further fragment remaining oak habitat (Scharffenberger 1999), and Sudden Oak Death (caused by the fungus-like *Phytophthora ramorum*) threatens oaks throughout coastal California. *Phytophthora ramorum* is presumed to be an introduced pathogen in the United States (Braiser 2003). Furthermore, exotic plants continue to threaten standing oak groves and the abundance and diversity of understory plant assemblages. However, oak recruitment in the Elkhorn Slough watershed is complex. In many areas, coast live oak woodland has recovered from past clearing, and in some areas it continues to expand. In the absence of fire it has even been shown to invade sensitive maritime chaparral habitat (Van Dyke and Holl 2001).

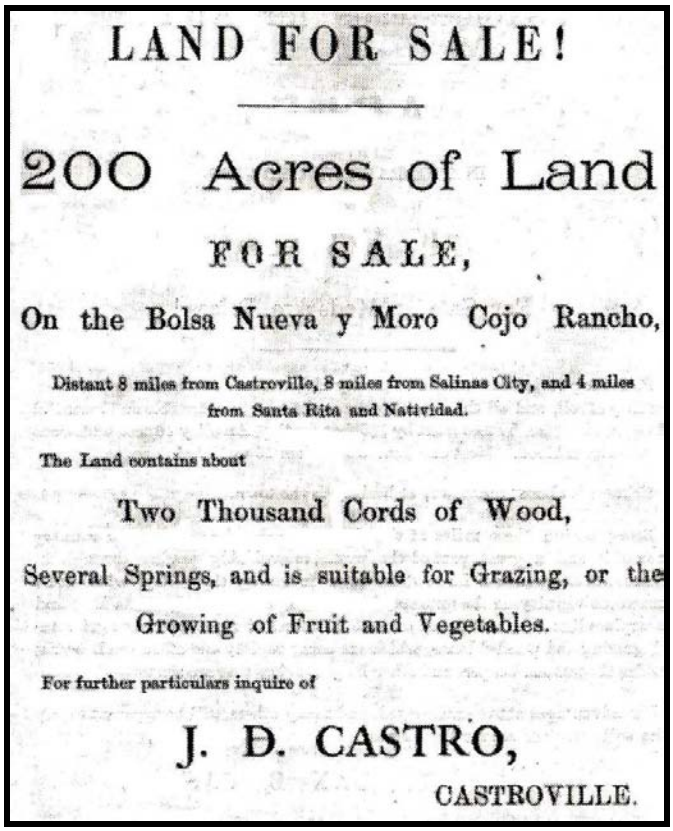

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Figure 7.1. 1875 advertisement for land in and around the Elkhorn Slough watershed, stressing the availability of oaks for firewood.

The Elkhorn Slough NERR has been successfully restoring coast live oak trees for over fifteen years. In the 1990s, staff, volunteers, and work crews removed a 13-acre exotic eucalyptus grove on the northern portion of the Reserve and, in its place, planted thousands of coast live oak acorns. Today, an open oak woodland, interspersed with scrub and grassland habitat, is developing in the area. Volunteers, school groups, and staff have also successfully planted hundreds of oaks on two north facing slopes, an area that was previously dominated by non-native radish, annual grasses, veldt grass, and Italian thistle. Dozens of oaks have also been planted elsewhere on the Reserve, restoring widely scattered oak trees known to have existed historically, but lost during the mid-1900s. More recently, as previously planted oaks have begun to mature, Reserve stewards have focused on oak understory restoration projects. We have successfully removed over two acres of invasive Cape ivy (*Delairea odorata*) and English ivy (*Hedera helix*), and we are currently experimenting with native shrub, forb, and grass plantings.

As in other habitats, invasive species in oak woodlands are very difficult to eradicate once they have become widespread and abundant. Therefore management efforts are focused on 1) identifying and prioritizing areas for exotic species monitoring and control efforts, 2) prevention of new introductions, 3) early detection and eradication of new introductions before establishment and spread, and 4) control strategies to prevent further spread of already widespread weeds and that help favor dominance by native assemblages. We also will complete an investigation of the habitat use of native oak vs. non-native eucalyptus groves. The Reserve's actions fall into these areas, as described below.

B. ESNERR Objectives and Strategies

Staff from the Reserve's Stewardship Program and Research Program are involved in the following objectives and strategies

Objective 1: Protect the watershed's coast live oak habitats from biological invaders.

Strategies:

1. The Stewardship staff will create a GIS map of historical coast live oak woodland in the Elkhorn Slough watershed.

2. The Stewardship staff will prevent the spread of exotic plants into high priority remnant or restored oak woodlands. Weed seeds can be transported on shoes and clothing. In order to prevent new invasions in remnant or restored oak understory, we will develop and implement an oak woodland access plan that decreases the likelihood of weed introductions.

3. The Stewardship staff will prevent the establishment of exotic pigs on the Elkhorn Slough NERR. In order to accomplish this we will:

i. continue to survey oak woodlands for evidence of feral pigs.
ii. if found, coordinate with the California Department of Fish and Game and local agencies to remove pigs.

4. The Stewardship staff will control prioritized invasive weeds through mechanical and chemical means in coast live oak understories. In order to accomplish this we will:

i. continue to monitor and control California Invasive Plant Council's (Cal-IPC) "high" priority invasive weeds in oak woodlands - those exotics which have the greatest impact on native habitats and those which will become more difficult to control if action is delayed. Target species are Cape ivy (*Delairea odorata*), English ivy (*Hedera helix*), French broom (*Genista monspessulana*), and Himalayan blackberry (*Rubus discolor*).
ii. control, when and where possible, Cal-IPC "moderate" priority species that are currently limited in extent, including bull thistle (*Cirsium vulgare*), calla lily (*Zantadeschia aethiopica*), panic veldt grass (*Ehrharta erecta*), and periwinkle (*Vinca major*).

5. The Stewardship staff will remove exotic eucalyptus trees where they threaten existing coast live oak woodland. In order to accomplish this we will:

i. continue to monitor for and remove eucalyptus saplings on the Elkhorn Slough NERR, with particular attention given to the perimeters of existing eucalyptus groves, around freshwater ponds, and near coast live oak woodlands.

ii. investigate the possibility of removing small outlier eucalyptus groves, especially where they grow adjacent to existing oak woodland.

6. The Stewardship and Education staff will prevent the establishment of Sudden Oak Death (SOD) on Elkhorn Slough NERR. In order to accomplish this we will:

i. continue to have visitors, researchers, volunteers, and staff clean their shoes before walking the trails or working in oak woodlands.

ii. regularly check for *P. ramorum* symptoms on host plans. Symptomatic plants will be sampled and submitted to the CA Department of Food and Agriculture lab for testing.

iii. keep staff up-to-date on symptom recognition and best management practices to prevent pathogen introduction.

Objective 2: Investigate the habitat use of native oak vs. non-native eucalyptus groves.

Strategy:

1. The Research staff will complete an on-going study of arthropod and bird abundance and species composition in paired oak and eucalyptus groves, in order to better understand consequences of eucalyptus invasions for native animal communities.

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Chapter VIII. ESNERR Goal #6
Reduce Pollution across the Elkhorn Slough Watershed

A. Introduction

Estuarine habitats often have particularly high levels of pollution relative to other coastal habitats, because human uses such as industry, agriculture, residential development, and harbors are often densely concentrated around them (Kennish 2002). Virtually all such human uses of the estuary and adjacent land potentially can supply some contaminants to adjacent habitats– for instance industrial chemicals, agricultural fertilizers and pesticides, residential sewage, and boat paints. In estuarine habitats of the Elkhorn Slough watershed, numerous contaminants from a variety of sources have been identified. In this largely rural watershed, the main cause of water and sediment quality degradation is agricultural non-point source pollution (Caffrey 2002, Phillips et al. 2002).

The Elkhorn Slough National Estuarine Research Reserve's (Elkhorn Slough NERR) water quality monitoring program has documented elevated nutrient levels in watershed wetlands. For instance, in the South Harbor, Tembladero Slough, and old Salinas river channel, nitrates average over 50 mg/L (vs. safe drinking water standard of 10 mg/L), and the peak values at these sites are among the highest ever reported for estuarine ecosystems (Caffrey 2002). In the main channel of Elkhorn Slough, nitrate concentrations are lower, averaging 5 mg/L or less. However even in these areas strongly flushed by the tides, higher concentrations occur in the rainy season, partly due to subwatershed sources. This is shown through data generated by the Elkhorn Slough NERR's System-wide water quality monitoring program, which has detected higher levels of nutrients in Reserve wetlands on outgoing tides, attributable to local sources, than on incoming tides. Furthermore, an array of in-situ nitrate monitoring instruments has recently documented nitrate from Salinas River channel / Tembladero Slough sources traveling up the Slough, into and well past the Reserve (K. Johnson in prep; www.mbari.org/lobo).

Nitrate concentrations in Elkhorn watershed wetlands have increased two orders of magnitude since the 1920s (Caffrey 2002). In addition to high levels of nutrients,

significant concentrations of legacy agricultural pesticides such as DDT, newer pesticides, and fecal coliform bacteria have been documented in some watershed wetlands, with highest levels in the areas receiving the most freshwater run-off (Phillips et al. 2002).

Though watershed pollution levels are well documented, there have been few studies of the direct ecological impacts of this pollution on Elkhorn Slough habitats. Parkin (1998) attributed the reproductive failure of a Caspian Tern colony to high levels of DDT and other contaminants she documented in eggs and embryos in a flood year. Beck & Bruland (2000) documented extremely high productivity and resultant hypoxia in a Slough wetland. Byrd et al. (2004) have shown that agricultural erosion can result in sediment fans that bury adjacent wetlands and result in marsh loss. Water collected from Tembladero Slough and sediments from the Moss Landing Harbor have been shown to cause toxicity to small crustaceans, attributed to organophosphate pesticides (Hunt et al. 2003, Anderson et al. 2004). In addition to these documented impacts, other ecological changes may be occurring in response to agricultural pollutants, as demonstrated at other estuaries, including many with nutrient-loading less than seen in some estuarine habitats in the Elkhorn watershed (Kennish 2002). These can include losses and declines of species due directly to sensitivity to high contaminant concentrations, or due to indirect effects such as increased hypoxia and macroalgal blooms associated with high nutrient concentrations (Valiela et al 1997).

The fundamental approach required to reduce pollution across watershed habitats is to decrease the amount of agricultural run-off and sediments leaving farms, and/or to decrease the concentration of contaminants in them. A number of organizations (Natural Resources Conservation Service, Resource Conservation District of Monterey County, Regional Water Quality Control Board, Elkhorn Slough Foundation, Agricultural and Land-based Training Alliance, Community Alliance of Family Farmers, Monterey County Farm Bureau, UC Cooperative Extension) have and continue to encourage, teach, and assist growers and landowners in improving land practices in the Elkhorn watershed, or by owning land and managing it directly. With on-going training efforts, voluntary

improvements, acquisition by land trusts of farmed lands adjacent to wetlands, and increasingly strict regulations, agricultural pollution is likely to decrease in the coming decades.

B. ESNERR Objectives and Strategies

Staff from the Reserve's Education Program, Coastal Training Program, Stewardship Program, and Research Program are involved in the following objectives and strategies

The Reserve's niche with regard to reducing agricultural pollution is primarily to support organizations more directly involved with improving farming practices. In particular, the Reserve can provide scientific information and education materials to improve decision-making about agricultural pollution. We will help inform key audiences about estuarine resources and how they are sensitive to agricultural pollution. We will collect, analyze, and disseminate water quality data. We will raise awareness about sources of contaminant-loading outside the watershed and help develop possible solutions. Finally, we will attempt to decrease direct effects of agricultural pollution on our own Reserve lands.

Objective 1: Improve understanding of pollution levels, sources, and effects on coastal habitats.

Strategies:

1. The Research staff will continue SWMP and monthly 24-station water quality monitoring programs (see Chapter IX).
2. The Research staff will analyze these water quality data to detect changes in water quality linked to upland land use practices and water control structure management.
3. The Research staff will conduct literature search to examine potential ecological impacts of nutrient levels documented in Elkhorn watershed wetlands.
4. The Research staff will convene at least two water quality workshops for key regional agencies, organizations, and researchers involved in water

quality sampling or regulation. Provide presentations on Elkhorn Slough NERR data on nutrient pollution levels, correlates, and potential ecological consequences, and facilitate information exchange about water quality issues.

Objective 2: Generate and disseminate information on estuarine values and how they are affected by pollution.

Strategies:

1. The Education staff will support education efforts through the visitor center and school programs. Content for educational materials on pollution will be informed by the Research team and incorporated into docent training materials, teacher curriculum materials, and visitor center exhibits as is determined appropriate by education program strategic planning.
2. The Education staff will provide educational experiences that inform audiences how estuarine resources are affected by pollution. This will include opportunities for hands-on field experiences, such as water quality monitoring activities, that illustrate basic concepts behind the movement of pollutants in the watershed
3. The Education staff will develop an interactive computer exhibit to highlight nutrient dynamics data resulting from the Reserve's water monitoring program and the Land-Ocean-Biogeochemical-Observatory of the Monterey Bay Aquarium Research Institute.
4. With the assistance of the Research staff, the CTP staff will one workshop with key agencies to document and share current knowledge about agricultural pollution impacts on estuarine wildlife and water quality with regional decision makers and scientists.
5. The CTP staff will serve as a clearing house for information on agricultural pollution impacts on estuarine wildlife and water quality to

enable decision makers to develop regional policy or prioritize efforts based on the best available science.

6. With the assistance of the Research staff, the CTP staff will post on the website information related to pollution on the Reserve's habitats.

Objective 3: Decrease effects of agricultural run-off and erosion on the Reserve.

Strategy:

1. The Stewardship staff will maintain and enhance structures that decrease the effects of agricultural run-off from neighboring agricultural lands (e.g., pipe into Willow Bend; sediment basin above lower Cattail Swale).

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Chapter IX. ESNERR Goal #7
Monitor Key Indicators of Coastal Ecosystem Health to Enhance Understanding of Spatial and Temporal Variation and Long-term Trends

A. Introduction

Long-term monitoring programs – those carried out consistently for at least a decade, and ideally many decades – are vital for detecting spatial and temporal trends in ecosystems, and for distinguishing natural from anthropogenic perturbations. Long-term datasets improve our understanding of, and thus decision-making about, complex ecological processes that occur at large spatial and temporal scales (Vos et al. 2000). In order for long-term monitoring programs to succeed, they must have strong institutional support and the explicit commitment to their consistent continuation over decades. While academic institutions are ideally suited to supporting scientists that carry out short-term research projects, and environmental consulting firms are often appropriate for completing finite restoration monitoring to determine whether quantitative objectives of a project have been met, neither of these types of organizations are likely to take on the commitment required for consistent continuity of long-term monitoring programs.

In the Elkhorn watershed, the Elkhorn Slough Reserve is ideally suited to designing and implementing long-term monitoring. There is strong institutional support at the local (Elkhorn Slough NERR) and national (National Estuarine Research Reserve System) level for carrying out high quality, consistent monitoring of key indicators of coastal health. The Reserve is committed to continuing its role as a leader in regional monitoring.

Purposes of long-term monitoring, with examples from the Elkhorn Watershed

1) Characterize current baseline conditions against which to evaluate future trends. Well-chosen monitoring indicators are capable of providing continued assessments even over a wide range of future stresses (Noss 1990). In the Elkhorn watershed, there is no water quality or biological data from the period preceding major human alterations to habitats and ecological processes. This

makes it hard to assess past ecological impacts of various threats and to set restoration targets. The Reserve is now committed to collecting such data so that resource managers a century into the future can assess how these indicators have changed. The Reserve is fortunate to have habitat change data (from old maps and photographs) that reveals 150 years of largely human-induced changes (Van Dyke and Wasson 2005). This dataset has been instrumental for motivating conservation action and setting restoration targets (see Tidal Wetland Project, Chapter III). This is a fine example of how baseline monitoring can support resource management and the public in setting and refining regional objectives by improving understanding of the status and trends of resources (Ringold et al. 1996), and in the future, the baseline water quality and biological data we are today collecting will serve this function.

2) Serve as an early warning for potential new threats. Each Reserve long-term monitoring program can detect marked changes in indicators of estuarine health (Vos et al. 2000). Data are usually analyzed within weeks of collection, and always within a year. If average values of indicators are more than two standard deviations from the average of the previous periods, Reserve staff contact regional researchers and resource management agencies to spark further investigations into the geographic extent of a potential crisis and its likely causes and possible solutions. For instance, declines of California Red-legged Frogs detected by the Reserve resulted in collaborations with the United States Fish and Wildlife Service and regional managers, and stimulated research on amphibian diseases in the watershed.

3) Identify potential impacts of emerging threats. Sensitive monitoring indicators can provide early warning about effects of environmental changes (Noss 1990). For instance, Reserve biological monitoring data from the past five years has revealed that a new invader to Elkhorn Slough, the European Green Crab, rapidly went from extreme rarity to high abundance, while native crab abundance declined. In the future, Reserve breeding bird monitoring will serve as a sensitive

indicator of local effects of global warming, since nesting would be likely to be initiated earlier. Reserve wetland habitat monitoring can detect changes in marsh cover in response to sea level rise.

4) Improve restoration strategies for threatened species. Reserve amphibian monitoring data on declines of threatened species have motivated improved Reserve and regional management of ponds (for appropriate hydroperiod and bullfrog eradication). Reserve intertidal monitoring has shed light on the extreme rarity and habitat requirements of native estuarine oysters and brackish snails, informing restoration and management strategies for these species.

5) Suggest causes of observed patterns. In general, long-term monitoring programs are much better suited for detecting patterns than for identifying the processes behind them. Short-term manipulative experiments are more appropriate for demonstrating the mechanisms behind observed changes. However, a well-designed monitoring program can at least provide circumstantial evidence of potential causes behind the patterns, if sampling is carried out at appropriate spatial and temporal scales. In this way, indicators being measured can be used to distinguish between natural cycles and trends resulting from anthropogenic stress (Noss 1990). For instance, the Reserve volunteer water monitoring program is carried out monthly at 24 stations in the watershed. This *spatial* scale has been essential for detecting predictors of poor water quality; the data reveal a strong role for both agricultural run-off and water control structure management in influencing nutrient concentrations. Likewise, the high *temporal* resolution of the Reserve NERR system-wide water quality program has revealed varying sources of nutrient loading. In the dry season, the highest nutrients are measured on incoming tides, suggesting an oceanic source, while in the rainy season, the highest nutrients are found at low tide, suggesting a subwatershed source.

6) Stimulate further research and management efforts. The data from Reserve monitoring programs are regularly requested by and made available to researchers

and resource managers, regionally and even nationwide. The Reserve receives hundreds of requests a year, particularly for water quality data and GIS layers. Many investigators, particularly regional graduate students, choose to carry out research at Elkhorn Slough because of the availability of baseline monitoring data and because these have highlighted interesting patterns that merit further exploration. By providing these data, we thus can stimulate additional research at the Slough, and direct it towards critical gaps in conservation priorities.

To improve the management of complex coastal ecosystems, it is important to use a combination of different indicators at multiple scales, from ecosystems to habitats to species (Noss 1990, Wilson 1994). Reserve monitoring programs fall into three main categories:

4. Water quality and weather monitoring to characterize overall ecosystem health

5. Biological monitoring of threatened species and characteristic estuarine and coastal communities.

6. Habitat and land use change monitoring to track changes in the extent and distribution of different land cover classes, and

Over the past decades, the Reserve has gradually developed, tested, and expanded a suite of long-term monitoring indicators. Workshops of regional experts have helped define the best indicators of estuarine ecosystem health that can be affordably monitored by a small staff with a limited budget. With the help of these experts, the parameters currently being monitored have been prioritized (see Table 9.1). In the next decades, the Reserve is firmly committed to continuing all existing priority 1 programs. The priority 2 programs will be continued unless severe budget decreases result in loss of research staff. The priority 3 programs are likely to be continued, but might be dropped in case of budget decreases or lack of sufficient volunteer or staff expertise.

Each program has a defined, written protocol and is coordinated by one lead Reserve staff member, with a second staff member fully trained as an alternate. Some projects also have a volunteer lead who assists the staff lead or handles the majority of the coordination. For all twenty monitoring programs (Table 9.1), data are consistently collected and archived in databases that include clear metadata, and back-ups are regularly made and stored in two separate buildings. The databases are made available to anyone who requests them. In addition, the data from one program, the system-wide water and weather program, are archived and made available by the NERR Central Database Management Office.

Information about the monitoring programs and the trends they have revealed thus far is regularly presented by Reserve staff in presentations to a variety of audiences, ranging from applied resource managers to college classes to the general public. The monitoring programs are also highlighted on the Reserve webpage, and graphs and tables are updated annually to highlight recent trends.

In addition to continuing existing monitoring programs, the Reserve will explore the development of new programs, in partnership with other regional agencies or universities. There are a number of high priority programs, which will be developed if funding and staffing permit, they include eelgrass, benthic infauna, and fish assemblages.

B. ESNERR Objectives and Strategies

Objective 1: Collect, archive, and disseminate consistent, high caliber data on critical ecosystem characteristics.

> **Strategies**: 1. The Reserve will collecting high caliber, consistent data according to specified protocols, will archive them and make them readily available to any requestors. The Reserve will also annually update the Reserve webpage with tables and graphs summarizing trends. The Reserve's long-term monitoring programs are summarized in Tables 9.1 through 9.6.

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Chapter X. ESNERR Goal # 8
Educate the Community about the Watershed and Inspire Them to Consider Environmental Conservation When Making Decisions Affecting Elkhorn Slough and Its Watershed

A. Introduction

The Reserve offers a mosaic of education programs that are designed to reach a variety of audiences through different venues using different delivery modes. Based on target audiences these programs can be grouped into four components:

5. Coastal Training Program – reaching local and regional decision makers though workshops, workgroups, independent scientific review, distribution of information, and networking with experts.

6. School Programs – current programs include: K-12 Teacher Professional Development, Reserve-based Field Experiences, Interactive Virtual Field Trips, Multicultural Outreach, K-12 and Non-formal Education Partnerships, and support of college and university courses, community service programs and student internships.

7. Public Education – centering on the visitor center and five miles of trails, offering guided tours, special events, and opportunities for outreach to neighbors in the Elkhorn Slough watershed.

8. Volunteer Program – trains a cadre of community volunteers to assist with the implementation of the other education programs and also serve to support the research, monitoring and restoration programs, and other aspects of the operation of the Reserve. (See Chapter XV, Volunteer Program Overview)

The challenge for the Reserve's environmental education program is to offer entry level experiences for all ages with opportunities to take "courses" of greater depth and increasing levels of involvement.

The venues range from trails through oak woodlands, grasslands, riparian corridors, next to freshwater ponds, salt marsh, mudflats and the waters of the estuary, to an outdoor amphitheater, visitor center with exhibits and a bookstore, teaching laboratory, conference room with multi-media capabilities, and the virtual experience of the world wide web on a computer screen in a classroom or someone's office.

The delivery modes range from self-guided hikes through a range of coastal habitats to docent lead tours, public events, school programs, and in-depth trainings and workshops.

The content ranges from nature and natural landscape appreciation to studies in natural history, historical ecology, environmental and restoration science, and resource management. Content is informed by the research and stewardship programs.

Priority topics/messages, optimum delivery modes, and target audiences are determined through strategic planning, (including needs assessments), in collaboration with other Reserve program coordinators and with input from appropriate community partners. General content is reviewed by appropriate experts and specific, current, in-depth topics are defined/informed by the habitat specific conservation goals and priorities of this management plan. Programs will have well-defined evaluation strategies that facilitate improvement of content and delivery modes and help to guide the professional development plans for Reserve staff and volunteers.

While implementing these education programs the Reserve will seek out opportunities to collaborate with local, state and national partners to benefit from sharing information and resources. The Education Coordinator will serve on state (DFG) and national (ERD) education committees that are relevant to the local efforts. The Education Program will fulfill obligations defined by the California Department of Fish and Game (CDFG) Statewide Aquatic Education 5-year Plan and the national K-12 Estuary Education Program (KEEP) of the National Estuarine Research Reserve System (NERRS). Program content will address the Natural Resource Education Messages of CDFG. As

we proceed with strategic planning we will refer to various guiding documents including the California Education on the Environment Initiative (http://www.calepa.ca.gov/Education/EEI/), the DFG statewide plan for conservation education that is being developed by the new Office of Education and Outreach, (in progress, will be available at www.DFG.ca.gov), and NOAA's Education Plan (http://www.oesd.noaa.gov/NOAA_Ed_Plan.pdf).

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B. Elkhorn Slough NERR Objectives and Strategies

Staff from the Reserve's Education Program and Coastal Training Program are involved in the following objectives and strategies

We will gather information from appropriate references, workshops, research projects, and forums. Material will then be packaged in ways appropriate for the different target audiences, building on core concepts and themes in conservation, and delivered in a variety of ways to address a broad range of learning styles. We will practice basic principles of interpretation, (Tilden 1977, Beck and Cable 2002), and experiential learning modalities, (Kolb 1985), recognizing that people of all ages learn in a progression from the concrete to the abstract. Simply put, we learn by doing. This translates into field activities such as plankton tows, crab trap surveys, and water quality monitoring for students, volunteers, and the general public on tours; as well as direct field experiences for participants in Coastal Training Program workshops and public forums.

We will gather key reference material and make it available in the visitor center library and on the website. Information pieces will then be crafted by staff, volunteers or student interns, reviewed by senior interpretive staff, and made available through the different education components.

Table 10.1. Educational and communication tools available through three of the Reserve's education programs. (Please see Appendix 3 for more details on CTP)

Public Education	Volunteer Program	School Programs
	docent training	teacher training
public forums	docent enrichments	teacher enrichments
interpretive materials for self-guided tours	interpretive tools for docents to use on public tours	interpretive tools and activities for classroom or trails
fact sheets available in visitor center	material for docent reader	material for teacher curriculum
newsletters	docent newsletter	electronic newsletter or bulletin board
video clips to show in visitor center exhibits	CD's , DVD's with multi-media background material to support training	CD's, DVD's with multi-media material to support curriculum
interactive computer in visitor center exhibits	interactive computer activities for home or office	interactive computer activities for the classroom
website	website	website, virtual field trips

Objective 1: Create and implement environmental education programs for school-aged children, visitors, our watershed neighbors, and decision makers.

Strategies:

1. The Coastal Training Program will carry out education programs, which are defined by the CTP strategic plan (see Appendix 3) which are, in part, echoed in the habitat specific conservation goals and priorities of this management plan. In order to accomplish this CTP staff will:
    - **i.** offer educational programs that target audiences on priority topics identified in the CTP strategic plan as informed by audience needs assessments and market analyses.
    - **ii.** with the help of the Coastal Training Network, generate materials and information for professionals, including fact sheets, white papers, peer reviewed publications, the Coastal Training Program website, etc.

iii. provide information for other education staff to use in generating materials appropriate for other audiences such as students, docents, teachers, and the general public

iv. the number of workshops and products will depend on funding level and information available. Efforts will be made to increase funding by leveraging partnerships as well as private and public grant support.

2. The Education staff will continue to offer existing programs at a level that our current staff can support, setting aside time to engage in strategic planning. This may include:

i. K-12 Teacher Professional Development, Reserve based Field Experiences, Interactive Virtual Field Trips, Multicultural Outreach, K-12 and nonformal education partnerships, and support of college and university courses, community service programs and student internships.

3. The Education staff will complete a market analysis and needs assessment and convene an advisory committee to guide the development of a strategic plan. In order to accomplish this we will:

i. review the current environment in the public schools which will help to inform changes in Reserve programs to address these realities.

ii. clarify the specific niche that the Reserve education programs can fill in the local/regional environmental education community, review existing and potential new programs, prioritize audiences and messages, and define appropriate delivery modes. From this process we will match programs with existing staff.

iii. create strategies for acquiring funds and staff to support additional priority programs.

4. The Volunteer staff will evaluate the overall program and work to improve the training and support of volunteers. In order to accomplish this we will:

i. revise the docent reader and update the volunteer training program content and presentations.
ii. coordinate with local volunteer programs to share resources and opportunities.
iii. cooperate with CDFG statewide volunteer coordination efforts. (See Chapter XV for more details.)

5. The Education staff will offer an informative and enjoyable experience for the public through the Visitor Center. In order to accomplish this we will:

i. Maintain current exhibits and create new and changeable exhibits featuring the habitats of the Slough.
ii. feature topics prioritized by strategic discussions with other Reserve program leads and the Education Advisory Committee.
iii. create background material, including internally generated brochures and fact sheets, which will be made available in the reading area, bookstore, and docent library.
iv. keep staff and volunteers up-to-date with information and interpretive techniques/tools through regular meetings and enrichments.

6. The Education staff will train volunteers to give informative public tours through the 9-week volunteer training course and follow-up enrichments.

7. The Education staff will strategically decide which on-site and off-site special events to participate in each year based on priority messages, audiences, and levels of staff and funding.

8. The Education staff will foster a watershed identity in the community and establish ourselves as the caretaker/spokesperson for the habitats and species in the estuary and watershed. In order to accomplish this we will:

i. include watershed neighbors in existing events and activities through targeted communications.

ii. work with other Reserve Programs and the staff of the Elkhorn Slough Foundation to acquire funding for and hire a Community Outreach Coordinator who will take on tasks prioritized through a strategic planning process but may include the following:

1. Coordinate events on and off-site specifically designed for neighbors in the watershed.
2. Develop a watershed welcome packet to be distributed to all neighbors in the watershed.
3. Produce a watershed newsletter to keep people informed of current events and issues effecting the watershed and slough.
4. Work on other actions defined in habitat goals that require community outreach efforts.

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Chapter XI. ESNERR Goal #9
Maintain a Viable Base for ESNERR Programs: Organization, Budget, and Facilities

A. Introduction

In order to successfully protect, restore, research, and educate, we must provide a strong organizational and infrastructure foundation upon which these activities can build. Important conservation goals can only be fully achieved when the staffs working on them have a productive and safe environment in which to work, as well as the resources and tools necessary to do their jobs. The rationale is simple: If an organization is plagued with unsafe or uncomfortable working conditions, low morale, bad communications, disorganization, too few funds, a poor public image, or inadequate facilities, it is less able to accomplish its mission.

B. ESNERR Objectives & Strategies

All staff are involved in the following objectives and strategies.

Objective 1. Maintain a productive, safe, and efficient ESNERR work environment.

Strategies:

1. The Administration staff will train, motivate, and evaluate staff. In order to accomplish this we will:
    i. Create and embrace opportunities for professional development and training.
    ii. Follow state-mandated and ESNERR policies that ensure fairness and appropriate behavior.
    iii. Provide safety and emergency training and information.
    iv. Evaluate staff performance and develop annual work plans.
    v. Express appreciation for ESNERR staff and volunteers.

2. The Administration staff will facilitate team-building, information exchange, and strategic planning. In order to accomplish this we will:
    i. Conduct all-staff (ESNERR and ESF) retreats and staff meetings.
    ii. Conduct regular meetings to revisit integrated ESNERR goals, strategies, and activities.

iii. Encourage regular and effective communication between ESNERR and ESF staff.

3. The Administration staff will procure and administer Reserve funding. In order to accomplish this we will:

i. Write grants to various funding entities and prepare requests for State funding as needed.

ii. Effectively track and administer grants, budgets, and match.

4. The Reserve will operate a "well-oiled machine." In order to accomplish this we will:

i. Maintain organized files, image media, maps, data, and other archives that are accessible to others as is appropriate or needed.

ii. Maintain organized work and storage spaces.

iii. Secure funding for a staff member or contractor to organize and maintain the Reserve's media (video/DVD, photo/slide/digital images, etc.) and historical archives.

iv. Provide up-to-date and sufficient information technology support (computer, networks, internet, wireless communication, software, etc.) to staff.

Objective 2. Maintain a visible and positive ESNERR image.

Strategies:

1. The Reserve will seek interaction with and input from professional colleagues, both regionally and nationally. In order to accomplish this we will:

i. Attend, participate, and present at meetings and conferences as is feasible.

ii. Maintain effective communications with colleagues through telephone and email.

2. The Reserve will maintain good communications with the general public and with citizen organizations working within the Elkhorn Slough Watershed. In order to accomplish this we will:
    i. Respond to general telephone, mail, and email.
    ii. Attend meetings and functions of citizen organizations as is feasible.
    iii. Develop an integrated communications and outreach plan.
    iv. Pursue funding for a communications staff position. This new position will produce a Reserve newsletter, site brochure, and press releases, as well as prepare and give presentations.

3. The Reserve will support partner organizations, with special emphasis on DFG, NERR, and ESF, and actively participate in appropriate partner-related activities. In order to accomplish this we will:
    i. Prepare various articles for and give presentations to partner organizations.
    ii. Participate in working groups, attend meetings and conference calls, and maintain good communications with partner organizations.

Objective 3. Maintain, repair, and construct ESNERR facilities and infrastructure.

The presence and maintenance of certain structures is essential to all programs on the Reserve. In order to provide workspace, allow for public and scientific access, and maintain habitats, facilities must be constructed and maintained. Often, there is a close connection between facilities and stewardship. For example, tide gates must be maintained to prevent flooding a county road and also to provide proper water depth for feeding birds. Many of the "maintenance" objectives below have both an operational and a stewardship component. Funding and staffing shortages are the largest barriers to implementing the Reserve's maintenance and construction strategies.

Strategies:

1. The Reserve will seek funding for the maintenance and repair of existing facilities and, if successful, will pursue the objectives listed below.

i. **Maintain existing buildings.** The visitor center was constructed in 1985 and is showing significant wear and tear, especially on the exterior. Laminated wood doors are peeling apart, paint is peeling, and wood has dry rot and termite damage. The garage and maintenance shop was also constructed in 1985 and is showing significant signs of wear and weathering. The administration building was constructed in 1993 and is now due for repairs. The conference room floor is peeling, exterior doors are warped, window screen are ripped, walls need patching and painting.

ii. **Investigate options to improve building security and seek funding for and implement recommended solutions.** In order to protect Reserve equipment and resources, an improved security system is needed.

iii. **Maintain native landscaping around buildings and modify landscape plans as needed.** Native landscaping requires weeding, mowing, and pruning for aesthetics and to maintain access along walkways and buildings.

iv. **Upgrade and maintain the Reserve's communication infrastructure.** With the rapid evolution of technology, the Reserve must find ways to stay current in order to function and interact efficiently with each other and with partner institutions. There is a growing need for ongoing, on-site technical support to both troubleshoot problems and to help plan for and implement new technologies. A new Information Technology staff position is necessary to achieve this.

v. **Maintain and repair the Reserve's public drinking water system, freshwater ponds, and wildlife drinking guzzlers.** Humans and wildlife require fresh, safe water to drink. In

2004/2005, CDFG installed a state-of-the-art ozonation system and new pumps to treat and distribute the public drinking water. However, the original pipelines that run for miles throughout the Reserve still need to be mapped, repaired, or replaced. In an area where the groundwater table has been over-tapped and freshwater springs and creeks no longer flow, special challenges arise to provide drinkable water for all.

vi. **Upgrade the Reserve's septic sewage system.** Currently, the Reserve's septic system is adequate, but as public use, programs, and facilities grow, it is anticipated that it will need to be expanded.

vii. **Repair access roads and trails.** Reserve roads are badly eroded and some are not properly constructed. In winter, staff cannot access certain areas of the Reserve for maintenance, research, habitat restoration, and emergency deliveries (e.g. sand for sandbagging). Trucks regularly get stuck on wet, unsurfaced roads causing damage to vehicles and loss of time and contracts.

viii. **Replace Reserve boundary fencing and boundary signs.** Various sections of the Reserve boundary are unfenced or have fencing in disrepair. Some fenced areas have no signs to designate the boundary. Fencing and boundary signs are necessary to decrease trespass and protect Reserve resources.

ix. **Explore options for either repairing or removing Rookery Berm.** Rookery Berm, located on the South Marsh Loop Trail, was damaged during the heavy El Nino rains of 1998 and currently harbors a large crack. It has been evaluated by engineers from a private firm as well as by CDFG engineers.

x. **Rebuild Whistlestop Causeway and replace its culverts**. The causeway that separates South Marsh and Whistlestop Lagoon has been severely eroded by extreme high tides and rains. Temporary repairs were made in 2005/2006; but, a more permanent rebuilding

of the structure, including replacing the existing damaged culverts and building a bulkhead on the north side of the levee to prevent gravel from entering the lagoon, is needed.

xi. **Repair and prevent bank and trail erosion on the South Marsh Loop Trail.** The banks of the South Marsh Lagoon near the site of an old dairy dump are severely eroded. The public and maintenance access trail along this section is in jeopardy of being closed due to this erosion. The surrounding terrain is such that this closure would have serious impacts on accessibility.

xii. **Repair or replace the North Marsh tide gates and associated structures.** Three of the four tide gates in North Marsh need repair in order to facilitate management of the marsh for migratory shore birds. The culverts have been bent into a "v" due to the weight of the tide gate levee and the grating above the eastern end of the culverts is skewed and partially missing.

xiii. **Maintain Cattail Swale sediment basins.** Cattail Swale (upper and lower ponds) is some of the area's best breeding habitat for endangered California Red-legged Frogs and Santa Cruz Long-toed Salamanders. The basins require continuous maintenance of sediment levels and water control structures.

xiv. **Repair the Large Dairy Barn.** A large, historic dairy barn is open to the public on the South Marsh Loop trail. The barn has severe dry rot and termite damage and major beams need replacing. The barn is used as a sun and rain shelter for visitors hiking the trails and as a gathering and teaching spot for school groups, public tours, and teacher workshops.

xv. **Repair the Small Dairy Barn.** The small barn left over from the dairy operation has dry rot and termite damage. The barn is currently used for storage of maintenance materials and is not open to the public.

xvi. **Replace the footings on the South Marsh Loop Trail footbridge.** The footbridge that was constructed in 2002 still requires upgraded footings at each end. These footings also need to be armored to protect them from tidal scour and wind wave erosion.

xvii. **Replace parking lot lights.** Three of the four parking lot light poles have rotten and fallen down. The final light is temporarily braced, but will require replacement soon. Providing lights in the parking lot, especially in the winter, is important for human safety and for building security.

xviii. **Repair or replace Reserve public use structures.** Various public use structures such as benches, outhouses, boardwalks, and viewing blinds are in need of repair or replacement. More than 50,000 people visit the Reserve each year and structures available for their use must be properly maintained.

xix. **Redesign and replace the Reserve's front entrance sign and trail signs.** The front entrance sign to the Reserve has not been replaced in over 20 years and is degraded and outdated. A portion of the planter box associated with the sign was burned in a small grass fire and needs replacing. Directional trail signs throughout the Reserve are old, rotten, and many are unreadable. Visitors need signs to welcome them through the Reserve entrance and to navigate around the trails and back to the visitor center and parking lot.

xx. **Repair and improve the Marsh Education Dock.** The Marsh Education Dock, located on the South Marsh Loop Trail, needs to be repaired and improved in order to be useable. An all-weather trail and an education staging area need to be developed to improve access.

xxi. **Repair and maintain employee residences.** The three employee residences on the Reserve were on the site before CDFG purchased

the property. One was a hunting lodge built in 1906, one was a caretaker's cottage built in 1914 and expanded in 1984, and one served as Elkhorn Dairy staff housing. All three buildings are aged and require infrastructure maintenance and repairs.

2. A variety of new facilities are necessary to meet the Reserve's program goals. (See Chapter XIX for over-arching facilities goals.) New facilities will require additional funding both for their initial construction and maintenance. New construction will also require appropriate permits and review. The Reserve will:

i. **Seek funding to develop a state and county-approved Facilities Master Plan for the Reserve.**

ii. **Continue to define goals and needs for further development of Reserve facilities.** We hope to work with a professional consultant to refine and develop a Facilities Master Plan, and shepherd it through the permitting process. This plan will provide more specific guidelines regarding the recommended timing and placement of various facilities as well as provide streamlined permitting review for individual projects. Some of the needs that will be included in the Facilities Master Plan development are listed below.

iii. **Seek funding for and, if successful, construct an equipment storage building, expanded carport, tractor shed, boat rack, and wood shed.** There is currently no indoor, locked storage facility for large equipment. Many expensive pieces of equipment are located in a carport or an uncovered area of the shop yard, both of which are not secure from the coastal elements or from theft. Covered storage is also needed for vehicles, tractors and attachments, boats, and construction materials such as wood and fencing.

iv. **Seek funding to plan for, and possibly construct a 200-person meeting space.** Meeting space is needed on a regular basis for Coastal Training Program workshops, teacher workshops, meetings, lectures, volunteer activities, public events, and fundraisers. Currently, the Reserve's meeting space can only hold about 50 people, which is not sufficient for many of the events we currently host or wish to host. Options to meet this need include holding larger events off-site in order to use other available venues, renting temporary structures for each event, remodeling and expanding the current administration building, or constructing a new meeting facility.

v. **Explore the possibility of expanding employee housing.** The high local cost of living presents employee recruitment problems for the Reserve. Additional staff housing may result from upcoming land acquisition but if it doesn't, housing options such as new construction or placement of a modular or mobile home may be investigated.

vi. **Explore the possibility of constructing (or remodeling) a facility to serve as a guesthouse or dormitory.** A dormitory or guesthouse is important to encourage research and education program participation. The high local cost of lodging presents a financial burden to scientists and educators who wish to use the Reserve on a temporary basis. Reserve programs, such as the Coastal Training Program, would save per diem costs if invited speakers could stay on-site instead of in a hotel.

vii. **Seek funding for and, if successful, create additional all-weather parking.** Additional parking is needed for employees and visitors during peak visitation times. Currently, the overflow parking area is a grassy field that is not accessible during the wet months.

viii. **Seek funding for and, if successful, construct support facilities for the restoration greenhouse.** Currently, there are funds in place to construct a new greenhouse to grow plants for native habitat restoration. If additional funds are acquired, necessary components to the greenhouse facility will be added.

ix. **Seek funding for and, if successful, construct a vehicle soil wash station.** A vehicle soil wash station is necessary to help prevent the introduction of Sudden Oak Death and invasive weed seeds to the Reserve. These stations are commonly used by other state and federal resource agencies.

x. **Consider seeking funding and, if successful, remodel and expand the Administration Building to better serve staff needs.** The Administration Building floor plan needs to be reconsidered to provide maximum workplace efficiency. Some work spaces are located near through-ways or near the mail and photocopy area that receives disruptive traffic, and the kitchen area is poorly located. The need for additional office space is anticipated.

xi. **Seek funding for and, if successful, create an archive storage area for maps, historical photos, and other large items.** The proper storage of maps, blueprints, historical data, images, and other items is an ongoing need.

Chapter XII.
Public Access

A. Introduction

The Elkhorn Slough National Estuarine Research Reserve offers a variety of opportunities for public access. The Reserve is open to the public Wednesdays through Sundays from 9:00 a.m. to 5:00 p.m. The 583 hectare property (1,439 acres) is a hub of activity, visited by more than 50,000 people each year, and providing some unique and interesting wildlife viewing opportunities.

Access to the Elkhorn Slough NERR is through the main gate at 1700 Elkhorn Road. A fee of $2.50 per person is collected for visitors aged 17 and older. Admission is free for children under age 16 and for anyone holding a valid California hunting or fishing license. Educational groups such as school field trips and scout troops are also admitted free of charge.

The California Department of Fish and Game (CDFG) is committed to public access on the Elkhorn Slough NERR. However, providing adequate maintenance in order to ensure ongoing public access has proved a serious challenge. Significant budget cuts throughout the state combined with recruitment challenges resulting from the local high cost of living have left the Reserve without any full-time state maintenance personnel since 2000.

B. Visitor's Center

Upon arrival at the Reserve, most people first stop by the Visitor's Center, where they learn about the Reserve and its inhabitants, the surrounding watershed, and the value of estuaries. The Visitor's Center provides a variety of exhibits as well as opportunities to interact with dedicated interpretive staff and docents. Visitors may also experience the Reserve's diverse habitats first-hand, by hiking the five miles of trails that meander through beautiful oak woodlands, grasslands, calm tidal lagoons and freshwater marshes.

The Visitor's Center has disabled-accessible men's and women's restrooms, and a drinking fountain.

Directly outside the Visitor's Center are a picnic area and an amphitheater. These facilities are available to the public on a first-come, first-served basis without charge. The picnic area includes trash and recycling cans, as well as a large grass field for games and educational activities.

C. Reserve Trails

The Elkhorn Slough NERR has three loop trails – the Long Valley Loop, Five Fingers Loop, and South Marsh Loop -- each with trailheads that begin within a half-mile of the Visitor's Center (Figure 12.1). These trails connect with several secondary trails that take visitors to additional sites of ecological, scenic, or cultural significance. The Reserve's three trailheads are connected by a paved, wheelchair-accessible path, which ends at a scenic overlook of the Elkhorn Slough and features two spotting scopes.

Long Valley Loop

Less than a quarter-mile from the Visitor's center is the Long Valley Loop trail. The trail is a 0.8 mile loop that passes through oak woodland and follows along one of the fingers of a waterway known appropriately as "Five Fingers" or Parsons Slough. Along the trail are two resting benches. A boardwalk extends into the marsh that allows for a closer look at the Slough's mudflat animals at low tides and estuarine animals at high tides. This boardwalk is a favorite place to view leopard sharks, smoothhound sharks, and sat rays in the summer when they come into the shallows to feed on crabs and bear their live young.

Five-Fingers Loop

The Five Fingers Loop is a little over one mile long. The trail takes visitors through coast live oak, eucalyptus groves, and to the trail head of the Parson's Slough Overlook. Most of the Five Fingers Loop follows the hillside for great views looking toward Monterey Bay in the distance. In 1982 this site held the record for most bird species seen in a

single day in all of North America -- 116 species were seen on October 31. The trail also features resting benches for tired hikers. A spur trail leads to a specially-constructed wildlife viewing blind that allows visitors a closer look at the Slough's wildlife without disturbing the animals.

South Marsh Loop

The longest trail on the Reserve is the South Marsh Loop, which is over two miles long and connects to secondary trails with access to the North Marsh Overlook and Hummingbird Island. The trail includes two old dairy barns, which were part of the Elkhorn Dairy Farm that operated on the property from 1915 until 1972. Public outhouses and drinking water are provided at the larger of the two barns. The trail passes through native oak woodlands, and non-native Monterey pine and eucalyptus forests, and features views of a large rookery that is home to nesting great blue herons, great egrets, and double crested cormorants. The trail features resting benches and a boardwalk that extends into South Marsh. At low tide, the boardwalk affords visitors the opportunity to view mud-dwelling invertebrate burrows and the tracks of many birds and mammals that forage on the mudflat. The footbridge allows visitors to witness the slough's daily tidal currents, as the tides transport sea water into and out of the Rookery Lagoon.

Hummingbird Island

Hummingbird Island is accessed via a westerly extension of the South Marsh Loop Trail. The 200 square-foot "island" (it is actually a small peninsula) was once an Ohlone campsite and is now being restored by a small group of active volunteers. While the other Reserve trails explore various fingers and lagoons of Elkhorn Slough, Hummingbird Island brings visitors to the edge of the main channel. A resting bench is provided at the western-most end of the island that overlooks channel waters.

Two sculptures funded by the California Environmental Arts Council are located on the island. The sculptures, which incorporate both natural and manufactured components, were inspired by the shapes of an Ohlone hut and a shell mound or "midden". These are not replicas, but instead are unique art pieces designed to each incorporate an ecological

function. The hut-shaped sculpture serves as a focal point for flowering native plants that are favored by hummingbirds. The midden-shaped sculpture is accompanied by a reflecting pool that serves as the island's freshwater drinking source for wildlife.

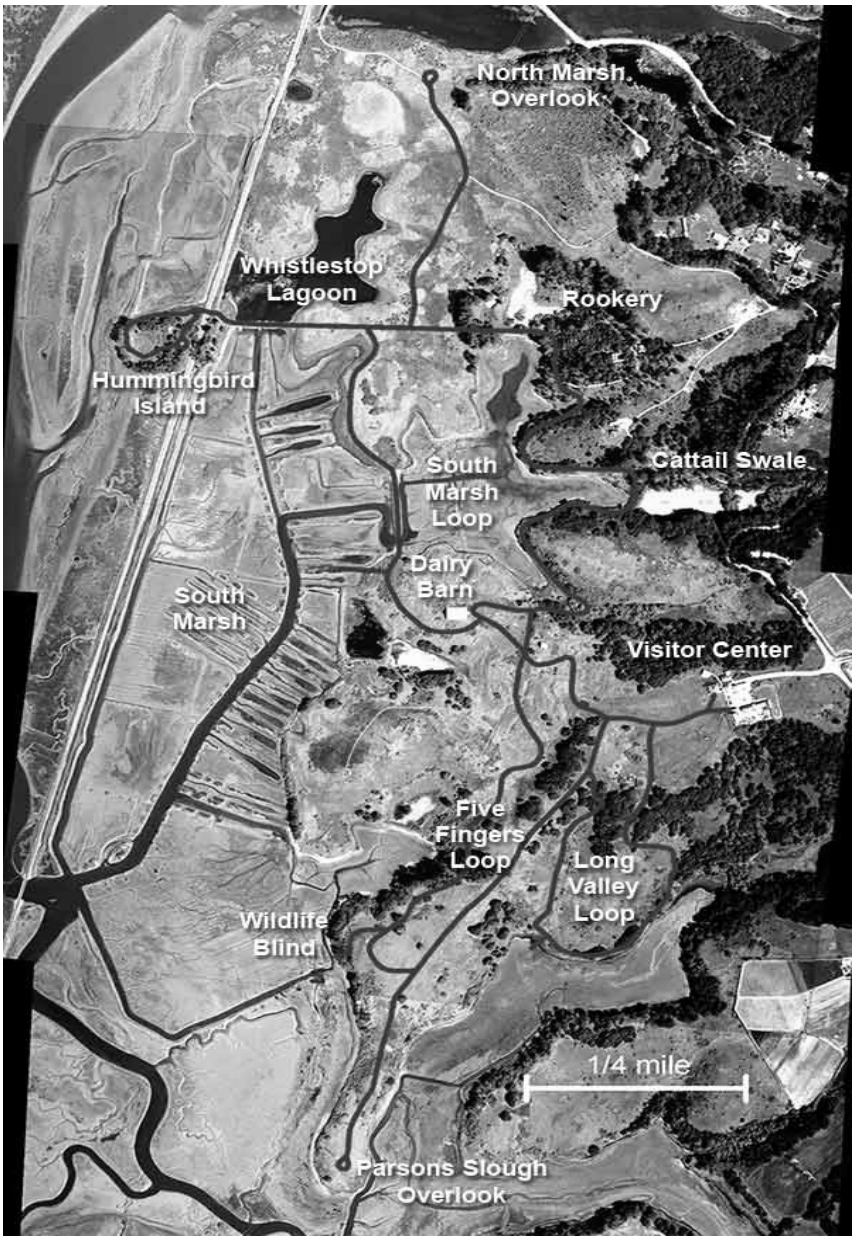

Figure 12.1. Aerial view of the Elkhorn Slough National Estuarine Research Reserve with public trails marked.

D. Reserve Regulations & Enforcement

The Elkhorn Slough NERR has a number of regulations that protect natural resources, while maintaining the safety and enjoyment of visitors. These regulations are posted in Title 14 of the California Administrative Code, Chapter 11. Ecological Reserves, and include the following:

1. Only foot traffic is allowed on trails.
2. Hikers must remain on designated trails.
3. All plants, animals, and artifacts are protected. No collecting is allowed.
4. Releasing of any animals, feeding of wildlife, or introduction of any plant is prohibited.
5. Camping and boating are not permitted within the Reserve.
6. No areas within the Reserve have been designated for hunting or fishing.
7. Pets are prohibited from entering the Reserve unless they are retained on a leash of less than ten feet or are inside a motor vehicle. Pets are not allowed on the trails.
8. Fires and firearms are not permitted.
9. Picnics are allowed in designated areas.
10. Litter must be disposed of in trash cans.
11. Researchers have established experiments around the Reserve. These experiments can not be removed or disturbed in any way.
12. Entrance to the Reserve is only available during the posted open hours and only through the main gate at 1700 Elkhorn Road.

Enforcement of all regulations is provided by DFG wardens.

E. ADA Accessibility of Reserve

In recent years, the Elkhorn Slough NERR has made several changes in order to provide better access to persons with impaired mobility. In 2000, the Reserve built a ¼ mile paved hiking path that extends from the Visitor's Center to the main overlook of Elkhorn

Slough, looking out toward Moss Landing. Additionally, in 2005 the following upgrades were implemented in order to be compliant with the Americans with Disabilities Act (ADA):

1. Added a wheelchair-accessible shelf to the Visitor's Center customer counter
2. Retrofitted public bathrooms
3. Graded the parking lot path to allow for wheelchair access
4. Lowered the conference room sink and counter
5. Installed ADA compliant signage

During special events, the Reserve also provides limited mobility van rides out to the bird rookery.

F. Public Access Near the Reserve

With several state beaches, parks, preserves, and wildlife areas nearby, the Elkhorn Slough watershed offers a wide range of access opportunities (Tales 12.1-12.2). At the Department of Fish and Game's Moss Landing Wildlife Area, fishing and seasonal hunting for waterfowl is permitted.

An excellent way to experience the Slough's vast marine life is by kayak or canoe. Paddling just above the water level, visitors can come face to face with sea otters, harbor seals, and many bird and fish species. Kayaks can be launched from Kirby Park (3 miles north of the Reserve) or the beach or boat ramp at the mouth of the Elkhorn Slough in Moss Landing.

Table 12.1. Public access to the Elkhorn Slough.

Park Name	Area (m^3)	Acreage	Perimeter (meters)	Managing Agency
Kirby Park	225838	55.8	2197.9	California Department of Fish and Game
Moss Landing Wildlife Area	2702850	667.9	15118.8	California Department of Fish and Game
Elkhorn Slough National Estuarine Research Reserve	6106975	1509.0	24507.6	Elkhorn Slough National Estuarine Research Reserve
Kirby Park	251805	62.2	4121.3	Moss Landing Harbor District
Royal Oaks Park	483757	119.5	3588.7	Monterey County
Manzanita Park	1934617	478.0	8721.7	Monterey County
Moss Landing State Beach	220198	54.4	3231.1	California State Parks
Salinas River State Beach	992885	245.3	10967.0	California State Parks
Salinas River National Wildlife Refuge	1485249	367.0	Unknown	U.S. Fish and Wildlife Service
Zmudowski State Beach	656824	162.3	5965.8	California State Parks

Table 12.2. Hiking trails in the Elkhorn Slough Watershed

Park Name	Total trails (meters)	Total trails (miles)
Elkhorn Slough NERR	8590	5.34
Moss Landing Wildlife Area	371	0.23
Kirby Park	865	0.54
Zmudowski State Beach	3027	1.88
Moss Landing State Beach	1486	0.92
Salinas River State Beach	3551	2.21
Manzanita County Park	11390	7.08
Royal Oaks County Park	4824	3.00

G. Reserve Objectives & Strategies

Objective 1. Maintain safe public access to the Reserve, with minimal impact on habitats.

Strategy:

6. The Reserve will maintain safe public access to the Reserve, with minimal impact on habitats. In order to accomplish this we will:

i. Maintain public trails, boardwalks, scenic overlooks, restrooms, and picnic facilities

ii. Provide visitors with a trail map and a list of Reserve regulations
iii. Display adequate signage designating areas off limits due to restoration, research, or sensitive habits
iv. Offer interpretation and information through the Visitor's Center

Objective 2. Work with public agencies and community groups to enhance public access to areas adjacent to the Elkhorn Slough NERR.

Strategy:

1. The Reserve will work with other public agencies and community groups to enhance public access to areas adjacent to the Elkhorn Slough NERR. In order to accomplish this we will:
   i. provide input to public agencies and community groups on ways to increase public access.
   ii. participate in the development of the Monterey Bay National Marine Sanctuary trail system through collaboration, meeting participation, and advice.

XIII. Elkhorn Slough Acquisition Plan

A. Introduction

The California Department of Fish and Game (CDFG) is actively involved in the conservation of tidal wetlands and adjacent upland habitat along the central California coast. In order to achieve habitat protection goals for wetlands, CDFG has developed strong partnerships in the conservation and management of natural resources of Elkhorn Slough. These partners include the Elkhorn Slough Foundation (ESF), the Natural Resources Conservation Service, the Resource Conservation District of Monterey County, the California Coastal Conservancy, and The Nature Conservancy. The interlocking work of these organizations and agencies provides a platform for the successful completion of key conservation goals in the watershed, and will insure the permanent protection of wildlife and habitat in the central Monterey Bay region.

Thirty years ago in its publication "The Natural Resources of Elkhorn Slough", CDFG identified Elkhorn Slough as a critical natural resource for California. This report galvanized active conservation activities in the slough and, today, a portion of the slough is managed by the CDFG as a State Ecological Reserve/National Estuarine Research Reserve and a Wildlife Area.

In the past twenty years, the CDFG has participated in the development of a series of conservation and management plans for Elkhorn Slough and its watershed. These plans include the *Elkhorn Slough Sanctuary, Final Environmental Impact Statement*,1979; *Elkhorn Slough Wetland Management Plan*,1989; *Moro Cojo Slough Management and Enhancement Plan*, 1996; *Elkhorn Slough Watershed Conservation Plan*,1999; and *Elkhorn Slough at the Crossroads, Natural Resources and Conservation Strategies for the Elkhorn Slough Watershed*, 2002. CDFG staff, along with a number of agency and non-profit partners, has relied on these plans for identifying key acquisitions to protect and enhance the fish and wildlife resources of Elkhorn Slough.

The habitats within and around Elkhorn Slough are home to a diverse array of important plant and animal species. Elkhorn Slough has been designated a Globally Important Bird

Area by the National Audubon Society and the American Birding Conservancy, and a Western Hemisphere Shorebird Reserve by the Manomet Bird Observatory. In addition to the remarkable concentrations of birds in the slough, the tidelands, marshes, and adjoining uplands support impressive numbers of wildlife. The following species are listed as critical biological resources by state and federal agencies and the California Native Plant Society. They were reported, along with their official and legal status, in Elkhorn Slough at the Crossroads, Natural Resources and Conservation Strategies for the Elkhorn Slough Watershed.

* Hooker's manzanita
* Monterey coanothus
* Eastwood's goldenbush
* Fragrant fritillary
* Congdon's tarplant
* Gairdner's yampah
* Yadon's piperia
* S.C. clover
* Southern sea otter
* CA brackishwater snail
* CA red-legged frog
* SC long-toed salamander
* Tidewater goby
* Double-crested cormorant (nesting)
* Great blue heron (nesting)
* Black-crowned night heron (nesting)
* Osprey
* Northern harrier
* Cooper's hawk
* Golden eagle
* CA black rail
* Western snowy plover
* Caspian tern
* CA least tern
* Burrowing owl
* Belted kingfisher
* Loggerhead shrike
* Monterey pigmy nuthatch
* Tricolored blackbird
* Lawrence's goldfinch
* Pajaro manzanita
* Monterey spineflower
* Coast wallflower
* Sand gilia
* Small-leaved lomatium
* Michael's rein orchid
* S.F. popcornflower
* Monterey Indian plant
* Black legless lizard
* Monarch butterfly
* CA tiger salamander
* Southwestern pond turtle
* CA brown pelican
* American bittern
* Great egret (nesting)
* Black brandt
* White-tailed kite (nesting)
* Sharp-shinned hawk
* Ferruginous hawk
* Merlin
* CA clapper rail
* Mountain plover
* Forster's tern
* Black skimmer
* Short-eared owl
* Olive-sided flycatcher
* CA horned lark
* Grasshopper sparrow
* Yellow-headed blackbird

B. Priorities

All lands proposed for acquisition are located in North Monterey County.

Acquisition priorities for the Elkhorn Slough NERR, as determined by the area conservation plans and CDFG, are to preserve those parcels that:

- help create an intact and interconnected network of natural communities;
- help complete acquisition of Elkhorn Slough tidal marshlands;
- will improve the water quality of Elkhorn Slough if taken out of current land use;
- protect biodiversity and sensitive species;
- have the greatest potential for restoration and improvement with the least amount of resources; and
- are in imminent jeopardy from development.

C. Strategies

State acquisitions for the Reserve are conducted with only willing landowners. When a property is identified for protection, based on the owner's willingness to sell and available funding sources, CDFG will choose the appropriate method of protection. Determining factors will include the properties' management requirements, location, ecological value, and cost.

Fee-simple acquisition will be used to:

- acquire property in the Reserve's core and buffer areas;
- expand Reserve boundaries into areas of high value in order to achieve our conservation goals; and
- acquire property that protects water quality and biodiversity.

Conservation easements are valuable tools that will be used to leverage funding with acquisition/protection needs. Easements allow property to be protected while reducing

costs and management responsibility, and ensuring permanent protected status. Conservation easements will be used to:

- purchase development rights;
- protect water quality and biodiversity;
- provide access for research and education programming; and
- protect property that holds significant ecological value.

The decision to choose fee-simple acquisition over the purchase of a conservation easement rests on several factors. If a property offers adequate public access and will provide additional areas for research and education activities, fee-simple acquisition will be favored. If a property contains habitat typical of other Reserve holdings, has limited public access, or has owners that are unwilling to consider fee-simple acquisition, purchase of a conservation easement will be favored.

Chapter XIV.
Administration Program Overview

A. Need for Administration Program

People and funding are the basis of all Reserve programs. If either one of these elements is missing or is mismanaged, the program will fail, and conservation goals will not be attained. Operating in a well-organized manner increases efficiency and productivity. Positive public relations help garner funding, partnerships, and community support which, in turn, promotes Elkhorn Slough watershed conservation.

B. Program History

For ten years after the Reserve was first designated in 1979, there was only a Reserve Manager and a Habitat Assistant on staff with the California Department of Fish and Game (CDFG). The Elkhorn Slough Foundation (ESF) staff consisted of an Executive Director and two part-time staff who spent some of their time assisting the Reserve. In 1989, CDFG launched their California Wildlands Program which brought two full-time interpreters to the site. Soon after, the first Administrative Assistant position was hired. Today, the staff of the Reserve (consisting of both CDFG and NOAA grant-funded positions, and both full and part-time staff) has risen to about 20, and the ESF staff has grown to 10. While the staff, budget, and programs have become larger and more complex, there has remained only one Reserve Administrative Assistant.

C. Program Purpose and Goals

The administration program's purpose is to provide human and fiscal resource management to the Reserve and to provide a framework of policies and processes necessary to support Reserve programs and operations.

Goals

- To provide well-trained staff to achieve the Reserve's conservation goals.
- To provide a stimulating, healthy work environment for all staff.
- To procure and responsibly manage funding to achieve the Reserve's conservation goals.
- To foster cooperation within and between CDFG, NOAA, and ESF.

- To facilitate the development and implementation of clear policies and procedures to guide the management of the Reserve.
- To operate the Reserve in a well-organized and efficient manner.
- To provide high quality public information about the Reserve.

D. Program Description

Administrative Framework

Partnerships

i. Role and Responsibility of NOAA

NOAA's Estuarine Reserves Division (ERD) administers the overall National Estuarine Research Reserve System (NERRS) and provides support for the Reserves. ERD disburses and oversees expenditures of federal funds. ERD also coordinates the design and implementation of system-wide programs, provides guidance for the development of NERRS policies, and is responsible for ensuring that the Reserve is managed according to NERRS policies and regulations.

As required by federal regulations *(15 C.F.R. Part 921.40),* NOAA periodically evaluates the performance of the Reserve for compliance with federal requirements and with the Reserve's federally-approved management plan. The last performance review (CZMA Section 312 evaluation) of Elkhorn Slough NERR's programs and operations was conducted in 2005.

ii. Role and Responsibility of CDFG

The role and responsibility of the California Department of Fish and Game (CDFG) is the direct management of the Reserve's facilities, habitat, and personnel. CDFG provides administrative support to the Reserve in the form

of personnel management, legal advice and representation, engineering, health and safety inspections, accounting, contract management, training, and other services.

The Wildlife Conservation Board (WCB) is the land acquisition arm of CDFG and is responsible for the purchase of properties for the Reserve.

The Reserve is governed by the California Code of Regulations, Title 14. Natural Resources, Division 1. Fish and Game Commission – Department of Fish and Game.

iii. Role and Responsibility of ESF

The mission of the Elkhorn Slough Foundation is to conserve and restore Elkhorn Slough and its watershed.

The Elkhorn Slough Foundation Strategic Initiative for 2006-10 identifies six major goals for the next five years:

- Conserve and protect key lands in the Elkhorn Slough Watershed.
- Manage these protected lands to conserve their natural resources and demonstrate successful conservation use.
- Support programs and activities at the Elkhorn Slough Reserve that are complimentary with our mission.
- Create dynamic partnerships to protect Elkhorn Slough and other threatened ecosystems.
- Build an organizational culture and capacity for long term stability and success.

- Assure the fiscal strength and stability of the Elkhorn Slough Foundation.

The ESF serves as an administrative liaison between NOAA and CDFG. They receive a portion of the annual NOAA award for Reserve operations on behalf of the Reserve. CDFG remains responsible for all Reserve program supervision and decision making, but ESF administers the funds and provides grant management services. ESF funds and operates the visitor center gift shop. ESF assists the Reserve in areas of land acquisition, volunteer program support, fundraising, and general administration.

This relationship is formalized in a Memorandum of Understanding (currently under revision) between CDFG and ESF.

iv. Role and Responsibility of the Reserve Advisory Committee (RAC) and the Technical Advisory Committees (TACs)

Reserve Advisory Committee

In support of the Reserve's mission, it is the role of the RAC members to serve as:

1. advisors to ESNERR and
2. liaisons between ESNERR, its partner agencies, and stakeholders.

It is the responsibility of the RAC to be knowledgeable of ESNERR's mission, programs, and activities in order to:

- support ESNERR in developing and achieving its vision and goals,
- serve as an ambassador for ESNERR within the

community each member represents,

- provide input to ESNERR about potential collaborations or impacts resulting from Reserve activities,
- help identify and anticipate external trends and changes that might affect ESNERR,
- provide input on NOAA 312 evaluations of ESNERR.

RAC membership is made up of Reserve stakeholders. Emphasis is placed on representatives who have a geographical link to Elkhorn Slough. For example, the Industry representative would be from a business that is located on or near the Slough.

The RAC is comprised of members representing each of the following categories:

Agriculture
California Coastal Commission
California Department of Fish and Game
Conservation
Formal K-12 Education
Industry (near Elkhorn Slough)
Monterey Bay National Marine Sanctuary
Monterey County (land use related office)
Moss Landing Harbor District
Non-formal Education
Non-profit Organization Land Owners
Recreation
Research Institution
Residential Property Owners (near Elkhorn Slough)

Sea Grant

Technical Advisory Committees

The role of TACs is to provide technical advice to ESNERR on specific Reserve projects, programs, or policies. TACs will be formed and disbanded as needed.

It is the responsibility of TAC members to provide expertise and information to ESNERR on identified subject matter in order to:

- advise on policy or program design and/or,
- develop strategies for implementation and/or,
- help form collaborations and partnerships.

Program Components

Personnel Administration

The Reserve is committed to providing supervision and oversight to staff and volunteers working to support or accomplish its mission. This includes attention to:

- Health and Safety
- Annual employee work plans and evaluations
- Training and professional development
- Adherence to all state and federal policies such as those providing a drug-free workplace and those preventing sexual harassment, violence, and lobbying in the workplace.

Budget Acquisition

i. Grants

Federal, state, and private grants make up the majority of the Reserve's budget. These grants are run through the State of California or the ESF on behalf of the Reserve. The Reserve manager and lead program staff write and

manage grants. Administrative support for grants is provided by the ESF and the CDFG.

Through Section 315 of the Coastal Zone Management Act, NOAA provides key federal operations funds to the Reserve on an annual basis. These dollars must be matched with 30% state dollars (cash or in-kind). The NOAA operations funds support a variety of programs as described in the annual NOAA Funding Allocations and Guidance. The NOAA operations budget for each Reserve doubled between 1995 and 2005. This increase in funding has allowed the NERRS to develop site-specific and national programs.

ii. State of California Funds

The State of California provides an annual operating budget for the Reserve. Currently, these funds are from the Environmental License Plate Fund, Sport Fish Restoration Act, and from revenue generated from the sale of day use fees and annual passes to the Reserve. The Reserve also periodically receives state funding for special and emergency repairs. The CDFG budget allocated to the Reserve for salaries, operations, equipment, and supplies, has remained relatively flat over the last ten years. As cost indexes have skyrocketed, this has posed a significant challenge to maintaining programs and meeting commitments.

Budget Tracking and Accounting

Reserve budgets are tracked and accounted for by CDFG headquarters staff in Sacramento. In addition to this statewide tracking, Reserve staff

maintains detailed spreadsheets and databases of Reserve budgets, expenditures, inventories, and match.

Purchasing

Purchases of goods and services are completed within the required guidelines set forth by the State of California Purchasing Authority Manual. Purchases made for the Reserve by the ESF are completed within the guidelines set forth by various grant guidance and by the Elkhorn Slough Foundation Fiscal Policies and Procedures Manual. This manual is reviewed annually by ESF auditors.

Archiving

The amount of important and useful information and images that are generated by or come to the Reserve has increased dramatically. This information must be properly archived and managed in order for it to be accessible to the many staff, scientists, educators, decision makers, and others who wish to use it. There is currently no staff available or qualified to do this work.

Public Information

In order to garner funding and maintain support from partners and the community, it is important to effectively distribute information about Elkhorn Slough. Newsletters, press releases, and websites are some ways this information can be shared. Additional staff is needed to implement these actions.

Office Policies and Organization

Keeping a busy office with multiple programs and dozens of staff organized is an important but time-consuming task. An efficiently-run office allows staff to focus their energy more on core programs and less on logistics. A key responsibility of all staff is to help the Reserve run like a well-oiled machine by maintaining good files (electronic and paper),

office spaces, and storage spaces. Reserve policies to encourage office efficiency are developed and revised as needed.

E. Staffing and Working Groups

Current Staffing

- 1, full-time Reserve Manager
- 1, full-time Management Services Technician (Office Manager)

Staffing Needs

- 1, full-time Office Assistant (see chapter XI)
- 1, full-time Grants Manager (see chapters III-XII)
- 1, part-time Archivist (see chapter XI)
- 1, part-time Public Information Specialist (see chapter XI)

Working groups

One or more Administration Program staff is involved in the following ESNERR strategic planning working group:

1. Administration Working Group (Lead)

The Reserve Manager oversees the following ESNERR strategic planning working groups:

2. Internship Working Group
3. Public Information Working Group
4. Information Technology Working Group
5. Education Working Group
6. Estuarine Working Group
7. Coastal Prairie Working Group
8. Maritime Chaparral Working Group
9. Freshwater Wetlands Working Group
10. Coast Live Oak Working Group
11. Pollution Working Group
12. Monitoring Working Group

F. Guiding Documents and References

The following manuals guide the administrative work of the Reserve:

- Department of Fish and Game Operations Manual
- Department of General Services State Administrative Manual
- Elkhorn Slough Foundation Fiscal Policies and Procedures Manual
- State of California Contracting Manual
- State of California Purchasing Authority Manual
- State of California Contracting Manual

XV. Volunteer Program Overview

A. Need For Volunteer Program

"Many hands make light work" (John Heywood, English playwright and poet, 1497-1580). At the Elkhorn Slough NERR this is only made possible by the hard work and dedication of the Reserve's volunteers. In addition to making work lighter, our volunteers help us to do *more* work. With volunteers, many tasks can be accomplished faster and easier, and in some cases, tasks would even need to be dropped if there were not volunteers to cover them.

Reserve volunteers assist with the work of stewardship, research, education, public outreach, maintenance, and administration. Their hours represent a significant contribution to Reserve programs. Moreover, the Reserve converts volunteer hours into a dollar value which is then used as in-kind match for grants. In 2005, the financial value of volunteer hours to the Reserve was over $100,000.

Some of the benefits of a volunteer program are less tangible than a dollar value represented by their hours worked. Well-trained and enthusiastic volunteers serve as important community ambassadors for conservation. It has been shown that volunteer programs are needed by society to provide a venue for like-minded people to get together and share their passion for a cause. Providing those opportunities, in the context of working toward important conservation goals, is part of what the Elkhorn Slough volunteer program can provide.

B. Program History

The shift of perception from characterizing Elkhorn Slough as "a weedy swamp waiting to be developed" into "one of California's rarest jewels…" (Silberstein and Ferguson 1991) has carried with it a mandate for protection and restoration. The challenges have been daunting, and the resources of the conservation agencies limited; volunteers have made up the difference.

Volunteers from the community were instrumental in helping the California Department of Fish and Game (CDFG) purchase areas of the Elkhorn Slough and establish the Reserve. Early on, it was recognized that in order to protect the slough the support of the community was essential.

With guidance from The Nature Conservancy (TNC), the Elkhorn Slough Foundation (ESF) carried out the first volunteer training in 1983 and managed the program through 1988. In 1989, responsibility for the volunteer program was transferred to CDFG under the auspices of its California Wildlands Program (CWP). With this transfer came the funds to hire a full-time Volunteer Coordinator as supervisor of the volunteers. Today, volunteers continue to function under the aegis of the CDFG and are considered unpaid state employees.

C. Program Purpose & Goals

Purpose

The purpose of the volunteer program is to recruit, train, and support volunteers so they can effectively assist Reserve and ESF staff in carrying out their conservation goals. Our core belief is that knowledge of and appreciation for nature precedes and motivates conservation behavior.

Program Goals

- **Address the needs of volunteers**
    - In order to be productive and have a positive personal experience, volunteers must enjoy what they do and feel appreciated.

- **Maintain a well-organized and well-managed volunteer program**
    - Clear guidance must be given regarding issues such as policies, procedures, and minimum requirements for training and service. Accurate and up-to-date data bases of volunteer information, hours and type of service must be maintained.

- **Focus volunteer efforts on the highest priority needs of the Reserve and ESF**
    - Annual evaluation of work plans of both staff and volunteers is necessary to insure that the most important tasks are being given the greatest effort.

- **Maintain high quality volunteer output**
    - In order to insure that volunteers serve as appropriate and effective ambassadors for the Reserve and for watershed conservation, regular evaluation of their performance is necessary. Evaluation results will inform where training or feedback is needed and will guide future program planning.

D. Program Description

Audiences

One hundred (100) active volunteers form the core of the Reserve's volunteer program. Collectively, they contribute an average of 7,000 hours of service annually. Our volunteers range in age from 18 to 96 and represent diverse educational and employment backgrounds, and talents. This diverse group includes birders, doctors, therapists, teachers, building contractors, and others with interests and talents that they are willing to share. Most volunteers come from Santa Cruz County and Monterey County, with the balance residing in San Benito and Santa Clara counties. The Reserve is committed to increase the ethnic and cultural diversity of its volunteers to better reflect the demographics of the neighboring communities which we serve.

Volunteer Services

Reserve volunteers work in the following service areas:

Interpretation and Public Contact

Trained volunteers greet visitors when they enter the Reserve visitor center, and are able to answer a variety of questions from “Where’s the bathroom?”, to “What bird is that?”. Visitor center volunteers help collect day use fees, sell gift store items, loan out

binoculars, and answer telephones. They also assist visitors in interpreting the exhibits and planning their hikes.

A number of volunteers lead regularly-scheduled tours of the Reserve trails on weekends or sign up to lead specially-scheduled tours throughout the week. Volunteers use interpretive skills to foster a caring connection between visitors and the natural world. They introduce visitors to new information, reinforce important concepts in environmental conservation and stewardship, and interpret the process and results of scientific research that bears on issues affecting Elkhorn Slough and its watershed.

Volunteers assist with other educational activities such as on-site special events, K-12 school programs, youth programs (scouts, after-school clubs), and off-site community outreach. The Reserve volunteer program works in partnership with many other agencies and volunteer organizations in the Monterey Bay area.

Stewardship

Habitat restoration and protection requires hours of hand labor. Volunteers assist with the restoration of native habitats through exotic species control, native seed collection and propagation, planting, erosion control, and maintenance of wildlife watering devices. Furthermore, volunteers help to educate visitors on how best to minimize their impacts on the Reserve. An example is our effort to prevent the spread of diseases, such as Sudden Oak Death, by using the Reserve's foot wash station.

Volunteers have assisted with the propagation and planting-out of tens of thousand of acorns, native grasses, herbs, and shrubs, the majority of which were propagated with volunteer help at the Reserve's native plant nursery. Much of the native landscaping around the Visitor Center and administration building is maintained by volunteers.

Volunteers assist with stewardship-related service activities such as beach, boat access, and roadside clean-ups, and other habitat restoration projects in the watershed.

Research and Monitoring

Volunteers assist with field, lab, and computer work related to many of the Reserve's research and monitoring projects. Without volunteers, the Reserve would not be able to carry out several research projects, including bird monitoring which requires hours of field data collection, data entry, and coordination. In addition to birds, volunteers help to monitor amphibians, including some endangered species. One dedicated volunteer has been responsible for monitoring 24 water quality stations in the watershed since 1988.

The Elkhorn Slough volunteers can be a source of support for visiting researchers. For example, if additional hands are needed to pull a seine or time-consuming lab work is required to be done in a short amount of time, the volunteer corps is contacted for recruits.

Volunteers have also been involved in researching and archiving the slough's historical records and other data.

Maintenance

Volunteers help maintain and repair the Reserve's trails, signs, landscaping, buildings, levees and other structures. During staffing shortages, volunteers have been essential to the Reserve's ability to remain open to the public.

Administrative Support

Volunteers answer phones, provide clerical support, maintain electronic databases, assist with mailings, and produce and distribute a volunteer newsletter. Volunteers also oversee and maintain the Reserve's lending library.

Program Components

Coordination

"Volunteer managers must be concerned with developing valuable, meaningful assignments and matching volunteers with them, and they are being challenged to recruit,

orient, recognize, and supervise a diverse and nontraditional volunteer pool. Volunteer management is becoming increasingly professional, with a literature base, professional societies, and formal education." (Kerka, 1998)

The Volunteer Coordinator is responsible for recruitment, training, placement, and supervision of volunteers. The Coordinator assists staff requesting volunteers, maintains personnel records of all volunteers, and organizes volunteer recognition events. Reserve staff provide direction for specific activities and act as immediate supervisors for volunteers working within their program area.

The Volunteer Coordinator serves as a communication conduit to volunteers regarding educational programs and ongoing workplace meetings to facilitate the interaction between staff and volunteers. The Coordinator is responsible for updating and maintaining the "Docent Handbook" which helps define the policies and procedures that affect the volunteers.

Additionally, the Coordinator manages a volunteer office (the "Docent Den"), oversees the production of a volunteer newsletter, supervises regular volunteer meetings, and organizes bulletin board and email postings to highlight events on and around the Reserve.

Recruitment

The Volunteer Coordinator recruits volunteers using press releases, the Reserve's website, the volunteer newsletter, and other marketing materials. Most people are motivated to volunteer because of their experiences from having visited the Reserve and walking the trails, attending a guided walk or special event, or through interactions with staff and current volunteers.

Training

Completion of a nine week training course is required for anyone to participate in the formal volunteer program. Those wishing to be a Reserve volunteer submit a written application in advance of the training. If accepted, they participate in the training, which

covers everything from Reserve administration, interpretive skills, and standards of volunteer conduct, to cultural and natural history of the watershed. The training strives to reveal how hands-on discovery and a personal connection with nature contribute to conservation behaviors. Additionally, the training period helps develop a sense of community among the new volunteers.

Community members are also allowed to volunteer as temporary service workers (TSW) for specific projects. TSWs are volunteers who have conflicts with the yearly training program, who want to volunteer during the interim between scheduled trainings, or who attend one of the many "Stewardship Days" offered as one-time volunteer opportunities. TSWs receive an orientation course on safety and conduct protocols, but cannot act as interpreters on tours or in the visitor center. TSWs are encouraged to complete the Reserve's volunteer training program and until they do so, their participation as a volunteer must be periodically reviewed to renew their TSW status.

Agreements

Volunteers agree to honor a written commitment of 100 service hours during their first year. To remain on the list of approved volunteers, 50 hours of service per year are required in years subsequent to their first year.

Risk Management

Although we strive to maintain a safe work environment, risk management is an essential component of the modern work place. The "Docent Handbook" presents safety guidelines to volunteers. The DFG provides California Workers Compensation coverage for volunteers working on the Reserve.

Recognition

Upon completion of the training course, volunteers receive a certificate, official name tag, and privileged access to the Reserve. Reserve staff shows their appreciation of all volunteers annually at an awards ceremony and dinner. The volunteer coordinator, Reserve and ESF staff collaborate to maintain a culture where volunteers feel welcomed, supported, and appreciated throughout the year.

E. Staffing and Working Groups

Current Staffing

The Volunteer Program is administered by a full-time, DFG-employed, Volunteer Coordinator who works within the Reserve's Education Program.

Staffing Needs

See Chapter XVI.

Working Groups

The Volunteer Coordinator is involved in the following ESNERR strategic planning working groups:

13. Internship (lead)
14. Education
15. Monitoring
16. Public Information

F. Guiding Documents and References

Kerka, Sandra 1998. Volunteer Management. Trends and Issues Alerts. ERIC Clearinghouse on Adult, Career, and Vocational Education, Columbus, OH.

Silberstein, Mark and Ferguson, Ava 1991. The Elkhorn Slough Reader: A compilation of Articles for the Elkhorn Slough Interpretive Guides. Introduction: page 1

XVI. Education Program Overview

A. NERR Education Plan

The reserve system provides a vehicle to increase understanding and awareness of estuarine systems and improve decision-making among key audiences to promote stewardship of the nation's coastal resources. Education and interpretation in the reserves incorporates a range of programs and methodologies that are systematically tailored to key audiences around priority coastal resource issues and incorporate science-based content. Reserve staff members work with local communities and regional groups to address coastal resource management issues, such as non-point source pollution, habitat restoration and invasive species. Through integrated research and education programs, the reserves help communities develop strategies to deal successfully with these coastal resource issues.

Formal and non-formal education and training programs in the NERRS target K-12 students, teachers, university and college students and faculty, as well as coastal decision-maker audiences such as environmental groups, professionals involved in coastal resource management, municipal and county zoning boards, planners, elected officials, landscapers, eco-tour operators and professional associations.

Reserve System Education Mission and Goals

The National Estuarine Research Reserve System's mission includes an emphasis on education, interpretation, and outreach. Education policy at the Elkhorn Slough NERR is designed to fulfill the reserve system goals as defined in the regulations (15 C.F.R Part 921(b). Education goals include:

- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

Reserve System Education Objectives

Education-related objectives in the Reserve System Strategic Plan (FY 03-08) include:

- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;

- Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

Reserve System K-12 Estuary Education Program

The K-12 and professional development programs for teachers include the use of established coastal and estuarine science curricula aligned with state and national science education standards and frequently involves both on-site and in-school follow-up activity. Reserve education activities are guided by national plans that identify goals, priorities, and implementation strategies for these programs. Education and training programs, interpretive exhibits and community outreach programs integrate elements of NERRS science, research and monitoring activities and ensure a systematic, multi-faceted, and locally focused approach to fostering stewardship.

Reserve System Coastal Training Program

The Coastal Training Program (CTP) provides up-to-date scientific information and skill-building opportunities to coastal decision-makers who are responsible for making decisions that affect coastal resources. Through this program, National Estuarine Research Reserves can ensure that coastal decision-makers have the knowledge and tools they need to address critical resource management issues of concern to local communities.

Coastal Training Programs offered by reserves relate to coastal habitat conservation and restoration, biodiversity, water quality and sustainable resource management and integrate reserve-based research, monitoring and stewardship activities. Programs target a range of audiences, such as land-use planners, elected officials, regulators, land developers, community groups, environmental non-profits, business and applied scientific groups. These training programs provide opportunities for professionals to

network across disciplines, and develop new collaborative relationships to solve complex environmental problems. Additionally, the CTP provides a critical feedback loop to ensure that professional audiences inform local and regional science and research agendas. Programs are developed in a variety of formats ranging from seminars, hands-on skill training, participatory workshops, lectures, and technology demonstrations. Participants benefit from opportunities to share experiences and network in a multidisciplinary setting, often with a reserve-based field activity.

Partnerships are important to the success of the program. Reserves work closely with State Coastal Programs, Sea Grant College extension and education staff, and a host of local partners in determining key coastal resource issues to address, as well as the identification of target audiences. Partnerships with local agencies and organizations are critical in the exchange and sharing of expertise and resources to deliver relevant and accessible training programs that meet the needs of specific groups.

The Coastal Training Program requires a systematic program development process, involving periodic review of the reserve niche in the training provider market, audience assessments, development of a three to five year program strategy, a marketing plan and the establishment of an advisory group for guidance, program review and perspective in program development. The Coastal Training Program implements a performance monitoring system, wherein staff report data in operations progress reports according to a suite of performance indicators related to increases in participant understanding, applications of learning and enhanced networking with peers and experts to inform programs.

B. Need For Education Program at ESNERR

As environmental educators we are facing an increasingly complex challenge, an obligation of global significance, and an urgency that requires us to be thoughtful and strategic in our efforts. Some of these challenges include:

- The population of California is incredibly diverse, with over 50 different languages spoken in the public schools, (Jepsen 2005) and is expected to increase by 11.3 million to a total of 45 million people by the year 2020, (CDOF 2001). Likewise, the Monterey Bay Area will see a population increase of over 130,000 people by 2020 and another 156,000 people will arrive by 2050 (Figure 16.1) (State of California, Dept of Finance 2004). These people will be neighbors to the Elkhorn Slough and many will inevitably live in its watershed. ESNERR education programs must reach these diverse and growing audiences to increase awareness of issues in the watershed.

- California is also home to one third of "at risk species" identified in the United States. The state is considered to be one of the 25 most significant biological hotspots in the world (Stein 2000). There are twenty-one threatened or endangered species in the Elkhorn Slough and neighboring Pajaro and Salinas River watersheds. These represent some of the most urgent problems in the area requiring immediate attention that can be supported by the ESNERR CTP and public outreach programs.

- Our terrestrial activities are linked to the world's ocean through watersheds and estuaries and have had significant detrimental effects. Recent reports from the US Commission on Ocean Policy (2004) and the Pew Oceans Commission (2003) have made it abundantly clear that the ocean and coastal habitats are in dire need of increased study and protection. ESNERR education programs can educate the public about the connection between watersheds, estuaries and ocean health.

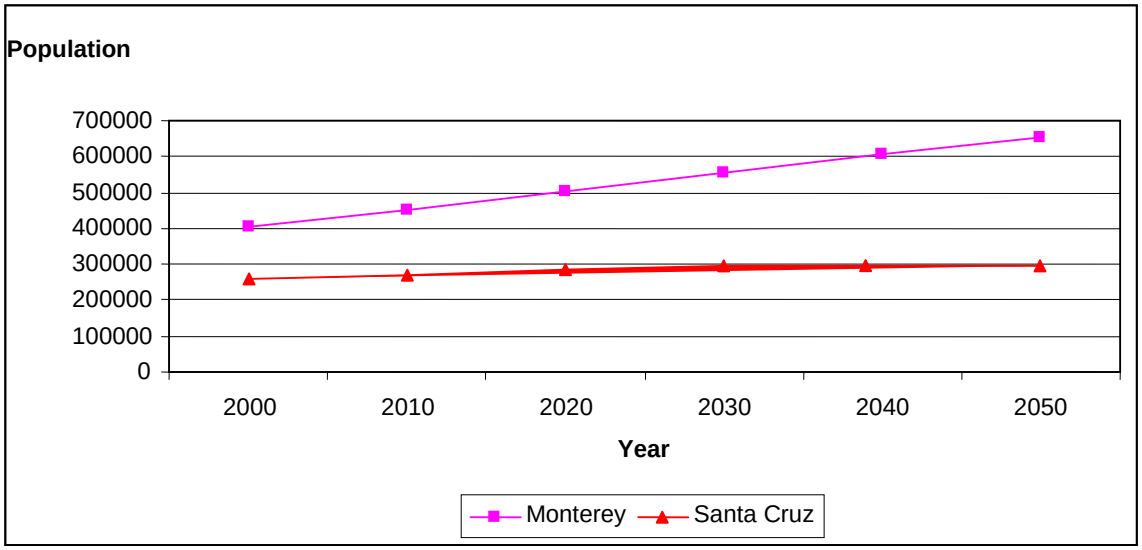

Figure 16.1. Population Forecast for Monterey and Santa Cruz Counties

> *"Our failure to properly manage the human activities that affect the nation's oceans, coasts, and Great Lakes is compromising their ecological integrity, diminishing our ability to fully realize their potential, costing us jobs and revenue, threatening human health, and putting our future at risk."* (US Commission on Ocean Policy)

The core effort of our education program must continue with even greater urgency as the population encroaches; people become more urbanized and divorced from nature; and social, political and economic forces converge in the next decade to determine what will be left of the natural systems in the watersheds of the central California coast. We cannot do it all, so collaborations and strategic planning will be critical. Through careful evaluation of existing programs and testing of new ideas, we can make the changes needed to meet new challenges.

C. Program History

Education has long been recognized as a key component to the conservation of Elkhorn Slough. Before there was a visitor center and established trails, when the grounds were still littered with the collapsed buildings and rusted remains of the old Elkhorn Dairy Farm, the Nature Conservancy sponsored hiking tours of the Reserve site to give people in the community the opportunity to witness the natural wonders of this land and the

estuary it borders. Still to this day, the core of the Reserve's education and outreach efforts is to provide opportunities for discovery in nature in the context of a working landscape. It is through such personal, emotional connections with nature that we hope to inspire the stewardship of these coastal habitats.

The Reserve Education Programs started with the training of a small group of volunteers to help lead public tours on the new trails, and the training of a few teachers to bring their students out on nature hikes. We now have a volunteer program with a dedicated cadre of nearly 100 volunteers to welcome over 40,000 visitors each year and assist with research, education and stewardship. Our K-12 program has expanded to offer certified teacher professional development, interpretive exhibits in our visitor center, and a small teaching lab with microscopes for the 8-10,000 school children who visit the Reserve each year. The field experiences have expanded to include water quality monitoring, plankton tows, marine invasive species monitoring, and restoration activities. In addition to the ESNERR run programs, we collaborate with numerous other organizations who seek out our unique offering of direct access to a variety of habitats, engaging activities based on real science investigations that can be witnessed on site, and supportive staff and volunteers.

We recognize a changing environment and new challenges for classroom teachers. To address these we are engaging in regional discussions, strategic planning, and collaborations with other nonformal educators. Efforts have been made to align curriculum to state standards and to address limited school budgets and administrative support for field experiences.

We have also supported efforts to reach new audiences. In the 1990's we were among the Reserves who piloted Coastal Decision Maker Workshops, designed to make pertinent research more accessible to an audience of professionals making critical decisions impacting our coastal areas. Burdened by the success of these workshops while still maintaining K-12 programs, the Education Coordinators worked with ERD to develop the Coastal Training Program. At ESNERR we have a CTP Coordinator who

oversees a program that has grown from offering a few workshops a year to over 6 annual large workshops with attendance increasing from 30-40 individuals to over 200 per workshop. In addition, a popular website and the Coastal Training Network (CTN) have been designed to address the overwhelming request for quality scientific information and access to experts. Smaller, shorter instructional meetings, independent scientific review through the CTN, and scientifically-informed, best practices guidance documents are increasingly in demand from the CTP. The lessons learned in the development of CTP are now being applied to the K-12 Estuary Education Program, and will inform the new initiative for Community Outreach.

D. Program Purpose and Goals

Purpose

The Reserve's education programs are designed to address different issues within different time frames. We strive to strategically define priorities and develop programs that address:

4. The most **immediate** threats to coastal habitats and species. Some issues require immediate intervention through education, regulation and enforcement. The audience here falls within the purview of CTP: the people who most need to understand the issues in order to make relatively urgent, well informed decisions.
5. The issues on an **intermediate** time frame that require the building of a baseline of understanding among professionals in both private and public sectors, public servants (politicians) and the general public who can get involved in the community decision making process, (public hearings, planning commissions, general plan updates). The Reserve education program can help by defining specific research needs, and/or by defining and interpreting existing research so people can be involved in discussions in the larger community pertinent to making well informed decisions. In this time frame we address an adult audience with professional development, a second tier of CTP workshops, graduate level research,

student internships, and collaborations with college level course instruction.

6. The **long-term** need of providing quality K-12 education programs to develop a culture of conservation that includes
    i. an awareness, appreciation for and understanding about nature
    ii. experience with scientific inquiry and appreciation for the strengths and limits of science
    iii. an understanding of career choices and the education required to work in these careers
    iv. an understanding of the decision making processes and power structures in the community, and a desire to be involved in shaping the local landscape.

    This time frame includes teacher professional development, curriculum development and field experiences for K-12 students. This arena is often neglected because it lacks a sense of urgency, but it is absolutely critical to the development of the social infrastructure that supports all the above endeavors.

Goals

We must add deeper layers to this core experience of a rekindled connection with nature, specific to the unique needs of coastal communities, watersheds and estuaries. The Reserve's key education goals are to:

- Provide opportunities to interact with nature through self-guided hikes, docent lead tours, creative activities, (writing, drawing, painting, photography) and tangible experiences such as restoration, (seed collection, propagation, planting).

- Provide opportunities to engage in or to witness research and restoration activities to increase an appreciation for how science can inform stewardship and help to define resource management efforts.

- Make scientific information accessible to the public to increase the level of understanding and appreciation about nature and the basic ecological principles that define natural landscapes.

- Provide opportunities to witness the interaction between humans and non- human communities and landscapes in the watershed, and to define/exercise alternatives that minimize negative impacts and maximize positive interactions.

- Encourage thoughtful design and planning of ecologically and economically sustainable communities by providing information and modeling sustainable behavior.

To achieve ESNERR's conservation goals our programs must continually adapt to a rapidly changing world to meet high standards of excellence in content and presentation. The critical information and experiences we provide must be clearly defined, the audiences understood, and the two brought together in carefully choreographed workshops, forums, events and activities with the use of appropriate communication mediums and technologies.

We strive to develop flexible, responsive programs of clearly defined geographical scope, integrated with the activities/programs of local partners, anchored by the needs of the local community (both human and non-human) and tied to the goals of our state and federal partners/agencies. The education staff has acquired expertise in defining the process of developing and maintaining such adaptive programs through the development of the Coastal Training Program. As a national program, the CTP is able to access national resources and apply them to very specific local needs. The CTP operational model includes the following components, which guarantee program success:

- Ongoing market analysis that help identify key audiences and subjects not targeted by similar programs;
- Needs assessments that identify specific needs of target audiences;
- A carefully chosen advisory committee that ensures communication with key partners and networking with appropriate agencies and professionals in the region;
- Strategic planning that provides vision while articulating the unique niche that the Reserve fills in the region;
- Short and long-term performance measures that help to track success and improve programs.

Aspects of this model are being applied to the other elements of the education program. (see Chapter X for details)

E. Program Description

Audiences and Avenues

Various layers of information and experience are offered to the general public, families, children of all ages, and professionals in the public and private sectors. This can be through self-guided tours, docent-led tours, school programs, teacher professional

development, student internships, graduate fellowships, community service, special public events, docent training, decision maker workshops and field trips, facilitated communications/networking with scientists/experts, web pages, distance learning programs, interactive virtual field trips, web conferences, and other web based resources.

Education contacts can occur in the visitor center, in front of the interpretive exhibits, in the bookstore; on the five miles of trails through oak woodland, grasslands, riparian corridors, fresh and salt marsh, mudflats and lagoons; on partner lands (ESF, State Parks, The Nature Conservancy, Moss Landing Harbor District) in the watershed; on partner waters contiguous with the watershed, (Monterey Bay National Marine Sanctuary); in the conference room, the outdoor amphitheater, or teaching lab; or in front of a computer monitor with a live link to researchers/educators waste deep in the waters of the slough, pulling in crab traps or water quality datasondes.

We seek ways to reach those who are not already coming through our gates but who need the information and experiences we have to offer. This includes the teacher who can't convince their administrators that field experiences are important for the educational experience and intellectual development of their students; the municipal planner who can't get away from their desk to learn more about the land, air and water they are charged to protect; or the hispanic family that is too uncomfortable due to language and cultural differences to even approach the Reserve. We are dedicated to equitable access to the experience and information that the Reserve has to offer.

Program Components

Coastal Training Program (CTP)

The Elkhorn Slough Coastal Training Program teaches and networks our region's decision makers, while serving as a hub for information and dialogue that facilitates adaptive management of several key ecosystems and ecological processes. We provide the latest, most relevant science to the key decision makers affecting ecological health. We ensure that the information we provide is relevant and applied effectively by

constantly assessing our program, promoting dialogue, and fostering collaboration. The CTP was born from the realization that our estuaries cannot be protected within reserve boundaries alone, and advancing knowledge and dialogue with regional decision makers is critical to advancing our NERRS mission. The CTP uses several tools towards this end, including:

- workshops where information is provided to diverse audiences;
- smaller workgroups where teams work on creating focused solutions;
- independent scientific review to provide better access to scientific expertise, and;
- a regional hub of easily accessed information on the pressing issues facing decision makers

The Coastal Training Program is a federal-state partnership program funded primarily from the NERRS, which provides several unique opportunities. First, the partnership guarantees steady funding of the program despite fluctuating funding at the state and regional level. This allows the program the long term support to foster behavioral change, which is often slow to respond to education. At the core of the CTP is a reliance on long term partnerships with key decision makers and institutions, with the hope that they will come to truly rely upon the CTP as an integral part of their decision making process. Second, to qualify for this funding, the federal partners have required an innovative and adaptive program design that addresses local needs through ongoing program assessment and minimum performance standards. These tools allow the CTP to remain effectively engaged as our regional and reserve needs change. Third, each reserve's CTP can access resources across the nation, leverage innovations and information while sustaining the quality of the entire program through mentorship, professional training, and program evaluation. And so, the Elkhorn Slough CTP staff actively participates in working groups and meetings at the national level, including focused attention on national decision making guidelines within CTP, creating national and regional strategies for integration between NERRS sectors, and marketing the CTP to key national partners.

Within ESNERR itself, the CTP uses an integrated approach to address key conservation objectives. In ESNERR's adaptive management framework, the CTP role is to facilitate the transfer of relevant research and stewardship information, to evaluate and communicate pressing information gaps, and to foster dialogue so that information and technology transfer is effective. The CTP therefore actively participates in all of the Reserve's conservation and adaptive management working groups.

The Elkhorn Slough CTP joins a number of regional and national partners in educating decision makers, strengthening and complementing these initiatives. In our region, we have a wealth of state and federal programs as well as NGO's that include components targeting education of the decision making audience. Our market analyses and ongoing program evaluations help identify gaps in these programs to more effectively target CTP activities. When these partners develop new initiatives that address ESNERR's conservation priorities, we work with them to provide access to information and expertise that can strengthen their approach.

While implementing CTP educational programs, CTP staff are able to identify scientists, policy makers, regulators, and land stewards who are recognized leaders in their fields, interdisciplinary thinkers, and have an excellent ability to translate their wisdom to broad audiences. These experts are asked, and largely accept, to be part of the CTP's "Coastal Training Network (CTN)." The CTN member agrees to be available to answer the questions and review information that comes to the CTP. The CTP is therefore able to offer professional and independent peer review that would otherwise be unavailable to many of ESNERR's partners.

School Programs

The Reserve K-12 programs provide teacher professional development, standards-based curriculum, hands-on field experiences, activities related to ongoing research and monitoring programs (such as SWMP), and the use of modern communications technologies to reach the students. These are all components that have been identified as

critical to creating a quality national K-12 Estuary Education Program (KEEP) for the NERRS.

- **Teacher Training**: Teachers are required to complete a 2 day training course before they can bring their students to the Elkhorn Slough Reserve. These environmental education workshops are officially certified by California State University Monterey Bay (CSUMB), and teachers receive Continuing Education Units for their training. They are designed to provide educators with the information and tools needed to integrate environmental science and conservation into their classroom curriculums and to prepare their students for informative and enjoyable field experiences at the Reserve.

- **Teacher Certification**: We are partners in the Environmental Education Certificate Program at CSUMB, a 2 year program that coordinates the teacher professional development efforts of several local agencies and institutions. This offers professional recognition to teachers who make the effort to acquire the skills needed to bring environmental education into the classroom and who get their students involved in the many field programs offered in the area.

- **Hands-on Field Experiences**: About 10,000 students and teachers per year engage in a variety of activities that include water quality monitoring, plankton sampling, shorebird surveys, nesting Heron and Egret observations, and restoration of upland habitats. We provide field equipment and a microscope lab for the investigation of plankton and other samples.

- **Interactive Virtual Field Trips**: We are working closely with the Earth Systems Science and Policy and WeTEC (Wireless Education and Technology Center) programs at CSUMB to develop the capacity to do interactive virtual field trips over the web and to broadcast live images of wildlife, such as our nesting colonies of Caspian Terns, Herons and Great Egrets. Through this technology we will be able to help teachers integrate the Elkhorn Slough environmental curriculum in their classrooms throughout the school year, so that the students can follow the

seasonal changes and ongoing research/monitoring efforts at the Reserve before and after their actual field trip to the site.

- **Multicultural Education**: We are part of a team of local environmental professionals making a concerted effort to outreach into the Latino communities of our area through the MERITO program, (Multicultural Education on Resource Issues Threatening Oceans) a collaboration with State Parks and the Monterey Bay National Marine Sanctuary (MBNMS).

- **K-12 and Non-formal Education Partners**: We support a number of programs that use our site for their field activities including: Camp SEA Lab Monterey Bay summer youth programs, (Science, Education and Adventure), a program offering field experiences for youth to inspire conservation of marine resources; the Ventana Wilderness Society's summer day camp program; the RISE program (Recruitment In Science Education) sponsored by CSUMB to encourage minority youth to seek careers in science and pursue college educations; COSMOS, a high school science program sponsored by the University of California at Santa Cruz; Upward Bound, a science education program for inner city youth sponsored by Monterey Peninsula College; and the Monterey Bay Aquarium's Young Women In Science program.

- **Colleges and Universities** We work closely with instructors from local colleges and universities, giving special tours and presentations to college students as part of courses on marine sciences, coastal ecology, wetland habitats, environmental education, interpretive exhibit design, and resource management. Many college students become involved in research, monitoring, restoration and education projects at the Reserve to fulfill academic requirements such as community service, internships, and capstones.

Public Education

Our public education programs focus on those who are not part of the other formal education programs so that they will make more informed decisions and help create a more ecologically and economically sustainable world. The Reserve volunteer program is critical to supporting public education and outreach, (see Chapter XVII). Public education helps bring the information we develop in our research, stewardship, and decision maker training programs to the community whose personal decisions impact the Slough.

- **Public Visitor Center**: Our visitor center offers a highly visible presence in the community for the NERRS and our partners, the California Department of Fish and Game, NOAA and the Elkhorn Slough Foundation. The award winning interpretive exhibits in the visitor center offer excellent interpretive exhibits that can be used by a variety of audiences. (Awarded first place in Interior Exhibit Category of the National Association for Interpretation 1998 Media Award Competitions.)

- **Guided Tours**: In addition to assisting staff with welcoming the general public to the Reserve our trained volunteers lead a morning and an afternoon walking tour every Saturday and Sunday. Guided tours may be requested for specific groups or for other days or times.

- **Special Events**: The education program sponsors or supports several special public events held each year at the Reserve and in the local community. (see Chapter X for details*)*

- **Watershed Outreach**: The need to reach specific audiences in the watershed has been identified as a priority for the Reserve, but one that requires the addition of a community outreach coordinator. (See Chapter X for details.)

F. Program Staffing & Working Groups

Current Staffing

Currently the Education Program staff includes a:

- Education Coordinator
- CTP Coordinator
- Volunteer Coordinator
- Education Assistant (½ time)
- Visitor Center Coordinator (full time)
- Visitor Center Naturalist (½ time)

and is supported by over 100 volunteers (6,000 hours/year +).

Staffing Needs

The Education Program needs adequate funding for the following new staff positions:

K-12 and Public Education (Please refer to Chapter X)

- Visitor Center Coordinator (full time)
- Visitor Center Naturalist (full time)
- Administrative/clerical support (full time)

Watershed Outreach

- Watershed Outreach Coordinator (full time) (see Chapter X for description of this position)

Coastal Training Program (see chapters III, V, VI, VIII, X)

- Office manager (full time)
- Contractors (to assist with workshops) (as needed)
- CTP Outreach and Development Officer (full time)
- 3 CTP Program Managers (part time)

Working Groups

One or more Education Program staff is involved in the following ESNERR strategic planning working groups:

17. Public Information
18. Administration
19. Internship
20. Information Technology (lead)
21. Education (lead)

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XVII. Research Program Overview

A. NERR Research Plan

The reserve system provides a mechanism for addressing scientific and technical aspects of coastal management problems through a comprehensive, interdisciplinary, and coordinated approach. Research and monitoring programs, including the development of baseline information, form the basis of this approach. Reserve research and monitoring activities are guided by national plans that identify goals, priorities, and implementation strategies for these programs. This approach, when used in combination with the education and outreach programs, will help ensure the availability of scientific information that has long-term, system-wide consistency and utility for managers and members of the public to use in protecting or improving natural processes in their estuaries.

Reserve System Research Goals

Research at the Elkhorn Slough NERR is designed to fulfill the Reserve System goals as defined in program regulations. These include:

- Address coastal management issues identified as significant through coordinated estuarine research within the System;
- Promote Federal, state, public and private use of one or more reserves within the System when such entities conduct estuarine research; and
- Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

Reserve System Research Funding Priorities

Federal regulations, 15 C.F.R. Part 921.50 (a), specify the purposes for which research funds are to be used:

- Support management-related research that will enhance scientific understanding of the Reserve ecosystem,
- Provide information needed by reserve managers and coastal ecosystem policy-makers, and
- Improve public awareness and understanding of estuarine ecosystems and estuarine management issues.

The reserve system is focusing on the following research areas to support the priorities above:

1. Eutrophication, effects of non-point source pollution and/or nutrient dynamics;
2. Habitat conservation and/or restoration;
3. Biodiversity and/or the effects of invasive species;
4. Mechanisms for sustaining resources within estuarine ecosystems; or
5. Economic, sociological, and/or anthropological research applicable to estuarine ecosystem management

There are two reserve system efforts to fund research on the previously described areas. The Graduate Research Fellowship Program (GRF) supports students to produce high quality research in the reserves. The fellowship provides graduate students with funding for 1-3 years to conduct their research, as well as an opportunity to assist with the research and monitoring program at a reserve. Projects must address coastal management issues identified as having regional or national significance; relate them to the reserve system research focus areas; and be conducted at least partially within one or more designated reserve sites.

Students work with the research coordinator or manager at the host reserve to develop a plan to participate in the reserve's research and/or monitoring program. Students are asked to provide up to 15 hours per week of research and/or monitoring assistance to the

reserve; this training may take place throughout the school year or may be concentrated during a specific season.

Secondly, research is funded through the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), a partnership between NOAA and the University of New Hampshire (UNH). CICEET uses the capabilities of UNH, the private sector, academic and public research institutions throughout the U.S., as well as the 27 reserves in the reserve system, to develop and apply new environmental technologies and techniques (http://ciceet.unh.edu/).

System-Wide Monitoring Program

It is the policy of the Elkhorn Slough NERR to implement each phase of the System-Wide Monitoring Plan initiated by ERD in 1989, and as outlined in the reserve system regulations and strategic plan:

- Phase I: Environmental Characterization, including studies necessary for inventory and comprehensive site descriptions;
- Phase II: Site Profile, to include a synthesis of data and information; and
- Phase III: Implementation of the System-wide Monitoring Program.

The System-wide Monitoring Program provides standardized data on national estuarine environmental trends while allowing the flexibility to assess coastal management issues of regional or local concern. The principal mission of the monitoring program is to develop quantitative measurements of short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective coastal zone management. The program is designed to enhance the value and vision of the reserves as a system of national references sites. The program currently has three main components and the first is in operation.

1. Abiotic Variables: The monitoring program currently measures pH, conductivity, salinity, temperature, dissolved oxygen, turbidity, water level and atmospheric

conditions. In addition, the program collects monthly nutrient and chlorophyll a samples and monthly diel samples at one SWMP data logger station. Each reserve uses a set of automated instruments and weather stations to collect these data for submission to a centralized data management office. Efforts are underway at Elkhorn Slough NERR to make data available via telemetry in accordance with standard protocols for ocean observing systems.

2. Biotic Variables: The reserve system will incorporate monitoring of organisms and habitats into the monitoring program as funds become available. The first aspect likely to be incorporated will quantify vegetation (e.g., marsh vegetation, submerged aquatic vegetation) patterns and their change over space and time. Other aspects that could be incorporated include monitoring infaunal benthic, nekton and plankton communities. Elkhorn Slough NERR has completed pilot efforts in crab monitoring, invasion monitoring, and emergent marsh biomonitoring testing standard NERR protocols.

3. Landuse, Habitat Mapping and Change: This component will be developed to identify changes in coastal ecological conditions with the goal of tracking and evaluating changes in coastal habitats and watershed land use/cover. The main objective of this element will be to examine the links between watershed land use activities and coastal habitat quality. Elkhorn Slough NERR has contributed to the development of the NERRS Habitat Classification Scheme and implemented its use for habitat change mapping.

These data are compiled electronically at a central data management “hub”, the Centralized Data Management Office (CDMO) at the Belle W. Baruch Institute for Marine Biology and Coastal Research of the University of South Carolina. They provide additional quality control for data and metadata and they compile and disseminate the data and summary statistics via the Web (http://cdmo.baruch.sc.edu) where researchers, coastal managers and educators readily access the information. The metadata meets the standards of the Federal Geographical Data Committee.

B. Need for Research to Promote Coastal Stewardship at ESNERR

To better fulfill our role as coastal stewards, we need to better understand the complex process and dynamics of our estuarine watershed and coastal biodiversity. We need to know more about the relative impacts of various potential threats and about the effectiveness of different restoration strategies. We need to better characterize the Slough's biodiversity to understand which estuarine species need our special support, because of the key role they play or because of their rarity. Applied research, while becoming more common, still comprises a tiny minority of the investigations conducted by academic institutions. The Elkhorn Slough NERR thus plays a critical role in encouraging, supporting, and synthesizing applied conservation research by regional scientists. Furthermore, Reserve researchers themselves conduct original conservation research to address critical gaps in our understanding.

C. Program History

For many decades, scientists have come to Elkhorn Slough to collect information and pose questions about its habitats, natural processes, and inhabitants. In the 1920s, George MacGinitie conducted some of the early biological investigations of the tide flats at the west end of the Slough. Over the years, students and faculty from a variety of academic institutions such as the Moss Landing Marine Laboratories, Stanford University's Hopkins Marine Station, University of California at Santa Cruz, and California State University at Monterey Bay, among others, have found themselves riding in a boat, walking on the shores, or slogging through the mud of Elkhorn Slough. The Reserve's research and monitoring program began with the site's designation as a National Estuarine Research Reserve in 1979. From 1983 until 1990, the Elkhorn Slough

Foundation oversaw the research activities on the Reserve. In 1990, the first Reserve Research Coordinator was hired as a part-time position. Today, the Research Program consists of two full-time and four part time staff who are conducting, overseeing, or permitting about thirty research and monitoring projects at any given time.

D. Program Purpose and Goals

Purpose

In order for coastal managers to make informed decisions, they must possess credible, relevant information about the systems and species under their charge. History has shown us what can happen when human actions, often with the best of intentions, are taken without proper knowledge of the consequences. Research is necessary to help insure the *intended* consequences are realized and to help minimize the risk of *unintended* consequences of human activities.

Goals

According to the CZMA, a key goal of the Reserves is to "conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas."

In order to meet this overarching coastal program goal, we strive to:

- Detect short term variability and long term change in Elkhorn Slough and its watershed through various monitoring projects
- Produce unbiased, scientifically robust data as a result of short-term applied conservation research

- Disseminate data, reports, theses, research conclusions, and other relevant scientific information about Elkhorn Slough
- Facilitate and encourage research to fill the highest-priority data gaps
- Encourage research by outside scientists
- Archive scientific information about Elkhorn Slough

E. Program Description

Audiences

There are three major audiences for the ESNERR research program and products:

- Coastal Managers and Policy Makers: land managers, infrastructure managers, land use planners, elected officials. This audience benefits from research and monitoring when the results of this work are used in informing coastal management and decision making.
- Scientists: university faculty, graduate students, and other staff, public agency employees, private institution scientists, non-profit organization scientists. The agency and academic communities benefit from our research and monitoring program in several ways. One way is by using the Reserve as a field site, and another is by using the data generated or made available by the Reserve as a foundation for their own work.
- Students: K-12 students, college and university students, volunteers, and the general public. A wide variety of students, in both formal and informal learning situations, make use of research and monitoring activities and outcomes. The Reserve's program serves as a model to provide real-world

examples of what researchers do and how they do it, and offers an opportunity to actively participate in collecting data. The result of research also helps to expand the knowledge of students and can act as a catalyst for subsequent research.

Venues

Many of the Reserve's research and monitoring activities occur within the ESNERR boundary. The Reserve provides relatively safe, undisturbed field sites for a variety of projects, both long and short term. Researchers working on-site apply for Reserve Research Permits, which, if granted, allow them to work during hours the Reserve is closed to the public, and allow them access to areas off of the trails to which the public is limited. In return, they agree to various conditions, including providing advance notice of sampling, sharing data or papers resulting from the project, and informing members of the public they encounter about their projects.

Many important ESNERR-supported scientific endeavors also occur outside the Reserve boundary but within the watershed. Choice of location for research and monitoring efforts is driven almost entirely by the needs and parameters of the project. Access to non-ESNERR lands is more restricted in the upland areas where most land is privately-owned. Within the estuary, we are particularly fortunate that the main channel is part of the Monterey Bay National Marine Sanctuary, a close partner of the NERR.

In 2006, we will be breaking ground on a new 3,500 square foot research and education laboratory. This building will house the offices, research laboratory, and teaching laboratory for the Reserve. In addition to on-site facilities to support Elkhorn Slough research, we have been fortunate to enjoy positive relationships with nearby academic institutions such as the Moss Landing Marine Laboratories who have generously provided laboratory space and equipment as needed.

Program Components

Long-term monitoring

Consistently collecting high caliber long-term monitoring data on key indicators of coastal ecosystem health is the highest priority of the Reserve research program because no other individual or organization is poised to play this role in the Elkhorn Slough watershed. Long-term monitoring, therefore, represents the largest investment of research staff time and resources. Chapter IX (Goal 7) describes in detail the Reserve's monitoring programs for water quality, habitat change, and biological indicators. The Reserve fully participates in the National Estuarine Research Reserve's System-wide Monitoring Program (SWMP), which includes water and weather monitoring (see Chapter IX). In addition, the Reserve conducts additional water quality, habitat change and biological monitoring. For more details on these programs see Chapter IX.

Short-term applied conservation research

The Reserve's scientists complement the monitoring they coordinate with short-term, applied research projects aimed at better understanding threats to coastal ecosystems and

strategies for diminishing them. As a part of the Reserve's integrated approach to stewardship, education and research, these research projects are described in Chapters III-VIII (Goals 1-6). The focus of such applied research projects stem directly from the Reserve's priorities for conservation and restoration in the watershed. For instance, Reserve scientists are informing estuarine restoration strategies by examining the dynamics of salt marsh loss, and by predicting responses of ecological indicators to proposed hydrological management alternatives. Likewise, they will perform rigorous scientific assessment of restoration experiments examining alternative management strategies for coastal prairie on the Reserve.

Facilitating and encouraging research at Elkhorn Slough

Faculty, students, and employees from a wide variety of research institutions and agencies utilize the Reserve for their research. The Reserve scientists invest a significant amount of time in encouraging and supporting research by others at Elkhorn Slough. Historically, some of the most useful knowledge that has informed conservation has come from such investigations, especially by regional graduate students conducting thesis work. Students are directed to priority research topics (available on the Reserve's webpage at http://www.elkhornslough.org/research.htm) and are supported through mentoring on research design, through logistical assistance, and through access to critical baseline data and knowledge. The Reserve serves as a protected field site for many research projects. Research staff coordinate the Reserve research permit process, which ensures that researchers follow guidelines to minimize ecological disturbance during their studies. Another way the Reserve supports outside research is by sponsoring Graduate

Research Fellows. This fellowship program is funded by NOAA to support the research of two students per year who are working on projects that provide information to assist with coastal management.

Informing management and policy

Reserve scientists work to enhance the scientific basis of decision-making about coastal ecosystems. Reserve research and stewardship staff work closely on adaptive management of coastal habitats on the Reserve itself. For instance, Reserve research on threatened amphibian dynamics has informed freshwater pond management strategies on site. Reserve staff have helped organize and contributed presentations to Coastal Training Program workshops, informing regional decision-makers about the ecological impacts of invasions and about maritime chaparral restoration strategies. Reserve scientists have played a critical role in the Tidal Wetland Project, helping to direct this initiative and providing presentations and written summaries to inform decision-making about the future of estuarine habitats in the watershed. Reserve staff also regularly contribute knowledge about coastal ecosystems to other regional decision-makers regarding coastal policy and management (e.g. Monterey Bay National Marine Sanctuary, Regional Water Quality Control Board, Monterey County Board of Supervisors, California Coastal Commission, Aquatic Nuisance Species Task Force). They attend National Estuarine Research Reserve meetings and contribute actively to national initiatives and committees.

Archiving and sharing knowledge about Elkhorn Slough

The research program archives and disseminates data collected in Reserve-run, long-term monitoring programs, as well as the accompanying metadata. In addition, datasets contributed by other researchers are regularly acquired and archived. The Reserve has an extensive, ever expanding collection of maps, photographs, and remote sensing data that are carefully archived. There is also a reference library containing all publications (including unpublished reports and theses) on research in the Elkhorn watershed, and these are entered and annually updated in an Endnote bibliography. The availability of the above resources is made widely known to regional researchers and the public, through presentations and on the Reserve webpage. Hundreds of requests for data, images, and references are received and filled each year by research staff.

Education and outreach about Slough conservation research

In addition to informing targeted decision-makers, Reserve scientists disseminate knowledge about coastal ecosystems, especially results of the Reserve's own monitoring and research, to a broad audience. In order to educate the general public and help motivate support for coastal conservation, they write newsletters for and give presentations to the public. They also maintain extensive webpages about Slough research to inform the public and students about the Reserve's role in understanding coastal ecosystems. Reserve staff also regularly publish peer-reviewed papers in scientific journals, both because such publications are the most powerful currency for informing local and regional scientifically-based management strategies, and in order to share with a wider audience of scientists and coastal decision-makers the lessons learned from Elkhorn Slough research.

F. Program Staffing & Working Groups

Current Staffing

The Research staff are divided into three programmatic areas. *Water quality and weather monitoring and research* are conducted by three staff members with expertise in water quality science. The NERR system-wide monitoring program is carried out with support by all three of these (one .75 time, and two at .25 time) with funding from NOAA. One of these staff members also coordinates a regional, monthly water quality program (.75 time funding from the Regional Water Quality Control Board, only through August 07). *Habitat change and land use* monitoring and research are conducted by one staff member with expertise in historical ecology, remote sensing and GIS (.75 time on NOAA funding, .25 time on a Packard Foundation grant through June 08). *Biological monitoring and research* are carried out by two staff members with expertise in field and laboratory biological research in a variety of taxa, a research biologist (.5 time on the NOAA grant) and the research coordinator (.5 time on the NOAA grant, .25 time on a grant from the Packard Foundation expiring in June 08), who also oversees the whole research program.

Staffing Needs

In the future, we hope to expand the research team so as to have two full time positions (or their equivalent spread over various part-time positions) in each of the programmatic areas. This would represent an expansion from 1.25 to 2.0 permanent positions in water quality, .75 to 2.0 positions in habitat change, and 1.0 to 2.0 positions in biology. Such

expansion would ensure adequate breadth in monitoring and improved depth in applied research in each of the three areas.

The Research Program needs adequate funding for the following new staff positions:

- Biologist (see chapters III, IV, V, VI, VII, VIII, IX, XI)
- SWMP Technician (see chapter IX)
- GIS Technician (see chapters III, IV, VII, VIII)

Working Groups
One or more Research Program staff is involved in the following ESNERR strategic planning working groups:

22. Internship
23. Administration
24. Monitoring (lead)
25. Pollution (lead)
26. Estuarine
27. Information Technology

G. References and Guiding Documents

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XVIII. Stewardship Program Overview

A. Need for Stewardship

California is a biologically rich region, home to well over 4000 species of plants and almost 600 species of vertebrates (Myers et al. 2000), but most of the state's natural ecosystems face serious anthropogenic threats. California has been designated a biodiversity hotspot, or an area where exceptional concentrations of endemic species are undergoing exceptional losses of habitat (Myers et al. 2000). These losses occur in two basic ways. The first is through conversion, or the outright change of natural habitat into developed or agricultural areas. The second is through qualitative losses which involve changes or degradation in the structure, function, or composition of an ecosystem. At some level of degradation, an ecosystem ceases to be natural (Noss et al. 1995). Losses due to both conversion and degradation have been significant. California native grasslands have been reduced to about one percent of their original extent, both through land conversion and degradation by exotic species invasions. Other seriously threatened ecosystems include wetlands and riparian woodlands, which have been reduced to 10 percent or less of their original area (Noss et al. 1995). Predictably, many of the animal species dependent on these habitats have declined as well.

The Elkhorn Slough watershed shares many of the same human impact issues as other habitats across the state and the nation. For example, the Elkhorn Slough Reserve's grassland and oak woodland understories are, with few exceptions, highly degraded and invaded by exotic plants; its freshwater springs have been almost entirely lost due to groundwater overdraft; and 75% of its historical salt marshes have been lost through conversion, first to agricultural land, and later to mudflats and permanently subtidal lagoons. In order to preserve the natural habitats that remain, the Elkhorn Slough Reserve's stewardship program gives high priority to habitat protection within Reserve boundaries. In areas already degraded by past land uses, invasive species, or pollution, the stewardship program endeavors to sustainably recover or restore at least some of the lost aspects of local biodiversity and natural processes.

B. Program History

Land management, or stewardship, has played an important role since the Reserve was designated as a Department of Fish and Game Ecological Reserve in 1980. Early stewardship was directed by the Reserve Manager with significant support from the California Conservation Corps (CCC). Projects included controlled cattle grazing for grassland management; the use of prescribed fire to control weeds; installation of a series of guzzlers to provide supplemental freshwater for wildlife; and the restoration of tidal flow to hundreds of acres of estuarine wetlands that had been reclaimed for pasture land in the early and mid-1900s. In the early and mid-1990s, land management projects were led largely by the California Department of Fish and Game's Fish and Wildlife Assistant with help from the CCC and Reserve volunteers. Notable projects included the creation of two ponds to increase freshwater habitat; the removal of a 13 acre exotic eucalyptus woodland; the creation of an on-site native plant greenhouse; the propagation and planting out of tens of thousands of native grasses, forbs, shrubs, and trees in habitat restoration projects; erosion control; and the targeted control of exotic plants and animals. In 1999, a Stewardship Coordinator was hired to oversee habitat protection and restoration projects, and soon thereafter, the program was expanded to include a Stewardship Ecologist. Today's stewardship program continues and expands upon many of the early land management projects, learning from past failures and building on its many past successes. Throughout its 25-year history, Reserve stewardship projects have relied heavily on internal and external partners, including Reserve docents, the California Conservation Corps, the California Department of Forestry, the Natural Resource Conservation District and the Resource Conservation District.

C. Program Purpose and Goal

Purpose

The purpose of the Reserve's stewardship program is to protect and restore coastal habitats in the Elkhorn Slough watershed, with emphasis on the Elkhorn Slough NERR. The stewardship staff works collaboratively with the Reserve research and education staff to design and implement a number of projects including invasive species control, endangered species management, habitat mapping, ecological restoration, erosion control, community outreach, and applied research. The Coastal Training Program (CTP) often

provides information critical to scientifically-sound project design, and Reserve volunteers are frequently instrumental in project implementation. Through these actions, the stewardship program helps to protect and rehabilitate the diversity and integrity of native species and communities natural to the region. The main components of the stewardship program are briefly described below.

Goals

The Reserve's key stewardship goals are to:

- Protect intact, native habitats and sensitive species
- Restore degraded conservation targets
- Manage habitats that require ongoing manipulation
- Use restoration science and or adaptive management techniques that allow us to share, scientifically, with other land managers which techniques work, and which do not.

D. Program Description

Using a variety of different strategies, the stewardship program seeks to help protect and restore the watershed's critical natural resources, as partly identified by the Elkhorn Slough Watershed Conservation Plan (Scharffenberger1999), and to address some of the watershed's most pressing management concerns as outlined in Changes in a California Estuary: A Profile of Elkhorn Slough (2002). Furthermore, stewardship staff members are participating in the Tidal Wetland Planning Process to help conserve, enhance, and restore local tidal habitats.

Stewardship staff is committed to developing and implementing science-based management strategies. Project design begins with a review of published literature on habitat values and management or restoration techniques; goal setting is informed by historical ecology research and a review of existing constraints; and strategies are strengthened by the utilization of GIS-based habitat maps and information. Because habitat restoration is still an evolving field, when possible, management and restoration

projects include an experimental design component. This allows staff to test, monitor, and report out on a variety of management techniques. In the absence of a formal experimental design, stewardship projects are at the very least monitored and strategies are modified as needed to increase the likelihood of project success.

Most of the Reserve's stewardship work is done within Reserve boundaries. This is largely due to the Reserve's limited staff resources and the fact that the Reserve lands have been highly impacted over time. However, we do assist a number of organizations in projects off the Reserve that are within the Elkhorn Slough Watershed. All areas of the Reserve and all habitats are addressed to some degree by the stewardship program.

Program Components

Historical Ecology

Historical ecology is the recovery and synthesis of diverse, underutilized, and diminishing historical data sources, in order to make sense of past and present ecosystems. It is an emerging field which, in Northern California, has been pioneered by the San Francisco Estuary Institute's Historical Ecology program. Historical ecology can help us understand past and current conditions, including how natural ecological and physical processes have functioned over long periods of time, and how present-day conditions have developed. Furthermore, historical ecology can help guide science-based restoration and management decisions, by helping us understand the restoration potential of various sites, and using history as a restoration reference. However, like most sciences, historical ecology does have its limitations: we cannot recover all historical information, ecosystem-level studies are always complex, and frequently we cannot turn back the clock to pre-European conditions. Despite these constraints, however, historical ecology has proven to be a useful and powerful tool in habitat management and restoration. Therefore, working collaboratively with the research program, the Elkhorn Slough stewardship program researches and acquires copies of original maps, journals, surveys, botanical collections, archaeological data, and geologic cores from a variety of

sources, and synthesizes the information in documents and public presentations, in order to reveal the past and help inform the future.

Habitat and Species Inventory and Mapping

A basic component of the stewardship program is to inventory and map the species and habitats currently on the Reserve. Working with the Reserve's GIS coordinator, the stewardship program will update existing habitat, invasive species, and sensitive species maps as necessary. All habitat map updates will conform to the proposed NERRS classification scheme.

Protection of Intact, Native Habitats and Sensitive Species

The conservation of relatively pristine estuarine, freshwater, maritime chaparral, coastal prairie, coastal scrub, and coast live oak habitats is a high priority for the stewardship program, as is the protection of sensitive species. In general, the protection of native species and assemblages relies on the removal of stresses that degrade or impair conservation targets. Several of the stresses outlined in Chapter III can be addressed through strategies of prevention, early detection, and rapid response. For example, working together with the Elkhorn Slough NERR education program, we are attempting to protect local coast live oak woodlands by preventing the introduction of the Sudden Oak Death pathogen, which has led to significant declines in other California coast live oak woodlands (Chapter VII). We also work with Reserve researchers to adaptively manage freshwater habitats used by threatened and endangered amphibians (Chapter IV). The stewardship program also works on early detection and eradication of newly introduced invasive species, and erosion control to protect sensitive species, oak woodlands, native grasslands, and wetlands from polluted runoff originating offsite.

Restoration of Degraded Conservation Targets

The Elkhorn Slough NERR is the site of many degraded habitats. As a result, a large portion of the Reserve's habitats are in need of restoration in order to recover at least some of the lost aspects of local biodiversity and natural processes. As much as possible, Reserve restoration projects will be designed as *restoration science* projects, incorporating both existing knowledge and experimentation into the design, allowing us

to focus on important questions about how to make a given project achieve its goals (Zedler 2001). Data from monitoring will not only help guide future projects on the Elkhorn Slough NERR, but information will be shared to help others better restore habitats throughout the region.

As part of restoration, the stewardship program oversees an exotic species control program. This program has been developed primarily to protect native habitats and threatened and endangered animals, but is also an important component of most upland restoration projects. Invasive species control is critical, because animal invaders can cause extinctions of vulnerable native species through predation, competition, and habitat alteration. Plant invaders can completely alter the fire regime, nutrient cycling, hydrology, and energy budgets in a native ecosystem, and greatly diminish the abundance or survival of native species (Mack et al. 2000, D'Antonio and Vitousek 1992). Furthermore, some non-native animals and plants can hybridize with native species (Mack et al. 2000). Therefore, controlling the abundance of and outlying populations of exotic species are important actions to take to protect and restore native species.

In support of restoration projects, the stewardship program also includes the following components:

- Maintenance and management of an on-site native plant greenhouse
- Local community involvement in Reserve restoration projects
- Support of restoration on other lands in the Elkhorn Slough watershed

Habitat Management

Constraints sometime preclude the true restoration of lost natural processes, habitats, and species. For example, Reserve stewards cannot restore natural freshwater seeps and springs with existing resources. Freshwater has been overdrawn, and saltwater intrusion is a problem. Instead, the Reserve has been supporting man-made guzzlers and ponds for wildlife. These waterbodies now support breeding populations of threatened and endangered amphibians. In these and other cases, Reserve stewards currently maintain man-made structures or management regimes instrumental in the upkeep of habitat. For

example, Reserve stewardship staff maintains plumbing to guzzlers and selected ponds; maintains and manages tide gates at the Reserve's North Marsh; and mows selected grasslands in an attempt to decrease the impact of weeds and simulate grazing by now locally-extinct herbivores, such as the Tule Elk.

Land Acquisition

The Reserve is active in land acquisition as part of its overall stewardship effort. The focus of the land acquisition program is on protecting the tidal wetlands of Elkhorn Slough and their immediately adjacent lands. For more information on the Reserve's land acquisition plan, see Chapter XIII.

E. Program Staffing & Working Groups

Current Staffing

The Elkhorn Slough NERR has a small stewardship staff, which is heavily augmented by many dedicated volunteers. Our staff currently consists of a:

- Stewardship Coordinator
- Stewardship Ecologist.

Staffing Needs

Additional staff is needed to conduct necessary field work and to oversee large areas of the stewardship program; and a stable budget is necessary to allow the program to hire contractors to help with a number of stewardship projects.

The Stewardship Program needs adequate funding for the following new staff positions:

- Permit Coordinator
- Landscape Crew (see chapters V, IV, VII)
- Stewardship Assistant (see chapters III, IV, VI, VII, VIII, XI)
- Hydrologist/Wetland Specialist (see chapter IV)
- Invasive Species Crew (see chapters IV, VI, VII,
- Propagation Greenhouse Specialist (see chapter IV, VII)

Working Groups

One or more Stewardship Program staff is involved in the following ESNERR strategic planning working groups:

28. Internship
29. Administration
30. Coastal Prairie (lead)
31. Maritime Chaparral
32. Freshwater Wetlands (lead)
33. Coast Live Oak (lead)

F. Guiding Documents and References

Caffrey, Jane, Martha Brown, W. Breck Tyler, and Mark Silberstein, eds. 2002. Changes in a California Estuary: A Profile of Elkhorn Slough. The Elkhorn Slough Foundation, Moss Landing, CA.

D'Antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Rev. Ecol. Syst. 23:63-87.

Mack, Richard N., Daniel Simberloff, W. Mark Lonsdale, Harry Evans, Michael Clout, and Fakhri Bazzaz. 2000. Biotic invasions: causes, epidemiology epidemiology, global consequences and control. Issues in Ecology 5. Ecological Society of America, Washington, DC.

Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca, and Jennifer Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Noss, R. F., LaRoe, E. T., III and Scott, J. M. 1995. *Endangered ecosystems of the United States: A preliminary assessment of loss and degradation.* 28. National Biological Service, Washington, D.C.

Scharffenberger, T. 1999. Elkhorn Slough Watershed Conservation Plan. Elkhorn Slough Foundation and The Nature Conservancy. Unpublished report, on file at Elkhorn Slough NERR.

Zedler, Joy B. 2001. Handbook for Restoring Tidal Wetlands. CRC Press, Boca Raton, FL.

Chapter XIX.
Operations and Facilities Program Overview

A. Need for Program

It is difficult and sometimes even impossible to achieve many conservation goals without a healthy physical infrastructure in place. Buildings, roads, and parking areas must be built and maintained in order for basic activities to take place. Providing researcher and public access as well as interpretive services presents another suite of physical site needs and an increased responsibility to public health and safety.

Some operations and facilities activities overlap strongly with the Stewardship Program. For example, managing weeds is important for both improving native habitat and for fire protection.

B. Program History

The property that is now Elkhorn Slough NERR at one time included two duck hunting clubs and later a dairy. Many of the structures from those activities have been removed, but some remain. For example, a beautiful hunting lodge built in 1906, a caretakers cottage, and a farm house remain today and are used for employee housing. Two barns from the dairy still stand, and one is used for public access and one for storage.

Levees were built for different purposes over the years, from impounding freshwater for duck hunting to restricting tidal flow in order to drain the wetland and provide pasture land. While some of the levees no longer serve these functions, in some cases they provide needed access and trail loops.

The biggest surge of facilities construction occurred in the early 1980s when the visitor center, the maintenance shop, and carport/storage areas were built. In 1993, the administration building was constructed, and in 1996 the outdoor amphitheater was installed. In 1996, Deaton Museum Services was contracted to design and build exhibits for the visitor center. Funds for all of these projects came from a combination of State and Federal sources.

California Department of Fish and Game (CDFG) staff was responsible for the demolition and removal of many of the old dairy buildings soon after the property was acquired by the State. Over the years, the California Conservation Corps (CCC) played a large role in assisting CDFG staff with many maintenance, emergency, and construction projects. Reserve volunteers have also long been critical in assisting with operations and facilities projects.

C. Program Purpose and Goals

Purpose

The purpose of the operations and facilities program is to provide a stable foundation of infrastructure upon which the Reserve's research, education, stewardship, and administration programs can succeed.

Goals

Elkhorn Slough NERR will strive to plan, construct, and operate facilities that:

- are well-maintained, attractive, safe, and fully-functional,
- comply with the requirements of the Americans with Disabilities Act,
- support multiple Reserve goals,
- minimize environmental impacts.

D. Program Description

Definitions

Facilities: For the purposes of this plan, facilities consist of all Reserve structures, utilities, roads, and trails.

Program Components

Existing Facilities

The following facilities are currently in place at the Elkhorn Slough NERR:

- Visitor Center
- Outdoor Amphitheater
- Picnic benches
- Administration Building and Conference Room
- Native Landscaping

- West Modular Office
- Central Modular Office
- East Modular Office
- Maintenance Building
- Maintenance Yard
- Carport
- Greenhouse Complex
- Research and Education Laboratory (to be completed in 2007)
- Large Dairy Barn
- Small Dairy Barn
- Roads and Trails
- Outdoor Public Access Structures (Benches, Boardwalks, Footbridge, Wildlife Viewing Blind, Overlooks, Signs, Outhouses)
- Parking lot
- Employee Residence: Farm House
- Employee Residence: Buck Meyer Hunting Lodge
- Employee Residence: Caretaker's Cottage
- Utilities (Gasoline/Diesel, Propane, Water, Septic, Electricity, Telecommunications)

Planning

The Reserve intends to develop a Facilities Master Plan to articulate the priorities and locations of future construction projects. Planning and fund procurement for regular maintenance and infrastructure repairs is ongoing.

A Technology/Communications Plan is also needed to organize and guide the development of the Reserve's technologic and communications infrastructure.

Maintenance

The California Department of Fish and Game (CDFG) is responsible for the ongoing maintenance of the Reserve's infrastructure and facilities. Maintenance of the Reserve is a serious challenge due to CDFG staffing and budget shortfalls. The Reserve does not

receive any regular funding for infrastructure maintenance. Funds are procured on a year-by-year basis, which makes it difficult to plan ahead for major repairs. Emergency funds are available from CDFG under certain circumstances.

Construction

The Reserve may receive engineering support from CDFG for construction projects with budgets under $500,000. Projects with budgets over $500,000 are supported by the California Department of General Services, who provide architectural, engineering, permitting, and project management support. The National Oceanic and Atmospheric Administration (NOAA), offers competitive funding for Reserve construction projects that support the NERR mission, which are matched (70/30) by the State. Construction funds have also been awarded to the Reserve from NOAA and from congressional earmarks.

Partnerships

Operations and facilities work, including many projects that overlap strongly with the Stewardship Program, has been conducted with the help of many partners. The primary partners which have assisted CDFG are listed below:

California Conservation Corps
California Department of Forestry (CDF)
California Department of Transportation (Cal Trans)
Monterey County RCD
Santa Cruz County RCD and Natural Resources and Employment Program (NREP)
Monterey County Agricultural Commission
Monterey County Department of Public Works
ESNERR Volunteers
Other Volunteers (Monterey Bay Aquarium, Duke Energy, Pacific Gas and Electric Company)

E. Program Staffing and Working Groups

Current Staffing

- One part-time, temporary, grant-funded Maintenance Supervisor

Staffing Needs (see chapter XI)

- One full-time, permanent, State-funded Habitat Supervisor I
- One full-time, permanent, State-funded Habitat Technician
- One part-time, Maintenance Seasonal Aid
- One full-time, permanent, Information Technology Specialist

The Reserve has not had a permanent operations and facilities position in place since 2000. Hiring freezes, budget cuts, and a lack of available employee housing have contributed to this situation. Highly dedicated volunteers and one part-time, grant-funded, maintenance position has kept the Reserve's facilities afloat since that time.

It is critical to the success of all programs to have adequate Reserve maintenance staff. At a minimum, the Reserve needs to employ one full-time Habitat Supervisor I, and one full-time Habitat Technician. Additional seasonal positions are also desirable.

Working Groups

One or more Operations Program staff is involved in the following ESNERR strategic planning working groups:

- Facilities (Lead)
- Information Technology

F. Guiding Documents and References

1989, Ace Design: Site Development and Interpretive Exhibits Master Plan, and Visitor Building and Trailside Interpretive Exhibits

1995, Joni L. Janecki and Associates: Visitor Center Landscape Plan

1998, NOAA, Office of Ocean and Coastal Resource Management: Facilities Plan for the National Estuarine Research Reserve System

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ESNERR- Elkhorn Slough National Estuarine Research Reserve
NERR- National Estuarine Research Reserve (NOAA)
NERRS- National Estuarine Research Reserve System (NOAA)
ERD- Estuarine Reserves Division (NOAA)
OCRM- Office of Ocean and Coastal Resource Management (NOAA)
CDFG- California Department of Fish and Game
NOAA- National Oceanic and Atmospheric Administration
ESF- Elkhorn Slough Foundation
CZMA- Coastal Zone Management Act
TWP- Tidal Wetland Project
MBNMS- Monterey Bay National Marine Sanctuary
CNDDB- California Natural Diversity Database
CTP-Coastal Training Program
SWMP- System-wide Monitoring Program
CPPW- Conservation Project Planning Workbook
TNC- The Nature Conservancy

APPENDICES

1. Program Integration Table
2. National Estuarine Research Reserve System Regulations
3. CTP Strategic Plan
4. Reserve Description
5. Watershed Habitats & Species
6. Research Questions
7. Core/Buffer Area Map
8. CDFG Outreach Messages
9. Reserve MOUs

Appendix 1. Program Integration Table

Ch. #	Goal #	Goal Description	Objective	Research	Stewardship	Education	Coastal Training Program	Administration
III	1	Protect and Restore Estuarine Habitats in the Watershed	Restore and Enhance Estuarine Habitats with Restricted Tidal Flows	X	X	X	X	X
			Reduce Erosion in Subtidal Habitats and the Loss and Degradation of Intertidal Habitats		X		X	X
			Prevent new biological introductions into estuarine habitats	X	X			*
			Detect and eradicate new biological introductions into estuarine habitats	X	X			*
			Develop restoration strategies that help favor dominance by native assemblages	X	X			*
IV	2	Protect and restore the watershed's key freshwater habitats	Maintain and enhance key freshwater habitats		X			*
			Explore and act upon opportunities for watershed partnerships and outreach		X	X		*
			Conduct research to improve management strategies for local freshwater habitats	X				*

			Protect Reserve and key neighboring freshwater habitats from selected invaders		X			*
V	3	Protect and Restore Maritime Chaparral in the Elkhorn Slough Watershed	Preserve existing maritime chaparral in the Elkhorn Slough watershed	X	X	X	X	*
			Reduce loss of maritime chaparral due to habitat type conversion	X			X	*
VI	4	Protect and Restore the Watershed's Key Coastal Prairie and Coastal Scrub Habitats	Reduce abundance of selected non-native plant and animal species in Reserve coastal prairie and coastal scrub assemblages		X			*
			Help build support for regional Coastal Prairie and Coastal Scrub projects		X	X	X	*
			Implement research that informs regional restoration strategies	X	X			*
VII	5	Protect and Restore Key Coast Live Oak Habitats	Protect the watershed's coast live oak habitats from biological invaders		X	X		*
			Investigate the habitat use of native oak vs. non-native eucalyptus	X				*

			groves					
VIII	6	Reduce Pollution across the Elkhorn Slough Watershed	Improve understanding of pollution levels, sources, and effects on coastal habitats	X				*
			Generate and disseminate information on estuarine values and how they are affected by pollution			X	X	*
			Decrease effects of agricultural run-off and erosion on the Reserve		X			*
IX	7	Monitor Key Indicators of Coastal Ecosystem Health to Enhance Understanding of Spatial and Temporal Variation and Long-term Trends	Collect, archive, and disseminate consistent, high caliber data on critical ecosystem characteristics	X				*
XI	8	Educate the Community about the Watershed and Inspire Them to Consider Environmental Conservation When Making Decisions Affecting Elkhorn Slough and Its Watershed	Create and implement environmental education programs for school-aged children, visitors, our watershed neighbors, and decision makers			X	X	*
XI	9	Maintain a Viable Base for ESNERR	Maintain a productive, safe, and	X	X	X	X	X

		Programs: Organization, Budget, and Facilities	efficient ESNERR work environment					
			Maintain a visible and positive ESNERR image	X	X	X	X	X
			Maintain, repair, and construct ESNERR facilities and infrastructure		X			X

* = Administrative Oversite

Appendix 2.
National Estuarine Research Reserve System Regulations

Source: http://www.access.gpo.gov/nara/cfr/waisidx_02/15cfr921_02.html
Last accessed 22 August 2005

TITLE 15--COMMERCE AND FOREIGN TRADE

CHAPTER IX--NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

PART 921--NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM REGULATIONS

[58 FR 38215, July 15, 1993, as amended at 62 FR 12540, Mar. 17, 1997; 63 FR 26717, May 14, 1998]

Subpart A--General

Sec. 921.1 Mission, goals and general provisions.

(a) The mission of the National Estuarine Research Reserve Program is the establishment and management, through Federal-state cooperation, of a national system (National Estuarine Research Reserve System or System) of estuarine research reserves (National Estuarine Research Reserves or Reserves) representative of the various regions and estuarine types in the United States. National Estuarine Research Reserves are established to provide opportunities for long-term research, education, and interpretation.

(b) The goals of the Program are to:

(1) Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve resources;

(2) Address coastal management issues identified as significant through coordinated estuarine research within the System;

(3) Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;

(4) Promote Federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and

(5) Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

(c) National Estuarine Research Reserves shall be open to the public to the extent permitted under state and Federal law. Multiple uses are allowed to the degree compatible with each Reserve's overall purpose as provided in the management plan (see Sec. 921.13) and consistent with paragraphs (a) and (b) of this section. Use levels are set by the state where the Reserve is located and analyzed in the management plan. The Reserve management plan shall describe the uses and establish priorities among these uses. The plan shall identify uses requiring a state permit, as well as areas where uses are encouraged or prohibited. Consistent with resource protection and research objectives, public access and use may be restricted to certain areas or components within a Reserve.

(d) Habitat manipulation for research purposes is allowed consistent with the following limitations. Manipulative research activities must be specified in the management plan, be consistent with the mission and goals of the program (see paragraphs (a) and (b) of this section) and the goals and objectives set forth in the Reserve's management plan, and be limited in nature and extent to the minimum manipulative activity necessary to accomplish the stated research objective. Manipulative research activities with a significant or long-term impact on Reserve resources require the prior approval of the state and the National Oceanic and Atmospheric Administration (NOAA). Manipulative research activities which can reasonably be expected to have a significant adverse impact on the estuarine resources and habitat of a Reserve, such that the activities themselves or their resulting short- and long-term consequences compromise the representative character and integrity of a Reserve, are prohibited. Habitat manipulation for resource management purposes is prohibited except as specifically approved by NOAA as: (1) A restoration activity consistent with paragraph (e) of this section; or (2) an activity necessary for the protection of public health or the preservation of other sensitive resources which have been listed or are eligible for protection under relevant Federal or state authority (e.g., threatened/endangered species or significant historical or cultural resources) or if the manipulative activity is a long-term pre-existing use (i.e., has occurred prior to designation) occurring in a buffer area. If habitat manipulation is determined to be necessary for the protection of public health, the preservation of sensitive resources, or if the manipulation is a long-term pre-existing use in a buffer area, then these activities shall be specified in the Reserve management plan in accordance with Sec. 921.13(a)(10) and shall be limited to the reasonable alternative which has the least adverse and shortest term impact on the representative and ecological integrity of the Reserve.

(e) Under the Act an area may be designated as an estuarine Reserve only if the area is a representative estuarine ecosystem that is suitable for long-term research. Many estuarine areas have undergone some ecological change as a result of human activities (e.g., hydrological changes, intentional/unintentional species composition changes--introduced and exotic species). In those areas proposed or designated as National Estuarine Research Reserves, such changes may have diminished the representative character and integrity of the site. Although restoration of degraded areas is not a primary purpose of the System, such activities may be permitted to improve the representative character and integrity of a Reserve. Restoration activities must be carefully planned and approved by NOAA through the Reserve management plan. Historical research may be necessary to determine the ``natural'' representative state of an estuarine area (i.e., an estuarine ecosystem minimally affected by human activity or influence). Frequently, restoration of a degraded estuarine area will provide an excellent opportunity for management oriented research.

(f) NOAA may provide financial assistance to coastal states, not to exceed, per Reserve, 50 percent of all actual costs or $5 million whichever amount is less, to assist in the acquisition of land and waters, or interests therein. NOAA may provide financial assistance to coastal states not to exceed 70 percent of all actual costs for the management and operation of, the development and construction of facilities, and the conduct of educational or interpretive activities concerning Reserves (see subpart I). NOAA may provide financial

assistance to any coastal state or public or private person, not to exceed 70 percent of all actual costs, to support research and monitoring within a Reserve. Notwithstanding any financial assistance limits established by this Part, when financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, such assistance may be used to pay 100 percent of all actual costs of activities carrier out with this assistance, as long as such funds are available. Predesignation, acquisition and development, operation and management, special research and monitoring, and special education and interpretation awards are available under the National Estuarine Reserve Program. Predesignation awards are for site selection/feasibility, draft management plan preparation and conduct of basic characterization studies. Acquisition and development awards are intended primarily for acquisition of interests in land, facility construction and to develop and/or upgrade research, monitoring and education programs. Operation and management awards provide funds to assist in implementing, operating and managing the administrative and basic research, monitoring and education programs, outlined in the Reserve management plan. Special research and monitoring awards provide funds to conduct estuarine research and monitoring projects with the System. Special educational and interpretive awards provide funds to conduct estuarine educational and interpretive projects within the System.

(g) Lands already in protected status managed by other Federal agencies, state or local governments, or private organizations may be included within National Estuarine Research Reserves only if the managing entity commits to long-term management consistent with paragraphs (d) and (e) of this section in the Reserve management plan. Federal lands already in protected status may not comprise a majority of the key land and water areas of a Reserve (see Sec. 921.11(c)(3)).

(h) To assist the states in carrying out the Program's goals in an effective manner, NOAA will coordinate a research and education information exchange throughout the National Estuarine Research Reserve System. As part of this role, NOAA will ensure that information and ideas from one Reserve are made available to others in the System. The network will enable Reserves to exchange information and research data with each other, with universities engaged in estuarine research, and with Federal, state, and local agencies. NOAA's objective is a system-wide program of research and monitoring capable of addressing the management issues that affect long-term productivity of our Nation's estuaries.

Sec. 921.2 Definitions.

(a) Act means the Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451 et seq.

(b) Assistant Administrator means the Assistant Administrator for Ocean Services and Coastal Zone Management or delegee.

(c) Coastal state means a state of the United States, in or bordering on, the Atlantic, Pacific, or Arctic Ocean, the Gulf of Mexico, Long Island Sound, or one or more of the Great Lakes. For the purposes of these regulations the term also includes Puerto Rico, the Virgin Islands, Guam, the Commonwealth of the Northern Marianas Islands, the Trust Territories of the Pacific Islands, and American Samoa (see 16 U.S.C. 1453(4)).

(d) State agency means an instrumentality of a coastal state to whom the coastal state has delegated the authority and responsibility for the creation and/or management/operation of a National Estuarine Research Reserve. Factors indicative of this authority may include the power to receive and expend funds on behalf of the Reserve, acquire and sell or convey real and personal property interests, adopt rules for the protection of the Reserve, enforce rules applicable to the Reserve, or develop and implement research and education programs for the reserve. For the purposes of these regulations, the terms ``coastal state'' and ``State agency'' shall be synonymous.

(e) Estuary means that part of a river or stream or other body of water having unimpaired connection with the open sea, where the sea water is measurably diluted with fresh water derived from land drainage. The term also includes estuary-type areas with measurable freshwater influence and having unimpaired connections with the open sea, and estuary-type areas of the Great Lakes and their connecting waters (see 16 U.S.C. 1453(7)).

(f) National Estuarine Research Reserve means an area that is a representative estuarine ecosystem suitable for long-term research, which may include all of the key land and water portion of an estuary, and adjacent transitional areas and uplands constituting to the extent feasible a natural unit, and which is set aside as a natural field laboratory to provide long-term opportunities for research, education, and interpretation on the ecological relationships within the area (see 16 U.S.C. 1453(8)) and meets the requirements of 16 U.S.C. 1461(b). This includes those areas designated as National Estuarine Sanctuaries or Reserves under section 315 of the Act prior to enactment of the Coastal Zone Act Reauthorization Amendments of 1990 and each area subsequently designated as a National Estuarine Research Reserve.

Sec. 921.3 National Estuarine Research Reserve System Biogeographic Classification Scheme and Estuarine Typologies.

(a) National Estuarine Research Reserves are chosen to reflect regional differences and to include a variety of ecosystem types. A biogeographic classification scheme based on regional variations in the nation's coastal zone has been developed. The biogeographic classification scheme is used to ensure that the National Estuarine Research Reserve System includes at least one site from each region. The estuarine typology system is utilized to ensure that sites in the System reflect the wide range of estuarine types within the United States.

(b) The biogeographic classification scheme, presented in appendix I, contains 29 regions. Figure 1 graphically depicts the biogeographic regions of the United States.

(c) The typology system is presented in appendix II.

Sec. 921.4 Relationship to other provisions of the Coastal Zone Management Act, and to the Marine Protection, Research and Sanctuaries Act.

(a) The National Estuarine Research Reserve System is intended to provide information to state agencies and other entities involved in addressing coastal management issues. Any coastal state, including those that do not have approved coastal management programs under section 306 of the Act, is eligible for an award under the National Estuarine Research Reserve Program (see Sec. 921.2(c)).

(b) For purposes of consistency review by states with a federally approved coastal management program, the designation of a National Estuarine Research Reserve is deemed to be a Federal activity, which, if directly affecting the state's coastal zone, must be undertaken in a manner consistent to the maximum extent practicable with the approved state coastal management program as provided by section 1456(c)(1) of the Act, and implementing regulations at 15 CFR part 930, subpart C. In accordance with section 1456(c)(1) of the Act and the applicable regulations NOAA will be responsible for certifying that designation of the Reserve is consistent with the state's approved coastal management program. The state must concur with or object to the certification. It is recommended that the lead state agency for Reserve designation consult, at the earliest practicable time, with the appropriate state officials concerning the consistency of a proposed National Estuarine Research Reserve.

(c) The National Estuarine Research Reserve Program will be administered in close coordination with the National Marine Sanctuary Program (Title III of the Marine Protection, Research and Sanctuaries Act, as amended, 16 U.S.C. 1431-1445), also administered by NOAA. Title III authorizes the Secretary of Commerce to designate discrete areas of the marine environment as National Marine Sanctuaries to protect or restore such areas for their conservation, recreational, ecological, historical, research, educational or esthetic values. National Marine Sanctuaries and Estuarine Research Reserves may not overlap, but may be adjacent.

Subpart B--Site Selection, Post Site Selection and Management Plan Development

Sec. 921.10 General.

(a) A coastal state may apply for Federal financial assistance for the purpose of site selection, preparation of documents specified in Sec. 921.13 (draft management plan (DMP) and environmental impact statement (EIS)), and the conduct of limited basic characterization studies. The total Federal share of this assistance may not exceed $100,000. Federal financial assistance for preacquisition activities under Sec. 921.11 and Sec. 921.12 is subject to the total $5 million for which each Reserve is eligible for land acquisition. Notwithstanding the above, when financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, such assistance may be used to pay 100 percent of all actual costs of activities carried out with this assistance, as long as such funds are available. In the case of a biogeographic region (see appendix I) shared by two or more coastal states, each state is eligible for Federal financial assistance to establish a separate National Estuarine Research Reserve within their respective portion of the shared biogeographic region. Each separate National Estuarine Research Reserve is eligible for the full complement of funding. Financial assistance application procedures are specified in subpart I.

(b) In developing a Reserve program, a state may choose to develop a multiple-site Reserve reflecting a diversity of habitats in a single biogeographic region. A multiple-site Reserve allows the state to develop complementary research and educational programs within the individual components of its multi-site Reserve. Multiple-site Reserves are treated as one Reserve in terms of financial assistance and development of an overall management framework and plan. Each

individual site of a proposed multiple-site Reserve shall be evaluated both separately under Sec. 921.11(c) and collectively as part of the site selection process. A coastal state may propose to establish a multiple-site Reserve at the time of the initial site selection, or at any point in the development or operation of the Reserve. If the state decides to develop a multiple-site National Estuarine Research Reserve after the initial acquisition and development award is made for a single site, the proposal is subject to the requirements set forth in Sec. 921.33(b). However, a state may not propose to add one or more sites to an already designated Reserve if the operation and management of such Reserve has been found deficient and uncorrected or the research conducted is not consistent with the Estuarine Research Guidelines referenced in Sec. 921.51. In addition, Federal funds for the acquisition of a multiple-site Reserve remain limited to $5,000,000 (see Sec. 921.20). The funding for operation of a multiple-site Reserve is limited to the maximum allowed for any one Reserve per year (see Sec. 921.32(c)) and preacquisition funds are limited to $100,000 per Reserve. Notwithstanding the above, when financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, such assistance may be used to pay 100 percent of all actual costs of activities carrier out with this assistance, as long as such funds are available.

Sec. 921.11 Site selection and feasibility.

(a) A coastal state may use Federal funds to establish and implement a site selection process which is approved by NOAA.

(b) In addition to the requirements set forth in subpart I, a request for Federal funds for site selection must contain the following programmatic information: (1) A description of the proposed site selection process and how it will be implemented in conformance with the biogeographic classification scheme and typology (Sec. 921.3); (2) An identification of the site selection agency and the potential management agency; and

(3) A description of how public participation will be incorporated into the process (see Sec. 921.11(d)).

(c) As part of the site selection process, the state and NOAA shall evaluate and select the final site(s). NOAA has final authority in approving such sites. Site selection shall be guided by the following principles:

(1) The site's contribution to the biogeographical and typological balance of the National Estuarine Research Reserve System. NOAA will give priority consideration to proposals to establish Reserves in biogeographic regions or subregions or incorporating types that are not represented in the system. (see the biogeographic classification scheme and typology set forth in Sec. 921.3 and appendices I and II);

(2) The site's ecological characteristics, including its biological productivity, diversity of flora and fauna, and capacity to attract a broad range of research and educational interests. The proposed site must be a representative estuarine ecosystem and should, to the maximum extent possible, be an estuarine ecosystem minimally affected by human activity or influence (see Sec. 921.1(e)).

(3) Assurance that the site's boundaries encompass an adequate portion of the key land and water areas of the natural system to approximate an ecological unit and to ensure effective conservation. Boundary size will vary greatly depending on the nature of the ecosystem. Reserve boundaries must encompass the area within which

adequate control has or will be established by the managing entity over human activities occurring within the Reserve. Generally, Reserve boundaries will encompass two areas: Key land and water areas (or ``core area'') and a buffer zone. Key land and water areas and a buffer zone will likely require significantly different levels of control (see Sec. 921.13(a)(7)). The term ``key land and water areas'' refers to that core area within the Reserve that is so vital to the functioning of the estuarine ecosystem that it must be under a level of control sufficient to ensure the long-term viability of the Reserve for research on natural processes. Key land and water areas, which comprise the core area, are those ecological units of a natural estuarine system which preserve, for research purposes, a full range of significant physical, chemical and biological factors contributing to the diversity of fauna, flora and natural processes occurring within the estuary. The determination of which land and water areas are ``key'' to a particular Reserve must be based on specific scientific knowledge of the area. A basic principle to follow when deciding upon key land and water areas is that they should encompass resources representative of the total ecosystem, and which if compromised could endanger the research objectives of the Reserve. The term buffer zone refers to an area adjacent to or surrounding key land and water areas and essential to their integrity. Buffer zones protect the core area and provide additional protection for estuarine-dependent species, including those that are rare or endangered. When determined appropriate by the state and approved by NOAA, the buffer zone may also include an area necessary for facilities required for research and interpretation. Additionally, buffer zones should be established sufficient to accommodate a shift of the core area as a result of biological, ecological or geomorphological change which reasonably could be expected to occur. National Estuarine Research Reserves may include existing Federal or state lands already in a protected status where mutual benefit can be enhanced. However, NOAA will not approve a site for potential National Estuarine Research Reserve status that is dependent primarily upon the inclusion of currently protected Federal lands in order to meet the requirements for Reserve status (such as key land and water areas). Such lands generally will be included within a Reserve to serve as a buffer or for other ancillary purposes; and may be included, subject to NOAA approval, as a limited portion of the core area;

(4) The site's suitability for long-term estuarine research, including ecological factors and proximity to existing research facilities and educational institutions;

(5) The site's compatibility with existing and potential land and water uses in contiguous areas as well as approved coastal and estuarine management plans; and

(6) The site's importance to education and interpretive efforts, consistent with the need for continued protection of the natural system.

(d) Early in the site selection process the state must seek the views of affected landowners, local governments, other state and Federal agencies and other parties who are interested in the area(s) being considered for selection as a potential National Estuarine Research Reserve. After the local government(s) and affected landowner(s) have been contacted, at least one public meeting shall be held in the vicinity of the proposed site. Notice of such a meeting, including the time, place, and relevant subject matter, shall be announced by the state through the area's principal newspaper at least

15 days prior to the date of the meeting and by NOAA in the Federal Register.

(e) A state request for NOAA approval of a proposed site (or sites in the case of a multi-site Reserve) must contain a description of the proposed site(s) in relationship to each of the site selection principals (Sec. 921.11(c)) and the following information:

(1) An analysis of the proposed site(s) based on the biogeographical scheme/typology discussed in Sec. 921.3 and set forth in appendices I and II;

(2) A description of the proposed site(s) and its (their) major resources, including location, proposed boundaries, and adjacent land uses. Maps are required;

(3) A description of the public participation process used by the state to solicit the views of interested parties, a summary of comments, and, if interstate issues are involved, documentation that the Governor(s) of the other affected state(s) has been contacted. Copies of all correspondence, including contact letters to all affected landowners must be appended;

(4) A list of all sites considered and a brief statement of the reasons why a site was not preferred; and

(5) A nomination of the proposed site(s) for designation as a National Estuarine Research Reserve by the Governor of the coastal state in which the state is located.

(f) A state proposing to reactivate an inactive site, previously approved by NOAA for development as an Estuarine Sanctuary or Reserve, may apply for those funds remaining, if any, provided for site selection and feasibility (Sec. 921.11a)) to determine the feasibility of reactivation. This feasibility study must comply with the requirements set forth in Sec. 921.11 (c) through (e).

Sec. 921.12 Post site selection.

(a) At the time of the coastal state's request for NOAA approval of a proposed site, the state may submit a request for funds to develop the draft management plan and for preparation of the EIS. At this time, the state may also submit a request for the remainder of the predesignation funds to perform a limited basic characterization of the physical, chemical and biological characteristics of the site approved by NOAA necessary for providing EIS information to NOAA. The state's request for these post site selection funds must be accompanied by the information specified in subpart I and, for draft management plan development and EIS information collection, the following programmatic information:

(1) A draft management plan outline (see Sec. 921.13(a) below); and

(2) An outline of a draft memorandum of understanding (MOU) between the state and NOAA detailing the Federal-state role in Reserve management during the initial period of Federal funding and expressing The state's long-term commitment to operate and manage the Reserve.

(b) The state is eligible to use the funds referenced in Sec. 921.12(a) after the proposed site is approved by NOAA under the terms of Sec. 921.11.

Sec. 921.13 Management plan and environmental impact statement development.

(a) After NOAA approves the state's proposed site and application for funds submitted pursuant to Sec. 921.12, the state may begin draft management plan development and the collection of information necessary for the preparation by NOAA of an EIS. The state shall develop a draft management plan, including an MOU. The plan shall set out in detail:

(1) Reserve goals and objectives, management issues, and strategies or actions for meeting the goals and objectives;

(2) An administrative plan including staff roles in administration, research, education/interpretation, and surveillance and enforcement;

(3) A research plan, including a monitoring design;

(4) An education/interpretive plan;

(5) A plan for public access to the Reserve;

(6) A construction plan, including a proposed construction schedule, general descriptions of proposed developments and general cost estimates. Information should be provided for proposed minor construction projects in sufficient detail to allow these projects to begin in the initial phase of acquisition and development. A categorical exclusion, environmental assessment, or EIS may be required prior to construction;

(7)(i) An acquisition plan identifying the ecologically key land and water areas of the Reserve, ranking these areas according to their relative importance, and including a strategy for establishing adequate long-term state control over these areas sufficient to provide protection for Reserve resources to ensure a stable environment for research. This plan must include an identification of ownership within the proposed Reserve boundaries, including land already in the public domain; the method(s) of acquisition which the state proposes to use--acquisition (including less-than-fee simple options) to establish adequate long-term state control; an estimate of the fair market value of any property interest--which is proposed for acquisition; a schedule estimating the time required to complete the process of establishing adequate state control of the proposed research reserve; and a discussion of any anticipated problems. In selecting a preferred method(s) for establishing adequate state control over areas within the proposed boundaries of the Reserve, the state shall perform the following steps for each parcel determined to be part of the key land and water areas (control over which is necessary to protect the integrity of the Reserve for research purposes), and for those parcels required for research and interpretive support facilities or buffer purposes:

(A) Determine, with appropriate justification, the minimum level of control(s) required [e.g., management agreement, regulation, less-than-fee simple property interest (e.g., conservation easement), fee simple property acquisition, or a combination of these approaches]. This does not preclude the future necessity of increasing the level of state control;

(B) Identify the level of existing state control(s);

(C) Identify the level of additional state control(s), if any, necessary to meet the minimum requirements identified in paragraph (a)(7)(i)(A) of this section;

(D) Examine all reasonable alternatives for attaining the level of control identified in paragraph (a)(7)(i)(C) of this section, and perform a cost analysis of each; and

(E) Rank, in order of cost, the methods (including acquisition) identified in paragraph (a)(7)(i)(D) of this section.

(ii) An assessment of the relative cost-effectiveness of control alternatives shall include a reasonable estimate of both short-term

costs (e.g., acquisition of property interests, regulatory program development including associated enforcement costs, negotiation, adjudication, etc.) and long-term costs (e.g., monitoring, enforcement, adjudication, management and coordination). In selecting a preferred method(s) for establishing adequate state control over each parcel examined under the process described above, the state shall give priority consideration to the least costly method(s) of attaining the minimum level of long-term control required. Generally, with the possible exception of buffer areas required for support facilities, the level of control(s) required for buffer areas will be considerably less than that required for key land and water areas. This acquisition plan, after receiving the approval of NOAA, shall serve as a guide for negotiations with landowners. A final boundary for the reserve shall be delineated as a part of the final management plan;

(8) A resource protection plan detailing applicable authorities, including allowable uses, uses requiring a permit and permit requirements, any restrictions on use of the research reserve, and a strategy for research reserve surveillance and enforcement of such use restrictions, including appropriate government enforcement agencies;
(9) If applicable, a restoration plan describing those portions of the site that may require habitat modification to restore natural conditions;

(10) If applicable, a resource manipulation plan, describing those portions of the Reserve buffer in which long-term pre-existing (prior to designation) manipulation for reasons not related to research or restoration is occurring. The plan shall explain in detail the nature of such activities, shall justify why such manipulation should be permitted to continue within the reserve buffer; and shall describe possible effects of this manipulation on key land and water areas and their resources;

(11) A proposed memorandum of understanding (MOU) between the state and NOAA regarding the Federal-state relationship during the establishment and development of the National Estuarine Research Reserve, and expressing a long-term commitment by the state to maintain and manage the Reserve in accordance with section 315 of the Act, 16 U.S.C. 1461, and applicable regulations. In conjunction with the MOU, and where possible under state law, the state will consider taking appropriate administrative or legislative action to ensure the long-term protection and operation of the National Estuarine Research Reserve. If other MOUs are necessary (such as with a Federal agency, another state agency or private organization), drafts of such MOUs must be included in the plan. All necessary MOU's shall be signed prior to Reserve designation; and

(12) If the state has a federally approved coastal management program, a certification that the National Estuarine Research Reserve is consistent to the maximum extent practicable with that program. See Secs. 921.4(b) and 921.30(b).

(b) Regarding the preparation of an EIS under the National Environmental Policy Act on a National Estuarine Research Reserve proposal, the state and NOAA shall collect all necessary information concerning the socioeconomic and environmental impacts associated with implementing the draft management plan and feasible alternatives to the plan. Based on this information, the state will draft and provide NOAA with a preliminary EIS.

(c) Early in the development of the draft management plan and the draft EIS, the state and NOAA shall hold a scoping meeting (pursuant to

NEPA) in the area or areas most affected to solicit public and government comments on the significant issues related to the proposed action. NOAA will publish a notice of the meeting in the Federal Register at least 15 days prior to the meeting. The state shall be responsible for publishing a similar notice in the local media.

(d) NOAA will publish a Federal Register notice of intent to prepare a draft EIS. After the draft EIS is prepared and filed with the Environmental Protection Agency (EPA), a Notice of Availability of the draft EIS will appear in the Federal Register. Not less than 30 days after publication of the notice, NOAA will hold at least one public hearing in the area or areas most affected by the proposed national estuarine research reserve. The hearing will be held no sooner than 15 days after appropriate notice of the meeting has been given in the principal news media by the state and in the Federal Register by NOAA. After a 45-day comment period, a final EIS will be prepared by the state and NOAA.

Subpart C--Acquisition, Development and Preparation of the Final Management Plan

Sec. 921.20 General.

The acquisition and development period is separated into two major phases. After NOAA approval of the site, draft management plan and draft MOU, and completion of the final EIS, a coastal state is eligible for an initial acquisition and development award(s). In this initial phase, the state should work to meet the criteria required for formal research reserve designation; e.g., establishing adequate state control over the key land and water areas as specified in the draft management plan and preparing the final management plan. These requirements are specified in Sec. 921.30. Minor construction in accordance with the draft management plan may also be conducted during this initial phase. The initial acquisition and development phase is expected to last no longer than three years. If necessary, a longer time period may be negotiated between the state and NOAA. After Reserve designation, a state is eligible for a supplemental acquisition and development award(s) in accordance with Sec. 921.31. In this post-designation acquisition and development phase, funds may be used in accordance with the final management plan to construct research and educational facilities, complete any remaining land acquisition, for program development, and for restorative activities identified in the final management plan. In any case, the amount of Federal financial assistance provided to a coastal state with respect to the acquisition of lands and waters, or interests therein, for any one National Estuarine Research Reserve may not exceed an amount equal to 50 percent of the costs of the lands, waters, and interests therein or $5,000,000, whichever amount is less, except when the financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of all actual costs of activities carrier out with this assistance, as long as such funds are available.

Sec. 921.21 Initial acquisition and development awards.

(a) Assistance is provided to aid the recipient prior to designation in:

(1) Acquiring a fee simple or less-than-fee simple real property interest in land and water areas to be included in the Reserve boundaries (see Sec. 921.13(a)(7); Sec. 921.30(d));

(2) Minor construction, as provided in paragraphs (b) and (c) of this section;

(3) Preparing the final management plan; and

(4) Initial management costs, e.g., for implementing the NOAA approved draft management plan, hiring a Reserve manager and other staff as necessary and for other management-related activities. Application procedures are specified in subpart I.

(b) The expenditure of Federal and state funds on major construction activities is not allowed during the initial acquisition and development phase. The preparation of architectural and engineering plans, including specifications, for any proposed construction, or for proposed restorative activities, is permitted. In addition, minor construction activities, consistent with paragraph (c) of this section also are allowed. The NOAA-approved draft management plan must, however, include a construction plan and a public access plan before any award funds can be spent on construction activities.

(c) Only minor construction activities that aid in implementing portions of the management plan (such as boat ramps and nature trails) are permitted during the initial acquisition and development phase. No more than five (5) percent of the initial acquisition and development award may be expended on such activities. NOAA must make a specific determination, based on the final EIS, that the construction activity will not be detrimental to the environment.

(d) Except as specifically provided in paragraphs (a) through (c) of this section, construction projects, to be funded in whole or in part under an acquisition and development award(s), may not be initiated until the Reserve receives formal designation (see Sec. 921.30). This requirement has been adopted to ensure that substantial progress in establishing adequate state control over key land and water areas has been made and that a final management plan is completed before major sums are spent on construction. Once substantial progress in establishing adequate state control/acquisition has been made, as defined by the state in the management plan, other activities guided by the final management plan may begin with NOAA's approval.

(e) For any real property acquired in whole or part with Federal funds for the Reserve, the state shall execute suitable title documents to include substantially the following provisions, or otherwise append the following provisions in a manner acceptable under applicable state law to the official land record(s):

(1) Title to the property conveyed by this deed shall vest in the [recipient of the award granted pursuant to section 315 of the Act, 16 U.S.C. 1461 or other NOAA approved state agency] subject to the condition that the designation of the [name of National Estuarine Reserve] is not withdrawn and the property remains part of the federally designated [name of National Estuarine Research Reserve]; and

(2) In the event that the property is no longer included as part of the Reserve, or if the designation of the Reserve of which it is part is withdrawn, then NOAA or its successor agency, after full and reasonable consultation with the State, may exercise the following rights regarding the disposition of the property:

(i) The recipient may retain title after paying the Federal

Government an amount computed by applying the Federal percentage of participation in the cost of the original project to the current fair market value of the property;

(ii) If the recipient does not elect to retain title, the Federal Government may either direct the recipient to sell the property and pay the Federal Government an amount computed by applying the Federal percentage of participation in the cost of the original project to the proceeds from the sale (after deducting actual and reasonable selling and repair or renovation expenses, if any, from the sale proceeds), or direct the recipient to transfer title to the Federal Government. If directed to transfer title to the Federal Government, the recipient shall be entitled to compensation computed by applying the recipient's percentage of participation in the cost of the original project to the current fair market value of the property; and

(iii) Fair market value of the property must be determined by an independent appraiser and certified by a responsible official of the state, as provided by Department of Commerce regulations at 15 CFR part 24, and Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally assisted programs at 15 CFR part 11.

(f) Upon instruction by NOAA, provisions analogous to those of Sec. 921.21(e) shall be included in the documentation underlying less-then-fee-simple interests acquired in whole or part with Federal funds.

(g) Federal funds or non-Federal matching share funds shall not be spent to acquire a real property interest in which the state will own the land concurrently with another entity unless the property interest has been identified as a part of an acquisition strategy pursuant to Sec. 921.13(7) which has been approved by NOAA prior to the effective date of these regulations.

(h) Prior to submitting the final management plan to NOAA for review and approval, the state shall hold a public meeting to receive comment on the plan in the area affected by the estuarine research reserve. NOAA will publish a notice of the meeting in the Federal Register at least 15 days prior to the public meeting. The state shall be responsible for having a similar notice published in the local newspaper(s).

Subpart D--Reserve Designation and Subsequent Operation

Sec. 921.30 Designation of National Estuarine Research Reserves.

(a) The Under Secretary may designate an area proposed for designation by the Governor of the state in which it is located, as a National Estuarine Research Reserve if the Under Secretary finds:

(1) The area is a representative estuarine ecosystem that is suitable for long-term research and contributes to the biogeographical and typological balance of the System;

(2) Key land and water areas of the proposed Reserve, as identified in the management plan, are under adequate state control sufficient to provide long-term protection for reserve resources to ensure a stable environment for research;

(3) Designation of the area as a Reserve will serve to enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation;

(4) A final management plan has been approved by NOAA;

(5) An MOU has been signed between the state and NOAA ensuring a long-term commitment by the state to the effective operation and implementation of the area as a National Estuarine Research Reserve;

(6) All MOU's necessary for reserve management (i.e., with relevant Federal, state, and local agencies and/or private organizations) have been signed; and

(7) The coastal state in which the area is located has complied with the requirements of subpart B.

(b) NOAA will determine whether the designation of a National Estuarine Research Reserve in a state with a federally approved coastal zone management program directly affects the coastal zone. If the designation is found to directly affect the coastal zone, NOAA will make a consistency determination pursuant to Sec. 307(c)(1) of the Act, 16 U.S.C. 1456, and 15 CFR part 930, subpart C. See Sec. 921.4(b). The results of this consistency determination will be published in the Federal Register when the notice of designation is published. See Sec. 921.30(c).

(c) NOAA will publish the notice of designation of a National Estuarine Research Reserve in the Federal Register. The state shall be responsible for having a similar notice published in the local media.

(d) The term state control in Sec. 921.30(a)(3) does not necessarily require that key land and water areas be owned by the state in fee simple. Acquisition of less-than-fee simple interests e.g., conservation easements) and utilization of existing state regulatory measures are encouraged where the state can demonstrate that these interests and measures assure adequate long-term state control consistent with the purposes of the research reserve (see also Secs. 921.13(a)(7); 921.21(g)). Should the state later elect to purchase an interest in such lands using NOAA funds, adequate justification as to the need for such acquisition must be provided to NOAA.

Sec. 921.31 Supplemental acquisition and development awards.

After National Estuarine Research Reserve designation, and as specified in the approved management plan, a coastal state may request a supplemental acquisition and/or development award(s) for acquiring additional property interests identified in the management plan as necessary to strengthen protection of key land and water areas and to enhance long-term protection of the area for research and education, for facility and exhibit construction, for restorative activities identified in the approved management plan, for administrative purposes related to acquisition and/or facility construction and to develop and/or upgrade research, monitoring and education/interpretive programs. Federal financial assistance provided to a National Estuarine Research Reserve for supplemental development costs directly associated with facility construction (i.e., major construction activities) may not exceed 70 percent of the total project cost, except when the financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of the costs. NOAA must make a specific determination that the construction activity will not be detrimental to the environment.

Acquisition awards for the acquisition of lands or waters, or interests therein, for any one reserve may not exceed an amount equal to 50 percent of the costs of the lands, waters, and interests therein of $5,000,000, whichever amount is less, except when the financial assistance is provided from amounts recovered as result of damage to

natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of all actual costs of activities carrier out with this assistance, as long as such funds are available. In the case of a biogeographic region (see appendix I) shared by two or more states, each state is eligible independently for Federal financial assistance to establish a separate National Estuarine Research Reserve within their respective portion of the shared biogeographic region. Application procedures are specified in subpart I. Land acquisition must follow the procedures specified in Secs. 921.13(a)(7), 921.21(e) and (f) and 921.81.

Sec. 921.32 Operation and management: Implementation of the management plan.

(a) After the Reserve is formally designated, a coastal state is eligible to receive Federal funds to assist the state in the operation and management of the Reserve including the management of research, monitoring, education, and interpretive programs. The purpose of this Federally funded operation and management phase is to implement the approved final management plan and to take the necessary steps to ensure the continued effective operation of the Reserve.

(b) State operation and management of the Reserves shall be consistent with the mission, and shall further the goals of the National Estuarine Research Reserve program (see Sec. 921.1).

(c) Federal funds are available for the operation and management of the Reserve. Federal funds provided pursuant to this section may not exceed 70 percent of the total cost of operating and managing the Reserve for any one year, except when the financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of the costs. In the case of a biogeographic region (see Appendix I) shared by two or more states, each state is eligible for Federal financial assistance to establish a separate Reserve within their respective portion of the shared biogeographic region (see Sec. 921.10).

(d) Operation and management funds are subject to the following limitations:

(1) Eligible coastal state agencies may apply for up to the maximum share available per Reserve for that fiscal year. Share amounts will be announced annually by letter from the Sanctuary and Reserves Division to all participating states. This letter will be provided as soon as practicable following approval of the Federal budget for that fiscal year.

(2) No more than ten percent of the total amount (state and Federal shares) of each operation and management award may be used for construction-type activities.

Sec. 921.33 Boundary changes, amendments to the management plan, and addition of multiple-site components.

(a) Changes in the boundary of a Reserve and major changes to the final management plan, including state laws or regulations promulgated specifically for the Reserve, may be made only after written approval by NOAA. NOAA may require public notice, including notice in the Federal Register and an opportunity for public comment before approving a boundary or management plan change. Changes in the boundary of a

Reserve involving the acquisition of properties not listed in the management plan or final EIS require public notice and the opportunity for comment; in certain cases, a categorical exclusion, an environmental assessment and possibly an environmental impact statement may be required.

NOAA will place a notice in the Federal Register of any proposed changes in Reserve boundaries or proposed major changes to the final management plan. The state shall be responsible for publishing an equivalent notice in the local media. See also requirements of Secs. 921.4(b) and 921.13(a)(11).

(b) As discussed in Sec. 921.10(b), a state may choose to develop a multiple-site National Estuarine Research Reserve after the initial acquisition and development award for a single site has been made. NOAA will publish notice of the proposed new site including an invitation for comments from the public in the Federal Register. The state shall be responsible for publishing an equivalent notice in the local newspaper(s). An EIS, if required, shall be prepared in accordance with section Sec. 921.13 and shall include an administrative framework for the multiple-site Reserve and a description of the complementary research and educational programs within the Reserve. If NOAA determines, based on the scope of the project and the issues associated with the additional site(s), that an environmental assessment is sufficient to establish a multiple-site Reserve, then the state shall develop a revised management plan which, concerning the additional component, incorporates each of the elements described in Sec. 921.13(a). The revised management plan shall address goals and objectives for all components of the multi-site Reserve and the additional component's relationship to the original site(s).

(c) The state shall revise the management plan for a Reserve at least every five years, or more often if necessary. Management plan revisions are subject to (a) above.

(d) NOAA will approve boundary changes, amendments to management plans, or the addition of multiple-site components, by notice in the Federal Register. If necessary NOAA will revise the designation document (findings) for the site.

Subpart E--Ongoing Oversight, Performance Evaluation and Withdrawal of Designation

Sec. 921.40 Ongoing oversight and evaluations of designated National Estuarine Research Reserves.

(a) The Sanctuaries and Reserve Division shall conduct, in accordance with section 312 of the Act and procedures set forth in 15 CFR part 928, ongoing oversight and evaluations of Reserves. Interim sanctions may be imposed in accordance with regulations promulgated under 15 CFR part 928.

(b) The Assistant Administrator may consider the following indicators of non-adherence in determining whether to invoke interim sanctions:

(1) Inadequate implementation of required staff roles in administration, research, education/interpretation, and surveillance and enforcement. Indicators of inadequate implementation could include: No Reserve Manager, or no staff or insufficient staff to carry out the required functions.

(2) Inadequate implementation of the required research plan, including the monitoring design. Indicators of inadequate implementation could include: Not carrying out research or monitoring that is required by the plan, or carrying out research or monitoring that is inconsistent with the plan.

(3) Inadequate implementation of the required education/interpretation plan. Indicators of inadequate implementation could include: Not carrying out education or interpretation that is required by the plan, or carrying out education/interpretation that is inconsistent with the plan.

(4) Inadequate implementation of public access to the Reserve. Indicators of inadequate implementation of public access could include: Not providing necessary access, giving full consideration to the need to keep some areas off limits to the public in order to protect fragile resources.

(5) Inadequate implementation of facility development plan. Indicators of inadequate implementation could include: Not taking action to propose and budget for necessary facilities, or not undertaking necessary construction in a timely manner when funds are available.

(6) Inadequate implementation of acquisition plan. Indicators of inadequate implementation could include: Not pursuing an aggressive acquisition program with all available funds for that purpose, not requesting promptly additional funds when necessary, and evidence that adequate long-term state control has not been established over some core or buffer areas, thus jeopardizing the ability to protect the Reserve site and resources from offsite impacts.

(7) Inadequate implementation of Reserve protection plan. Indicators of inadequate implementation could include: Evidence of non-compliance with Reserve restrictions, insufficient surveillance and enforcement to assure that restrictions on use of the Reserve are adhered to, or evidence that Reserve resources are being damaged or destroyed as a result of the above.

(8) Failure to carry out the terms of the signed Memorandum of Understanding (MOU) between the state and NOAA, which establishes a long-term state commitment to maintain and manage the Reserve in accordance with section 315 of the Act. Indicators of failure could include: State action to allow incompatible uses of state-controlled lands or waters in the Reserve, failure of the state to bear its fair share of costs associated with long-term operation and management of the Reserve, or failure to initiate timely updates of the MOU when necessary.

Sec. 921.41 Withdrawal of designation.

The Assistant Administrator may withdraw designation of an estuarine area as a National Estuarine Research Reserve pursuant to and in accordance with the procedures of section 312 and 315 of the Act and regulations promulgated thereunder.

Subpart F--Special Research Projects

Sec. 921.50 General.

(a) To stimulate high quality research within designated National

Estuarine Research Reserves, NOAA may provide financial support for research projects which are consistent with the Estuarine Research Guidelines referenced in Sec. 921.51. Research awards may be awarded under this subpart to only those designated Reserves with approved final management plans. Although research may be conducted within the immediate watershed of the Reserve, the majority of research activities of any single research project funded under this subpart may be conducted within Reserve boundaries. Funds provided under this subpart are primarily used to support management-related research projects that will enhance scientific understanding of the Reserve ecosystem, provide information needed by Reserve management and coastal management decision-makers, and improve public awareness and understanding of estuarine ecosystems and estuarine management issues. Special research projects may be oriented to specific Reserves; however, research projects that would benefit more than one Reserve in the National Estuarine Reserve Research System are encouraged.

(b) Funds provided under this subpart are available on a competitive basis to any coastal state or qualified public or private person. A notice of available funds will be published in the Federal Register. Special research project funds are provided in addition to any other funds available to a coastal state under the Act. Federal funds provided under this subpart may not exceed 70 percent of the total cost of the project, consistent with Sec. 921.81(e)(4) (``allowable costs''), except when the financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of the costs.

Sec. 921.51 Estuarine research guidelines.

(a) Research within the National Estuarine Research Reserve System shall be conducted in a manner consistent with Estuarine Research Guidelines developed by NOAA.

(b) A summary of the Estuarine Research Guidelines is published in the Federal Register as a part of the notice of available funds discussed in Sec. 921.50(c).

(c) The Estuarine Research Guidelines are reviewed annually by NOAA. This review will include an opportunity for comment by the estuarine research community.

Sec. 921.52 Promotion and coordination of estuarine research.

(a) NOAA will promote and coordinate the use of the National Estuarine Research Reserve System for research purposes.

(b) NOAA will, in conducting or supporting estuarine research other than that authorized under section 315 of the Act, give priority consideration to research that make use of the National Estuarine Research Reserve System.

(c) NOAA will consult with other Federal and state agencies to promote use of one or more research reserves within the National Estuarine Research Reserve System when such agencies conduct estuarine research.

Subpart G--Special Monitoring Projects

Sec. 921.60 General.

(a) To provide a systematic basis for developing a high quality estuarine resource and ecosystem information base for National Estuarine Research Reserves and, as a result, for the System, NOAA may provide financial support for basic monitoring programs as part of operations and management under Sec. 921.32. Monitoring funds are used to support three major phases of a monitoring program:

(1) Studies necessary to collect data for a comprehensive site description/characterization;

(2) Development of a site profile; and

(3) Formulation and implementation of a monitoring program.

(b) Additional monitoring funds may be available on a competitive basis to the state agency responsible for Reserve management or a qualified public or private person or entity. However, if the applicant is other than the managing entity of a Reserve that applicant must submit as a part of the application a letter from the Reserve manager indicating formal support of the application by the managing entity of the Reserve. Funds provided under this subpart for special monitoring projects are provided in addition to any other funds available to a coastal state under the Act. Federal funds provided under this subpart may not exceed 70 percent of the total cost of the project, consistent with Sec. 921.81(e)(4) (``allowable costs''), except when the financial assistance is provided from amounts recovered as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of the costs.

(c) Monitoring projects funded under this subpart must focus on the resources within the boundaries of the Reserve and must be consistent with the applicable sections of the Estuarine Research Guidelines referenced in Sec. 921.51. Portions of the project may occur within the immediate watershed of the Reserve beyond the site boundaries. However, the monitoring proposal must demonstrate why this is necessary for the success of the project.

Subpart H--Special Interpretation and Education Projects

Sec. 921.70 General.

(a) To stimulate the development of innovative or creative interpretive and educational projects and materials to enhance public awareness and understanding of estuarine areas, NOAA may fund special interpretive and educational projects in addition to those activities provided for in operations and management under Sec. 921.32. Special interpretive and educational awards may be awarded under this subpart to only those designated Reserves with approved final management plans.

(b) Funds provided under this subpart may be available on a competitive basis to any state agency. However, if the applicant is other than the managing entity of a Reserve, that applicant must submit as a part of the application a letter from the Reserve manager indicating formal support of the application by the managing entity of the Reserve. These funds are provided in addition to any other funds available to a coastal state under the Act. Federal funds provided under this subpart may not exceed 70 percent of the total cost of the project, consistent with Sec. 921.81(e)(4) (``allowable costs''), except when the financial assistance is provided from amounts recovered

as a result of damage to natural resources located in the coastal zone, in which case the assistance may be used to pay 100 percent of the costs.

(c) Applicants for education/interpretive projects that NOAA determines benefit the entire National Estuarine Research Reserve System may receive Federal assistance of up to 100% of project costs.

Subpart I--General Financial Assistance Provisions

Sec. 921.80 Application information.

(a) Only a coastal state may apply for Federal financial assistance awards for preacquisition, acquisition and development, operation and management, and special education and interpretation projects under subpart H. Any coastal state or public or private person may apply for Federal financial assistance awards for special estuarine research or monitoring projects under subpart G. The announcement of opportunities to conduct research in the System appears on an annual basis in the Federal Register. If a state is participating in the national Coastal Zone Management Program, the applicant for an award under section 315 of the Act shall notify the state coastal management agency regarding the application.

(b) An original and two copies of the formal application must be submitted at least 120 working days prior to the proposed beginning of the project to the following address: Sanctuaries and Reserves Division Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, 1825 Connecticut Avenue, NW., suite 714, Washington, DC 20235. Application for Federal Assistance Standard Form 424 (Non-construction Program) constitutes the formal application for site selection, post-site selection, operation and management, research, and education and interpretive awards. The Application for Federal Financial Assistance Standard Form 424 (Construction Program) constitutes the formal application for land acquisition and development awards. The application must be accompanied by the information required in subpart B (predesignation), subpart C and Sec. 921.31 (acquisition and development), and Sec. 921.32 (operation and management) as applicable. Applications for development awards for construction projects, or restorative activities involving construction, must include a preliminary engineering report, a detailed construction plan, a site plan, a budget and categorical exclusion check list or environmental assessment. All applications must contain back up data for budget estimates (Federal and non-Federal shares), and evidence that the application complies with the Executive Order 12372, ``Intergovernmental Review of Federal Programs.'' In addition, applications for acquisition and development awards must contain:

(1) State Historic Preservation Office comments;

(2) Written approval from NOAA of the draft management plan for initial acquisition and development award(s); and

(3) A preliminary engineering report for construction activities.

Sec. 921.81 Allowable costs.

(a) Allowable costs will be determined in accordance with applicable OMB Circulars and guidance for Federal financial assistance, the financial assistant agreement, these regulations, and other

Department of Commerce and NOAA directives. The term ``costs'' applies to both the Federal and non-Federal shares.

(b) Costs claimed as charges to the award must be reasonable, beneficial and necessary for the proper and efficient administration of the financial assistance award and must be incurred during the award period.

(c) Costs must not be allocable to or included as a cost of any other Federally-financed program in either the current or a prior award period.

(d) General guidelines for the non-Federal share are contained in Department of Commerce Regulations at 15 CFR part 24 and OMB Circular A-110. Copies of Circular A-110 can be obtained from the Sanctuaries and Reserves Division; 1825 Connecticut Avenue, NW., suite 714; Washington, DC 20235. The following may be used in satisfying the matching requirement:

(1) Site selection and post site selection awards. Cash and in-kind contributions (value of goods and services directly benefiting and specifically identifiable to this part of the project) are allowable. Land may not be used as match.

(2) Acquisition and development awards. Cash and in-kind contributions are allowable. In general, the fair market value of lands to be included within the Reserve boundaries and acquired pursuant to the Act, with other than Federal funds, may be used as match. However, the fair market value of real property allowable as match is limited to the fair market value of a real property interest equivalent to, or required to attain, the level of control over such land(s) identified by the state and approved by the Federal Government as that necessary for the protection and management of the National Estuarine Research Reserve. Appraisals must be performed according to Federal appraisal standards as detailed in Department of Commerce regulations at 15 CFR part 24 and the Uniform Relocation Assistance and Real Property Acquisition for Federal land Federally assisted programs in 15 CFR part 11. The fair market value of privately donated land, at the time of donation, as established by an independent appraiser and certified by a responsible official of the state, pursuant to 15 CFR part 11, may also be used as match. Land, including submerged lands already in the state's possession, may be used as match to establish a National Estuarine Research Reserve. The value of match for these state lands will be calculated by determining the value of the benefits foregone by the state, in the use of the land, as a result of new restrictions that may be imposed by Reserve designation. The appraisal of the benefits foregone must be made by an independent appraiser in accordance with Federal appraisal standards pursuant to 15 CFR part 24 and 15 CFR part 11. A state may initially use as match land valued at greater than the Federal share of the acquisition and development award. The value in excess of the amount required as match for the initial award may be used to match subsequent supplemental acquisition and development awards for the National Estuarine Research Reserve (see also Sec. 921.20). Costs related to land acquisition, such as appraisals, legal fees and surveys, may also be used as match.

(3) Operation and management awards. Generally, cash and in-kind contributions (directly benefiting and specifically identifiable to operations and management), except land, are allowable.

(4) Research, monitoring, education and interpretive awards. Cash and in-kind contributions (directly benefiting and specifically identifiable to the scope of work), except land, are allowable.

Sec. 921.82 Amendments to financial assistance awards.

Actions requiring an amendment to the financial assistance award, such as a request for additional Federal funds, revisions of the approved project budget or original scope of work, or extension of the performance period must be submitted to NOAA on Standard Form 424 and approved in writing.

Appendix I to Part 921-- Biogeographic Classification Scheme

Acadian

1. Northern of Maine (Eastport to the Sheepscot River.)
2. Southern Gulf of Maine (Sheepscot River to Cape Cod.)

Virginian

3. Southern New England (Cape Cod to Sandy Hook.)
4. Middle Atlantic (Sandy Hook to Cape Hatteras.)
5. Chesapeake Bay.

Carolinian

6. North Carolinas (Cape Hatteras to Santee River.)
7. South Atlantic (Santee River to St. John's River.)
8. East Florida (St. John's River to Cape Canaveral.)

West Indian

9. Caribbean (Cape Canaveral to Ft. Jefferson and south.)
10. West Florida (Ft. Jefferson to Cedar Key.)

Louisianian

11. Panhandle Coast (Cedar Key to Mobile Bay.)
12. Mississippi Delta (Mobile Bay to Galveston.)
13. Western Gulf (Galveston to Mexican border.)

Californian

14. Southern California (Mexican border to Point Conception.)
15. Central California (Point Conception to Cape Mendocino.)
16. San Francisco Bay.

Columbian

17. Middle Pacific (Cape Mendocino to the Columbia River.)
18. Washington Coast (Columbia River to Vancouver Island.)
19. Puget Sound.

Great Lakes

20. Lake Superior (including St. Mary's River.)
21. Lakes Michigan and Huron (including Straits of Mackinac, St. Clair River, and Lake St. Clair.)

22. Lake Erie (including Detroit River and Niagara Falls.)
23. Lake Ontario (including St. Lawrence River.)

Fjord

24. Southern Alaska (Prince of Wales Island to Cook Inlet.)
25. Aleutian Island (Cook Inlet Bristol Bay.)

Sub-Arctic

26. Northern Alaska (Bristol Bay to Damarcation Point.)

Insular

27. Hawaiian Islands.
28. Western Pacific Island.
29. Eastern Pacific Island.

Appendix II to Part 921-- Typology of National Estuarine Research Reserves

This typology system reflects significant differences in estuarine characteristics that are not necessarily related to regional location. The purpose of this type of classification is to maximize ecosystem variety in the selection of national estuarine reserves. Priority will be given to important ecosystem types as yet unrepresented in the reserve system. It should be noted that any one site may represent several ecosystem types or physical characteristics.

Class I--Ecosystem Types

Group I--Shorelands

A. Maritime Forest-Woodland. That have developed under the influence of salt spray. It can be found on coastal uplands or recent features such as barrier islands and beaches, and may be divided into the following biomes:

1. Northern coniferous forest biome: This is an area of predominantly evergreens such as the sitka spruce (Picea), grand fir (Abies), and white cedar (Thuja), with poor development of the shrub and herb leyera, but high annual productivity and pronounced seasonal periodicity.

2. Moist temperate (Mesothermal) coniferous forest biome: Found along the west coast of North America from California to Alaska, this area is dominated by conifers, has relatively small seasonal range, high humidity with rainfall ranging from 30 to 150 inches, and a well-developed understory of vegetation with an abundance of mosses and other moisture-tolerant plants.

3. Temperate deciduous forest biome: This biome is characterized by abundant, evenly distributed rainfall, moderate temperatures which exhibit a distinct seasonal pattern, well-developed soil biota and herb and shrub layers, and numerous plants which produce pulpy fruits and nuts. A distinct subdivision of this biome is the pine edible forest of the southeastern coastal plain, in which only a small portion of the

area is occupied by climax vegetation, although it has large areas covered by edaphic climax pines.

4. Broad-leaved evergreen subtropical forest biome: The main characteristic of this biome is high moisture with less pronounced differences between winter and summer. Examples are the hammocks of Florida and the live oak forests of the Gulf and South Atlantic coasts. Floral dominants include pines, magnolias, bays, hollies, wild tamarine, strangler fig, gumbo limbo, and palms.

B. Coast shrublands. This is a transitional area between the coastal grasslands and woodlands and is characterized by woody species with multiple stems and a few centimeters to several meters above the ground developing under the influence of salt spray and occasional sand burial. This includes thickets, scrub, scrub savanna, heathlands, and coastal chaparral. There is a great variety of shrubland vegetation exhibiting regional specificity:

1. Northern areas: Characterized by Hudsonia, various erinaceous species, and thickets of Myricu, prunus, and Rosa.
2. Southeast areas: Floral dominants include Myrica, Baccharis, and Iles.
3. Western areas: Adenostoma, arcotyphylos, and eucalyptus are the dominant floral species.

C. Coastal grasslands. This area, which possesses sand dunes and coastal flats, has low rainfall (10 to 30 inches per year) and large amounts of humus in the soil. Ecological succession is slow, resulting in the presence of a number of seral stages of community development. Dominant vegetation includes mid-grasses (5 to 8 feet tall), such as Spartina, and trees such as willow (Salix sp.), cherry (Prunus sp.), and cottonwood (Pupulus deltoides.) This area is divided into four regions with the following typical strand vegetation:

1. Arctic/Boreal: Elymus;
2. Northeast/West: Ammophla;
3. Southeast Gulf: Uniola; and
4. Mid-Atlantic/Gulf: Spartina patens.

D. Coastal tundra. This ecosystem, which is found along the Arctic and Boreal coasts of North America, is characterized by low temperatures, a short growing season, and some permafrost, producing a low, treeless mat community made up of mosses, lichens, heath, shrubs, grasses, sedges, rushes, and herbaceous and dwarf woody plants. Common species include arctic/alpine plants such as Empetrum nigrum and Betula nana, the lichens Cetraria and Cladonia, and herbaceous plants such as Potentilla tridentata and Rubus chamaemorus. Common species on the coastal beach ridges of the high arctic desert include Bryas intergrifolia and Saxifrage oppositifolia. This area can be divided into two main subdivisions:

1. Low tundra: Characterized by a thick, spongy mat of living and undecayed vegetation, often with water and dotted with ponds when not frozen; and
2. High Tundra: A bare area except for a scanty growth of lichens and grasses, with underlaying ice wedges forming raised polygonal areas.

E. Coastal cliffs. This ecosystem is an important nesting site for many sea and shore birds. It consists of communities of herbaceous, graminoid, or low woody plants (shrubs, heath, etc.) on the top or along rocky faces exposed to salt spray. There is a diversity of plant

species including mosses, lichens, liverworts, and ``higher'' plant representatives.

Group II--Transition Areas

A. Coastal marshes. These are wetland areas dominated by grasses (Poacea), sedges (Cyperaceae), rushes (Juncaceae), cattails Typhaceae), and other graminoid species and is subject to periodic flooding by either salt or freshwater. This ecosystem may be subdivided into: (a) Tidal, which is periodically flooded by either salt or brackish water; (b) nontidal (freshwater); or (c) tidal freshwater. These are essential habitats for many important estuarine species of fish and invertebrates as well as shorebirds and waterfowl and serve important roles in shore stabilization, flood control, water purification, and nutrient transport and storage.

B. Coastal swamps. These are wet lowland areas that support mosses and shrubs together with large trees such as cypress or gum.

C. Coastal mangroves. This ecosystem experiences regular flooding on either a daily, monthly, or seasonal basis, has low wave action, and is dominated by a variety of salt-tolerant trees, such as the red mangrove (Rhizophora mangle), black mangrove (Avicennia Nitida), and the white mangrove (Laguncularia racemosa.) It is also an important habitat for large populations of fish, invertebrates, and birds. This type of ecosystem can be found from central Florida to extreme south Texas to the islands of the Western Pacific.

D. Intertidal beaches. This ecosystem has a distinct biota of microscopic animals, bacteria, and unicellular algae along with macroscopic crustaceans, mollusks, and worms with a detritus-based nutrient cycle. This area also includes the driftline communities found at high tide levels on the beach. The dominant organisms in this ecosystem include crustaceans such as the mole crab (Emerita), amphipods (Gammeridae), ghost crabs (Ocypode), and bivalve mollusks such as the coquina (Donax) and surf clams (Spisula and Mactra.)

E. Intertidal mud and sand flats. These areas are composed of unconsolidated, high organic content sediments that function as a short-term storage area for nutrients and organic carbons. Macrophytes are nearly absent in this ecosystem, although it may be heavily colonized by benthic diatoms, dinoflaggellates, filamintous blue-green and green algae, and chaemosynthetic purple sulfur bacteria. This system may support a considerable population of gastropods, bivalves, and polychaetes, and may serve as a feeding area for a variety of fish and wading birds. In sand, the dominant fauna include the wedge shell Donax, the scallop Pecten, tellin shells Tellina, the heart urchin Echinocardium, the lug worm Arenicola, sand dollar Dendraster, and the sea pansy Renilla. In mud, faunal dominants adapted to low oxygen levels include the terebellid Amphitrite, the boring clam Playdon, the deep sea scallop Placopecten, the Quahog Mercenaria, the echiurid worm Urechis, the mud snail Nassarius, and the sea cucumber Thyone.

F. Intertidal algal beds. These are hard substrates along the marine edge that are dominated by macroscopic algae, usually thalloid, but also filamentous or unicellular in growth form. This also includes the rocky coast tidepools that fall within the intertidal zone. Dominant fauna of these areas are barnacles, mussels, periwinkles, anemones, and chitons.

Three regions are apparent:

1. Northern latitude rocky shores: It is in this region that the community structure is best developed. The dominant algal species

include Chondrus at the low tide level, Fucus and Ascophylium at the mid-tidal level, and Laminaria and other kelplike algae just beyond the intertidal, although they can be exposed at extremely low tides or found in very deep tidepools.

2. Southern latitudes: The communities in this region are reduced in comparison to those of the northern latitudes and possesses algae consisting mostly of single-celled or filamentour green, blue-green, and red algae, and small thalloid brown algae.

3. Tropical and subtropical latitudes: The intertidal in this region is very reduced and contains numerous calcareous algae such as Porolithon and Lithothamnion, as well and green algae with calcareous particles such as Halimeda, and numerous other green, red, and brown algae.

Group III--Submerged Bottoms

A. Subtidal hardbottoms. This system is characterized by a consolidated layer of solid rock or large pieces of rock (neither of biotic origin) and is found in association with geomorphological features such as submarine canyons and fjords and is usually covered with assemblages of sponges, sea fans, bivalves, hard corals, tunicates, and other attached organisms. A significant feature of estuaries in many parts of the world is the oyster reef, a type of subtidal hardbottom. Composed of assemblages of organisms (usually bivalves), it is usually found near an estuary's mouth in a zone of moderate wave action, salt content, and turbidity. If light levels are sufficient, a covering of microscopic and attached macroscopic algae, such as keep, may also be found.

B. Subtidal softbottoms. Major characteristics of this ecosystem are an unconsolidated layer of fine particles of silt, sand, clay, and gravel, high hydrogen sulfide levels, and anaerobic conditions often existing below the surface. Macrophytes are either sparse or absent, although a layer of benthic microalgae may be present if light levels are sufficient. The faunal community is dominated by a diverse population of deposit feeders including polychaetes, bivalves, and burrowing crustaceans.

C. Subtidal plants. This system is found in relatively shallow water (less than 8 to 10 meters) below mean low tide. It is an area of extremely high primary production that provides food and refuge for a diversity of faunal groups, especially juvenile and adult fish, and in some regions, manatees and sea turtles. Along the North Atlantic and Pacific coasts, the seagrass Zostera marina predominates. In the South Atlantic and Gulf coast areas, Thalassia and Diplanthera predominate. The grasses in both areas support a number of epiphytic organisms.

Class II--Physical Characteristics

Group I--Geologic

A. Basin type. Coastal water basins occur in a variety of shapes, sizes, depths, and appearances. The eight basic types discussed below ill cover most of the cases:

1. Exposed coast: Solid rock formations or heavy sand deposits characterize exposed ocean shore fronts, which are subject to the full force of ocean storms. The sand beaches are very resilient, although the dunes lying just behind the beaches are fragile and easily damaged.

The dunes serve as a sand storage area making them chief stabilizers of the ocean shorefront.

2. Sheltered coast: Sand or coral barriers, built up by natural forces, provide sheltered areas inside a bar or reef where the ecosystem takes on many characteristics of confined waters-abundant marine grasses, shellfish, and juvenile fish. Water movement is reduced, with the consequent effects pollution being more severe in this area than in exposed coastal areas.

3. Bay: Bays are larger confined bodies of water that are open to the sea and receive strong tidal flow. When stratification is pronounced the flushing action is augmented by river discharge. Bays vary in size and in type of shorefront.

4. Embayment: A confined coastal water body with narrow, restricted inlets and with a significant freshwater inflow can be classified as an embayment. These areas have more restricted inlets than bays, are usually smaller and shallower, have low tidal action, and are subject to sedimentation.

5. Tidal river: The lower reach of a coastal river is referred to as a tidal river. The coastal water segment extends from the sea or estuary into which the river discharges to a point as far upstream as there is significant salt content in the water, forming a salt front. A combination of tidal action and freshwater outflow makes tidal rivers well-flushed. The tidal river basin may be a simple channel or a complex of tributaries, small associated embayments, marshfronts, tidal flats, and a variety of others.

6. Lagoon: Lagoons are confined coastal bodies of water with restricted inlets to the sea and without significant freshwater inflow. Water circulation is limited, resulting in a poorly flushed, relatively stagnant body of water. Sedimentation is rapid with a great potential for basin shoaling. Shores are often gently sloping and marshy.

7. Perched coastal wetlands: Unique to Pacific islands, this wetland type found above sea level in volcanic crater remnants forms as a result of poor drainage characteristics of the crater rather than from sedimentation. Floral assemblages exhibit distinct zonation while the faunal constituents may include freshwater, brackish, and/or marine species. Example: Aunu's Island, American Samoa.

8. Anchialine systems: These small coastal exposures of brackish water form in lava depressions or elevated fossil reefs have only a subsurface connection in the ocean, but show tidal fluctuations. Differing from true estuaries in having no surface continuity with streams or ocean, this system is characterized by a distinct biotic community dominated by benthis algae such as Rhizoclonium, the mineral encrusting Schiuzothrix, and the vascular plant Ruppia maritima. Characteristic fauna which exhibit a high degree of endemicity, include the mollusks Theosoxus neglectus and Tcariosus. Although found throughout the world, the high islands of the Pacific are the only areas within the U.S. where this system can be found.

B. Basin structure. Estuary basins may result from the drowning of a river valley (coastal plains estuary), the drowning of a glacial valley (fjord), the occurrence of an offshore barrier (bar-bounded estuary), some tectonic process (tectonic estuary), or volcanic activity (volcanic estuary).

1. Coastal plains estuary: Where a drowned valley consists mainly of a single channel, the form of the basin is fairly regular forming a simple coastal plains estuary. When a channel is flooded with numerous tributaries an irregular estuary results. Many estuaries of the eastern United States are of this type.

2. Fjord: Estuaries that form in elongated steep headlands that alternate with deep U-shaped valleys resulting from glacial scouring are called fjords. They generally possess rocky floors or very thin veneers of sediment, with deposition generally being restricted to the head where the main river enters. Compared to total fjord volume river discharge is small. But many fjords have restricted tidal ranges at their mouths due to sills, or upreaching sections of the bottom which limit free movement of water, often making river flow large with respect to the tidal prism. The deepest portions are in the upstream reaches, where maximum depths can range from 800m to 1200m while sill depths usually range from 40m to 150m.

3. Bar-bounded estuary: These result from the development of an offshore barrier such as a beach strand, a line of barrier islands, reef formations a line of moraine debris, or the subsiding remnants of a deltaic lobe. The basin is often partially exposed at low tide and is enclosed by a chain of offshore bars of barrier islands broken at intervals by inlets. These bars may be either deposited offshore or may be coastal dunes that have become isolated by recent seal level rises.

4. Tectonic estuary: These are coastal indentures that have formed through tectonic processes such as slippage along a fault line (San Francisco Bay), folding or movement of the earth's bedrock often with a large inflow of freshwater.

5. Volcanic estuary: These coastal bodies of open water, a result of volcanic processes are depressions or craters that have direct and/or subsurface connections with the ocean and may or may not have surface continuity with streams. These formations are unique to island areas of volcanic orgin.

C. Inlet type. Inlets in various forms are an integral part of the estuarine environment as they regulate to a certain extent, the velocity and magnitude of tidal exchange, the degree of mixing, and volume of discharge to the sea.

1. Unrestricted: An estuary with a wide unrestricted inlet typically has slow currents, no significant turbulence, and receives the full effect of ocean waves and local disturbances which serve to modify the shoreline. These estuaries are partially mixed, as the open mouth permits the incursion of marine waters to considerable distances upstream, depending on the tidal amplitude and stream gradient.

2. Restricted: Restrictions of estuaries can exist in many forms: Bars, barrier islands, spits, sills, and more. Restricted inlets result in decreased circulation, more pronounced longitudinal and vertical salinity gradients, and more rapid sedimentation. However, if the estuary mouth is restricted by depositional features or land closures, the incoming tide may be held back until it suddenly breaks forth into the basin as a tidal wave, or bore. Such currents exert profound effects on the nature of the subtrate, turbidity, and biota of the estuary.

3. Permanent: Permanent inlets are usually opposite the mouths of major rivers and permit river water to flow into the sea.

4. Temporary (Intermittent): Temporary inlets are formed by storms and frequently shift position, depending on tidal flow, the depth of the sea, and sound waters, the frequency of storms, and the amount of littoral transport.

D. Bottom composition. The bottom composition of estuaries attests to the vigorous, rapid, and complex sedimentation processes characteristic of most coastal regions with low relief. Sediments are derived through the hydrologic processes of erosion, transport, and deposition carried on by the sea and the stream.

1. Sand: Near estuary mouths, where the predominating forces of the sea build spits or other depositional features, the shore and substrates of the estuary are sandy. The bottom sediments in this area are usually coarse, with a graduation toward finer particles in the head region and other zones of reduced flow, fine silty sands are deposited. Sand deposition occurs only in wider or deeper regions where velocity is reduced.

2. Mud: At the base level of a stream near its mouth, the bottom is typically composed of loose muds, silts, and organic detritus as a result of erosion and transport from the upper stream reaches and organic decomposition. Just inside the estuary entrance, the bottom contains considerable quantities of sand and mud, which support a rich fauna. Mud flats, commonly built up in estuarine basins, are composed of loose, coarse, and fine mud and sand, often dividing the original channel.

3. Rock: Rocks usually occur in areas where the stream runs rapidly over a steep gradient with its coarse materials being derived from the higher elevations where the stream slope is greater. The larger fragments are usually found in shallow areas near the stream mouth.

4. Oyster shell: Throughout a major portion of the world, the oyster reef is one of the most significant features of estuaries, usually being found near the mouth of the estuary in a zone of moderate wave action, salt content, and turbidity. It is often a major factor in modifying estuarine current systems and sedimentation, and may occur as an elongated island or peninsula oriented across the main current, or may develop parallel to the direction of the current.

Group II--Hydrographic

A. Circulation. Circulation patterns are the result of combined influences of freshwater inflow, tidal action, wind and oceanic forces, and serve many functions: Nutrient transport, plankton dispersal, ecosystem flushing, salinity control, water mixing, and more.

1. Stratified: This is typical of estuaries with a strong freshwater influx and is commonly found in bays formed from ``drowned'' river valleys, fjords, and other deep basins. There is a net movement of freshwater outward at the top layer and saltwater at the bottom layer, resulting in a net outward transport of surface organisms and net inward transport of bottom organisms.

2. Non-stratified: Estuaries of this type are found where water movement is sluggish and flushing rate is low, although there may be sufficient circulation to provide the basis for a high carrying capacity. This is common to shallow embayments and bays lacking a good supply of freshwater from land drainage.

3. Lagoonal: An estuary of this type is characterized by low rates of water movement resulting from a lack of significant freshwater influx and a lack of strong tidal exchange because of the typically narrow inlet connecting the lagoon to the sea. Circulation whose major driving force is wind, is the major limiting factor in biological productivity within lagoons.

B. Tides. This is the most important ecological factor in an estuary as it affects water exchange and its vertical range determines the extent of tidal flats which may be exposed and submerged with each tidal cycle. Tidal action against the volume of river water discharged into an estuary results in a complex system whose properties vary according to estuary structure as well as the magnitude of river flow and tidal range. Tides are usually described in terms of the cycle and

their relative heights. In the United States, tide height is reckoned on the basis of average low tide, which is referred to as datum. The tides, although complex, fall into three main categories:

1. Diurnal: This refers to a daily change in water level that can be observed along the shoreline. There is one high tide and one low tide per day.

2. Semidiurnal: This refers to a twice daily rise and fall in water that can be observed along the shoreline.

3. Wind/Storm tides: This refers to fluctuations in water elevation to wind and storm events, where influence of lunar tides is less.

C. Freshwater. According to nearly all the definitions advanced, it is inherent that all estuaries need freshwater, which is drained from the land and measurably dilutes seawater to create a brackish condition. Freshwater enters an estuary as runoff from the land either from a surface and/or subsurface source.

1. Surface water: This is water flowing over the ground in the form of streams. Local variation in runoff is dependent upon the nature of the soil (porosity and solubility), degree of surface slope, vegetational type and development, local climatic conditions, and volume and intensity of precipitation.

2. Subsurface water: This refers to the precipitation that has been absorbed by the soil and stored below the surface. The distribution of subsurface water depends on local climate, topography, and the porosity and permeability of the underlying soils and rocks. There are two main subtypes of surface water:

a. Vadose water: This is water in the soil above the water table. Its volume with respect to the soil is subject to considerable fluctuation.

b. Groundwater: This is water contained in the rocks below the water table, is usually of more uniform volume than vadose water, and generally follows the topographic relief of the land being high hills and sloping into valleys.

Group III--Chemical

A. Salinity. This reflects a complex mixture of salts, the most abundant being sodium chloride, and is a very critical factor in the distribution and maintenance of many estuarine organisms. Based on salinity, there are two basic estuarine types and eight different salinity zones (expressed in parts per thousand-ppt.)

1. Positive estuary: This is an estuary in which the freshwater influx is sufficient to maintain mixing, resulting in a pattern of increasing salinity toward the estuary mouth. It is characterized by low oxygen concentration in the deeper waters and considerable organic content in bottom sediments.

2. Negative estuary: This is found in particularly arid regions, where estuary evaporation may exceed freshwater inflow, resulting in increased salinity in the upper part of the basin, especially if the estuary mouth is restricted so that tidal flow is inhibited. These are typically very salty (hyperhaline), moderately oxygenated at depth, and possess bottom sediments that are poor in organic content.

3. Salinity zones (expressed in ppt):

a. Hyperhaline--greater than 40 ppt.

b. Euhaline--40 ppt to 30 ppt.

c. Mixhaline--30 ppt to 0.5 ppt.

(1) Mixoeuhaline--greater than 30 ppt but less than the adjacent euhaline sea.

(2) Polyhaline--30 ppt to 18 ppt.
(3) Mesohaline--18 ppt to 5 ppt.
(4) Oligohaline--5 ppt to 0.5 ppt.
d. Limnetic: Less than 0.5 ppt.
B. pH Regime: This is indicative of the mineral richness of estuarine waters and falls into three main categories:
1. Acid: Waters with a pH of less than 5.5.
2. Circumneutral: A condition where the pH ranges from 5.5 to 7.4.
3. Alkaline: Waters with a pH greater than 7.4.

Appendix 3.

Elkhorn Slough National Estuarine Research Reserve Coastal Training Program Strategic Plan 2003-2008

Introduction

Decisions made on behalf of coastal communities can have profound, long-term consequences for estuarine and coastal environments. Elected officials, land use planners, regulatory personnel, coastal managers, and agricultural and fisheries interests are key decision makers who often do not have adequate access to relevant science-based information, training, or available technology to make informed decisions affecting the coast.

The National Estuarine Research Reserve System (NERRS) has been building the capability to address these information and technology needs through targeted training and education programs at the local and regional levels.

The Elkhorn Slough National Estuarine Research Reserve (NERR) Coastal Training Program (CTP) has been established to build on the experience and research of the NERRS' community and enhance reserve capabilities to deliver training. The goals and objectives of the CTP as a whole have been described as follows:

*The **goal** of the Coastal Training Program is to improve decision-making related to coastal resources management at local and regional levels.*

*The **objectives** of the Coastal Training Program are to:*

- *Provide the best available science-based information, tools, and techniques to those individuals and groups that are making important decisions regarding resources within coastal watersheds, estuaries, and nearshore waters;*
- Increase networking and collaboration across sectors and disciplines related to coastal management issues in local and bio-geographic areas; and
- *Increase understanding of the environmental, social and economic consequences of human activity within the coastal landscape.*

The Elkhorn Slough Coastal Training Program will accomplish program objectives by enhancing the capability at Elkhorn Slough National Estuarine Research Reserve (ESNERR) to:

- Systematically assess the science-based knowledge and skill needs of decision-makers and environmental professionals located in coastal communities within the Monterey and Santa Cruz county areas.

- Identify and/or develop information products and technical resources relevant to audience needs, training delivery, and follow-up.

- Design and conduct technical training programs for decision makers, land managers, and environmental professionals, ranging from seminars, workshops, publications and web-based media to field-based courses and distance learning forums.

- Evaluate the effectiveness of training programs and continuously assess priority information needs of the local coastal communities.

The Elkhorn Slough NERR is uniquely positioned to assume a leadership role with its Coastal Training Program. The mission of the Elkhorn Slough NERR is to:

> *"ensure the perpetual health of ecosystems in Elkhorn Slough and the surrounding watershed through preservation, restoration, research, information exchange and education with particular emphasis on the Research Reserve."*

The Reserve staff is dedicated to applied research and education that can support training program content, design, and delivery. The Reserve has cultivated strong partnerships, including with the Elkhorn Slough Foundation, a highly successful land trust focusing on conservation within the Elkhorn Slough watershed.

The Elkhorn Slough NERR is unique in the state in employing a large, diversely talented staff of researchers, educators, land stewards, and GIS experts. This staff has extensive experience providing training to coastal decision makers within the Monterey and Santa Cruz county areas. Because the Elkhorn Slough NERR Coastal Training Program is located in the midst of 4,400 acres protected by the Elkhorn Slough NERR and the Elkhorn Slough Foundation, we can provide sites for field components of many types of technical training. Finally, reserve staff work with local communities and coastal decision makers on a regular basis and have developed close relationships, credibility, and a broad understanding of local and regional information and technology needs.

Partnerships

Reserve staff will not implement the CTP alone. Partnerships will be an important aspect of the program.

Current formal partnerships with the CTP include:

- National Oceanic and Atmospheric Administration (NOAA),
- Elkhorn Slough Foundation (ESF)
- California Department of Fish and Game (CDFG)

The National Oceanic and Atmospheric Administration provides base program funding and general oversight for the CTP. The Elkhorn Slough Foundation provides grant and personnel administration services as well as expertise with local cultural, historic, and ecological knowledge. The California Department of Fish and Game provides equipment, office and meeting space, program oversight, and many other services.

Current informal partnerships for specific training programs/workshops have been developed with several organizations including:

- California Coastal Commission
- California Coastal Conservancy
- California State University Monterey Bay
- Monterey Bay Aquarium
- Monterey Bay National Marine Sanctuary
- Monterey County Department of Planning and Building Inspection
- Monterey County Resource Conservation District

Some of the existing informal partnerships are expected to become formalized and new partnerships will be developed in a manner that maximizes the ability of the CTP to deliver services to identified target audiences. Potential new partnerships include:

- California Department of Water Resources
- Moss Landing Duke Power Plant
- Moss Landing Harbor District
- San Benito County Planning and Building Department
- Santa Clara County Planning Department
- Santa Cruz County Planning Department
- Santa Cruz Resource Conservation District
- University of California at Santa Cruz
- University of California Cooperative Extension
- US Army Corps of Engineers
- US Department of Agriculture Natural Resource Conservation Service
- US Department of Interior Fish and Wildlife Service
- Wildland Restoration Team

Issues

Estuaries are critical living resources that provide Americans with vast aesthetic, recreation, and economic opportunities. Estuaries reduce polluted runoff, control flooding, and support birds, fish and other wildlife. As species rich and threatened ecosystems, estuaries also have intrinsic ecological values that may not be readily enumerated by their human utility. Through integrated scientific and educational programs, the National Estuarine Research Reserve System addresses a number of important topics to improve the management of these coastal areas.

Issues of National Priority

The National Estuarine Research Reserve System has identified the following 4 national priority issues:

- **Polluted runoff** – urban areas and farms are a major source of water contamination, causing health hazards from well water, beach closings, and shellfish advisories as well as the loss of habitat critical to many wildlife species' survival.
- **Habitat restoration** – the process of rehabilitating damaged or injured ecosystems.
- **Maintaining biodiversity and controlling invasive species** – essential mechanisms to maintaining healthy and productive estuaries.
- **Sustaining estuarine ecosystems** – critical to human health as well as the health of the economy.

Issues of local importance for the Elkhorn Slough NERR

Issues that are locally important to ESNERR were identified based on a review of the following documents:

- ESNERR management plan (1985)
- Elkhorn Slough Wetland Management Plan (1989)
- Elkhorn Slough NERR CTP Market Analysis (2001)
- Elkhorn Slough at the Crossroads (2001)
- Elkhorn Slough Watershed Conservation Plan (2002)

Specific local and regional issues that are the focus of the Elkhorn Slough CTP have been tiered to the 4 national priority issues identified for the NERRS (above). Because of limited funding and personnel, the Elkhorn Slough NERR CTP has chosen two issues of primary importance: habitat restoration and maintaining biodiversity. We will pursue partnerships and additional funding for two issues of secondary priority: polluted runoff and sustainable human systems.

Primary Priority Issues

Habitat restoration

The habitat restoration educational programs will focus on gathering baseline information and scientific consensus on conservation and policy issues regarding species, habitats, and ecological processes identified as critical by regional planning documents and ongoing local needs assessments. Three specific educational foci have been identified at this time.

- Tidal erosion of Elkhorn Slough
- Conservation, ecology, restoration, and management of unique coastal habitats, including coastal prairie, wetlands and riparian areas, oak woodlands, dunes, and maritime chaparral
- Recovering endangered species

Maintaining biodiversity

There are many issues in maintaining biological diversity in California, but a primary one identified by local and regional analyses has been controlling non-native species.

- Control of non-native, invasive plants
- Control of non-native wildlife

Secondary Priority Issues

Polluted runoff

Agriculture and its concomitant pollutants are widely recognized as an important issue in our region. The combination of local research, political pressure, and an innovative agricultural community make for fertile ground for the development of ESNERR CTP educational programs in this area. Until additional resources are obtained, we will largely focus on developing partnerships to explore the following issues.

- Sediment and nutrients from agricultural fields adjacent to Elkhorn Slough, nearshore waters, and other regional wetlands
- Sediment and nutrients as a non-point source pollution that is associated with intense livestock grazing
- Pesticide contamination of Elkhorn Slough, nearshore waters, and other regional wetlands

Sustainable human systems

Nationally, this educational focus is termed ‘sustaining estuarine ecosystems,’ but locally this topic largely reflects the need to create more sustainable human

systems in and around our regional estuaries. As complex and multidimensional as this subject is, two priority topics have been identified through our analyses.

- Management of Elkhorn Slough recreation use
- Saltwater intrusion

Proposed training to be offered during period addressed by the Strategic Plan

The following tables are intended to be updated annually and can be utilized to record actual partners, dates, and attendance after training is conducted. Because science constantly changes and new critical resource issues may surface, the ESNERR CTP must remain flexible to a certain degree in developing its educational programs.

The tables depict only major workshops and symposia; several smaller, facilitated discussions between community leaders and instructors typically follow these educational programs to answer the many issues that may be raised without complete resolution during the larger gatherings. Other workshops, not focused on these focal areas may be designed to address cross-cutting issues such as the use of science in decision making, organizational development, etc.

Two tables follow: the first lists the priority education programs and the second lists areas that will be secondary focuses, which can be expanded through additional funding or increased need. These lists are meant to be illustrative of the number and type of educational programs envisioned for the CTP.

Issues of primary focus to the Elkhorn Slough CTP

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
Habitat restoration: Tidal erosion of Elkhorn Slough stream channels	Review and synthesis of tidal erosion history and causes in Elkhorn Slough	Army Corps of Engineers; ESNERR; University Researchers	Seminar/ workshop	University researchers; ESNERR staff		X			
Habitat restoration: Tidal erosion of Elkhorn Slough stream channels	Development of strategies to reduce tidal erosion of Elkhorn Slough channels	Army Corps of Engineers; ESNERR; University researchers	Facilitated Seminar/ workshop	Army Corps of Engineers; ESNERR University researchers			X		X
Habitat restoration: Managing and protecting unique habitats	Restoration and management of California's coastal prairie	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; CA State Parks	X		X		X
Habitat restoration: Managing and protecting unique habitats	Restoration and management of California's Maritime Chaparral	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; USFWS; Monterey and Santa Cruz counties	X			X	
Habitat restoration: Managing and protecting unique habitats	Restoration and management of California's Maritime Chaparral	Land managers, County planners USFWS, CDFG, USFS, CCC	Publication on conservation concerns and maritime chaparral	BLM; USFWS; Monterey and Santa Cruz counties	pub				
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of California's central coast fresh water wetlands	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; MBMS; Monterey and Santa Cruz counties	X		X		X
Habitat restoration: Managing and protecting unique habitats	Restoration and management of California's central coast fresh water wetlands	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; MBMS; Monterey and Santa Cruz counties	X			X	

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of Monterey County's coastal sensitive plant species	Land managers, County planners USFWS, CDFG, USFS, CCC	Website based information that is available 24/7 on the ESF website	BLM; various municipalities Monterey County Planning Department; USFWS; CDFG	web				
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of Santa Cruz County's coastal sensitive plant species	Land managers, County planners USFWS, CDFG, USFS, CCC	Website based information that is available 24/7 on the ESF website	BLM; various municipalities Santa Cruz County Planning Department; USFWS; CDFG		web			
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of Monterey County's coastal sensitive animal species	Land managers, County planners USFWS, CDFG, USFS, CCC	Website based information that is available 24/7 on the ESF website	BLM; various municipalities Monterey County Planning Department; USFWS; CDFG			web		
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of Santa Cruz County's coastal sensitive animal species	Land managers, County planners USFWS, CDFG, USFS, CCC	Website based information that is available 24/7 on the ESF website	BLM; various municipalities Santa Cruz County Planning Department; USFWS; CDFG				web	
Habitat restoration: Managing and protecting unique habitats	Ecology and conservation of California's central coast riparian areas	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; CDFG; Monterey and Santa Cruz counties		X			X
Habitat restoration: Managing and protecting unique habitats	Restoration and management of California's central coast riparian areas	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; CDFG; Monterey and Santa Cruz counties		X			X
Habitat restoration: Managing and protecting	Yearly review of sensitive habitats	Land managers, County planners	Workshop/ field day review	BLM; CDFG; CDPR Monterey and Santa				X	X

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
unique habitats		USFWS, CDFG, USFS, CCC		Cruz counties					
Habitat restoration: Managing and protecting unique habitats	Prescribed fire	Land managers, CDF; USFWS, CDFG, USFS, CCC	Workshop/ field day review	BLM; CDPR; CDF		X	X		
Habitat restoration: Recovering endangered species	Recovery workshop for Yadon's Piperia	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review + agency training workshop	BLM; CDFG; CDPR	X				
Habitat restoration: Recovering endangered species	Recovery workshop for Monterey spineflower and sand gilia	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review + agency training workshop	BLM; CDFG; CDPR		X			
Habitat restoration: Recovering endangered species	Recovery workshop for Eastwood's goldenbush and Pajaro manzanita	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review + agency training workshop	BLM; CDFG; CDPR			X		
Habitat restoration: Recovering endangered species	Recovery workshop for Hooker's and Sandmat manzanitas	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review + agency training workshop	BLM; CDFG; CDPR				X	
Habitat restoration: Recovering endangered species	Recovery workshop for tidewater goby	Land managers, County planners USFWS, CDFG, USFS, CCC	Workshop/ field day review + agency training workshop	BLM; CDFG; CDPR					X
Maintaining biodiversity: Control of non-native invasive plants	Ecological impacts of non-native invasive plants: Eucalyptus	land managers, planning departs consultants, conservation	Workshop/ field day review	California Exotic Pest Plant Council; Wildland Restoration Team	X		X		

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
		organizations, Audubon Society, CCC, scientists							
Maintaining biodiversity: Control of non-native invasive plants	Eradication of major non-native invasive plants: Eucalyptus	land managers, planning departs consultants, conservation organizations, Audubon Society, CCC, scientists	Workshop/ field day review	California Exotic Pest Plant Council; Wildland Restoration Team	X		X		
Maintaining biodiversity: Control of non-native invasive plants	Ecological impacts of non-native invasive plants: Poison hemlock	land managers, planning departs consultants, conservation organizations, Audubon Society, CCC, scientists	Workshop/ field day review	California Exotic Pest Plant Council; Wildland Restoration Team		X		X	
Maintaining biodiversity: Control of non-native invasive plants	Eradication of major non-native invasive plants: Poison hemlock	land managers, planning departs consultants, conservation organizations, Audubon Society, CCC, scientists	Workshop/ field day review	California Exotic Pest Plant Council; Wildland Restoration Team		X		X	
Maintaining biodiversity: Control of non-native invasive plants	Ecological impacts of non-native invasive plants: Scotch broom	land managers, planning departs consultants, conservation organizations, Audubon Society, CCC, scientists	Workshop/ field day review	California Exotic Pest Plant Council; Wildland Restoration Team			X		X
Maintaining biodiversity:	Eradication of major	land managers,	Workshop/ field	California Exotic				X	

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
Control of non-native invasive plants	non-native invasive plants: Scotch broom	planning departs consultants, conservation organizations, Audubon Society, CCC, scientists	day review	Pest Plant Council; Wildland Restoration Team					
Maintaining biodiversity: Control of non-native invasive plants	Develop website info with relevant ID info and control techniques for 4 non-native Invasives that are a problem within ESNERR zone	land managers, planning departs consultants, conservation organizations,	Website based information that is available 24/7 on the ESF website	California Exotic Pest Plant Council; Wildland Restoration Team; ESF	web				
Maintaining biodiversity: Control of non-native invasive plants	Expand the number of species of non-native plants included on website.	land managers, planning departs consultants, conservation organizations,	Website based information that is available 24/7 on the ESF website	California Exotic Pest Plant Council; Wildland Restoration Team; ESF		web			
Maintaining biodiversity: Control of non-native wildlife	Regulatory, detection, and management strategies for non-native marine wildlife species	land managers, planning departs consultants, conservation organizations,	Seminar	California Exotic Pest Plant Council; CDFG; CA Coastal Commission; NMFS	X			X	
Maintaining biodiversity: Control of non-native wildlife	Regulatory and management strategies for non-native marine wildlife species	land managers, planning departs consultants, conservation organizations,	Website based information that is available 24/7 on the ESF website	California Exotic Pest Plant Council; CDFG; CA Coastal Commission; NMFS	web				
Maintaining biodiversity: Control of non-native wildlife	Regulatory and management strategies for non-native upland wildlife species (feral cats, dogs, foxes)	land managers, county planners city planners, consultants, conservation organizations,	Seminar	SPCA; CDFG; CA Coastal Commission; USFWS		X			
Maintaining biodiversity: Control of non-native wildlife	Regulatory and management strategies for non-native upland	land managers, county planners city planners,	Website based information that is available 24/7	SPCA; CDFG; CA Coastal Commission;		web			

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
	wildlife species (feral cats, dogs, foxes)	consultants, conservation organizations,	on the ESF (website page for each species)	USFWS					
Planned workshops/seminars					**8**	**8**	**8**	**8**	**8**
Planned publications					**1**				
Planned Website themes					**3**	**3**	**1**	**1**	

Focal Issues of secondary importance to the CTP: these will be implemented with additional funding and/or other assistance

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
Polluted runoff: Nitrogen runoff from areas adjacent to Elkhorn Slough.	Review and development of a model used to predict nitrogen nonpoint source pollution	Farm Bureau Coop extension; University researchers; Regional water board; Local RCD's	Seminar/ workshop	CICEET	X (funded)				
Polluted runoff: Nitrogen runoff from areas adjacent to Elkhorn Slough.	Review and development of BMP's related to nitrogen nonpoint source pollution	Farm Bureau Coop extension County planner Local RCD's	Seminar/ workshop	NRCS Coop extension RWQCB		X			X
Polluted runoff: Sediment from agriculture fields adjacent to Elkhorn Slough.	Review and development of BMP's related to row crops	Farm Bureau Coop extension County planner Local RCD's	Seminar/ workshop	NRCS Coop extension RWQCB			X		X

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
Polluted runoff: Sediment from agriculture fields adjacent to Elkhorn Slough.	Understanding and implementing BMP's for row crops	Agriculturists Local RCD's County ag	Workshop/ field day review	Coop extension County planning RWQCB			X		X
Polluted runoff: Sediment as a non-point source pollution that is associated with intense livestock grazing	Development of grazing guidelines for meeting non-point source pollution on grazing lands.	NRCS Coop extension agriculturists	Reference guidelines in publication format	Coop extension RWQCB	pub				
Polluted runoff: Sediment as a non-point source pollution that is associated with intense livestock grazing	Understanding grazing strategies that meet non-point source pollution guidelines	Graziers Agriculturists NRCS RCD's	Workshop/ field day review	Coop extension RCD's		X		X	
Polluted runoff: Pesticide contamination of Elkhorn Slough and other coastal waters	Review of pesticide occurrence, sources and potential solutions	Agriculturists CA EPA Farm Bureau RCD's	Seminar/ Workshop	ESNERR staff CA EPA CA DF&G County planners	X			X	
Polluted runoff: Pesticide contamination of Elkhorn Slough and other coastal waters	Integrated Pest Management & Reduced pesticide use strategies	Agriculturists RCD's	Workshop/ field day review	County AG CA EPA CA DF&G				X	
Sustaining estuarine ecosystems: Management of Elkhorn Slough recreation users	Description of proper etiquette and acceptable recreation use within Elkhorn Slough	Local businesses Ducks unlimited Audubon Kayakers ESF,	Revise and update Brochure available for distribution to the recreating public	Monterey Bay Kayak, Moss Landing Harbor, CCC			pub		
Sustaining estuarine ecosystems: Saltwater intrusion	Salt water intrusion: Defining the issue and consequences	RCDs County planning Coastal commission Agriculturalists City water depts	Seminar	ESNERR State DWR			X		
Sustaining estuarine	Salt water intrusion:	RCDs	Facilitated	ESNERR		X			

Training plan updated June 25,

Prioritized Focal Issues	Training Item	Audience	Training format	Partners	Training -Scheduled/ and date accomplished				
					2004	2005	2006	2007	2008
ecosystems: Saltwater intrusion	Solutions regulatory and voluntary	County planning Coastal commission Agriculturalists City water depts	workshop	State DWR					
Sustaining estuarine ecosystems: Management of Elkhorn Slough recreation users	Implementing carrying capacity analysis-based monitoring and control of recreation use within Elkhorn Slough	Local businesses Ducks unlimited Audubon Kayakers ESF, ESNERR CDFG Moss landing	Seminar workshop	Monterey Bay Kayak; Moss Landing Harbor; CCC	X				
Sustaining estuarine ecosystems: Management of Elkhorn Slough recreation users	Implementing carrying capacity analysis-based monitoring and control of recreation use within Elkhorn Slough	Business, CDFG Ducks unlimited Audubon Kayakers ESF, ESNERR Moss landing	Website based information that is available 24/7 on the ESF (website page)	Monterey Bay Kayak, Moss Landing Harbor, CCC	web				
Sustaining estuarine ecosystems: Management of Elkhorn Slough recreation users	Description of proper etiquette and acceptable recreation use within Elkhorn Slough	Local businesses Ducks unlimited Audubon Kayakers ESF,	Brochure available for distribution to the recreating public	Monterey Bay Kayak, Moss Landing Harbor, CCC		pub			
Sustaining estuarine ecosystems: Validation of local issues	Annual review and validation of issues for ESNERR CTP strategic plan	ESNERR CTP review team	Facilitated workshop	ESNERR CTP team NOAA NERR CTP	X	X	X	X	X
				Planned workshops/seminars	**4**	**4**	**4**	**4**	**4**
				Planned publications	**1**	**1**	**1**		
				Planned Website themes	**1**				

Monitoring and Evaluation

The best measure of success for the ESNERR CTP would be an ability to directly measure the improvement of knowledge and decision making acquired by participants in the various training efforts being offered by the ESNERR CTP. It is clearly not feasible to directly measure the knowledge gained by participants and whether they will have an opportunity to utilize the knowledge and skills presented during CTP sponsored training. A number of specific proxy measures will be used to annually monitor and evaluate the extent and quality of the ESNERR CTP being offered.

Some of the specific criteria used to evaluate the extent of the ESNERR CTP will be to annually summarize:

- Number of workshops/seminars provided
- Number of participants served
- Number of class hours provided
- Publications produced
- Request for CTP publications – brochures, videos, PowerPoint presentations, etc.
- Website pages developed
- Website visits to developed web pages
- Number of partners included as cosponsors of workshops/seminars
- Number of formal partners providing direct support to ESNERR CTP

Some of the specific criteria used to evaluate the quality of the ESNERR CTP will be to annually summarize:

- Workshops ESNERR CTP is requested to cosponsor by other organizations
- Number or agencies/organizations represented at each workshop
- Number of workshops with participants attending from outside of ESNERR area
- Number of workshops developed by ESNERR CTP that are adopted for other areas
- Number of non ESNERR CTP workshops that ESNERR CTP coordinator is requested to participate in as instructor
- Self reported evaluations prepared by participants
- Percent of ESNERR CTP program funded by sources other than NOAA NERR CTP

Staffing and infrastructure support

The ESNERR CTP currently consists of a full time program coordinator and part time help. Additional ESNERR staff and partners provide subject specific expertise depending on the issue and topic.

ESNERR CTP Coordinator – Responsible for development and scheduling of training programs identified in the ESNERR CTP strategic plan. This is a full time position.

CTP Workshop Coordinator – Responsible for logistical support of workshops. This position manages announcing workshops, workshop registration, and workshop logistics. At present, due to budget constraints and current needs, this is a part time, contracted position. This position could be expanded as program is increased.

ESNERR staff – The ESNERR staff provides a variety of specialized skills which are utilized as needed to accomplish CTP objectives. ESNERR staff includes:

- Reserve Manager
- Education Coordinator
- Research Coordinator and research staff
- Stewardship Coordinator
- GIS Coordinator

California Department of Fish and Game – CDFG provides high quality office space, office support, and office and conference room facilities for the CTP at the Elkhorn Slough NERR facility.

Partners and cooperators on a regular basis provide additional workshop staff and instructors.

Projected Financial plan for Elkhorn Slough NERR Coastal Training Program (June 25, 2003)							
	Fiscal Year						
	2001-2	2002-3	2003-4	2004-5	2005-6	2006-7	2007-8
Funding Sources							
NOAA NERR CTP	146,000	105,000	110,000	115,000	120,000	126,000	132,300
CA Dept of Fish and Game (contrib. office space/supplies)	7,000	7,000	8,000	12,000	12,000	12,600	13,230
Elkhorn Slough Foundation (contributed services)			8,000	8,000	10,000	10,500	11,025
NRCS EQIP grants				5,000	5,000	5,250	5,513
Monterey college					10,000	10,500	11,025
Grants, other			5,000	15,000	20,000	21,000	22,050
Grants, other							
Grants, other							
Total funding for year	**153,000**	**112,000**	**131,000**	**155,000**	**177,000**	**198,000**	**220,050**
Program Expenses							
Salary /benefits Program manager	58,000	51,000	61,000	65,000	67,000	70,350	73,868
Part time and interns	20,000	16,000	16,000	29,000	35,000	36,750	38,588
Travel	3,000	3,000	5,000	6,000	8,000	8,400	8,820
Office space (CDFG)	2,000	2,000	2,000	3,000	3,000	3,150	3,308
Utilities (CDFG)	1,000	1,000	1,000	1,000	1,000	1,050	1,103
Office supplies (CDFG)	2,000	2,000	2,000	4,000	4,000	4,200	4,410
Miscellaneous supplies	3,000	3,000	2,000	2,000	2,000	2,100	2,205
Equipment	2,000	2,000	1,000	1,000	1,000	1,050	1,103
Workshop expenses Room rental (CDFG)	2,000	2,000	3,000	4,000	4,000	4,200	4,410
Materials	26,000	4,000	6,000	7,000	10,000	10,500	11,025
Instructor fee/stipends	5,000	1,000	2,000	7,000	10,000	10,500	11,025
Market analysis contract							
Publication costs							

Grant administration	29,000	21,000	30,000	30,000	32,000	42,500	53,525
Overhead		4,000					
Total expenses for year	**153,000**	**112,000**	**131,000**	**155,000**	**177,000**	**240,500**	**273,575**

Appendix 4.
Reserve and Watershed Description

Much of the text and images found in Appendix 4 have been excerpted from:
Caffery, Jane, M. Brown, W.B. Tyler, M. Silberstein (editors). 2002. Changes in a California Estuary, A Profile of Elkhorn Slough. Moss Landing, California: Elkhorn Slough Foundation.

A. Watershed & Property Description

1. Reserve Setting

The Elkhorn Slough National Estuarine Research Reserve (Elkhorn Slough NERR) is an ecologically diverse 583 hectare (1,439 acre) protected area located on the eastern shore of the Elkhorn Slough, near the Monterey Bay in Central California. In 1980 over 400 hectares of land was purchased for the Reserve by the California Department of Fish and Game (DFG), through its Wildlife Conservation Board (WCB). A few years later an additional 133 hectares was acquired. Over the last 100 years the property within the Reserve boundaries has been used as a private hunting club, dairy, farm operation, general cattle grazing and now an estuarine research reserve.

2. Geographical Setting

Watershed

The most prominent feature within and adjacent to the Reserve is the Elkhorn Slough. The Elkhorn Slough opens into Monterey Bay at Moss Landing, a small fishing, tourist, and marine research community 145 kilometers (90 mi) south of San Francisco and 32 kilometers (20 mi) north of Monterey. The slough is a shallow estuary that extends inland east from Moss Landing Harbor for approximately 6.4 kilometers (4 mi) before turning and curving north for another 5 kilometers (3.1 mi). Two hundred meters (656 ft) wide at its widest point and 7.5 meters (25 ft) deep at the Highway 1 bridge at mean lower low water, the main slough channel grows narrower and shallower as it travels inland. The winding branches of the slough encompass more than 1,420 hectares (3,506 ac) of marsh and tidal flats (Figure A4.1).

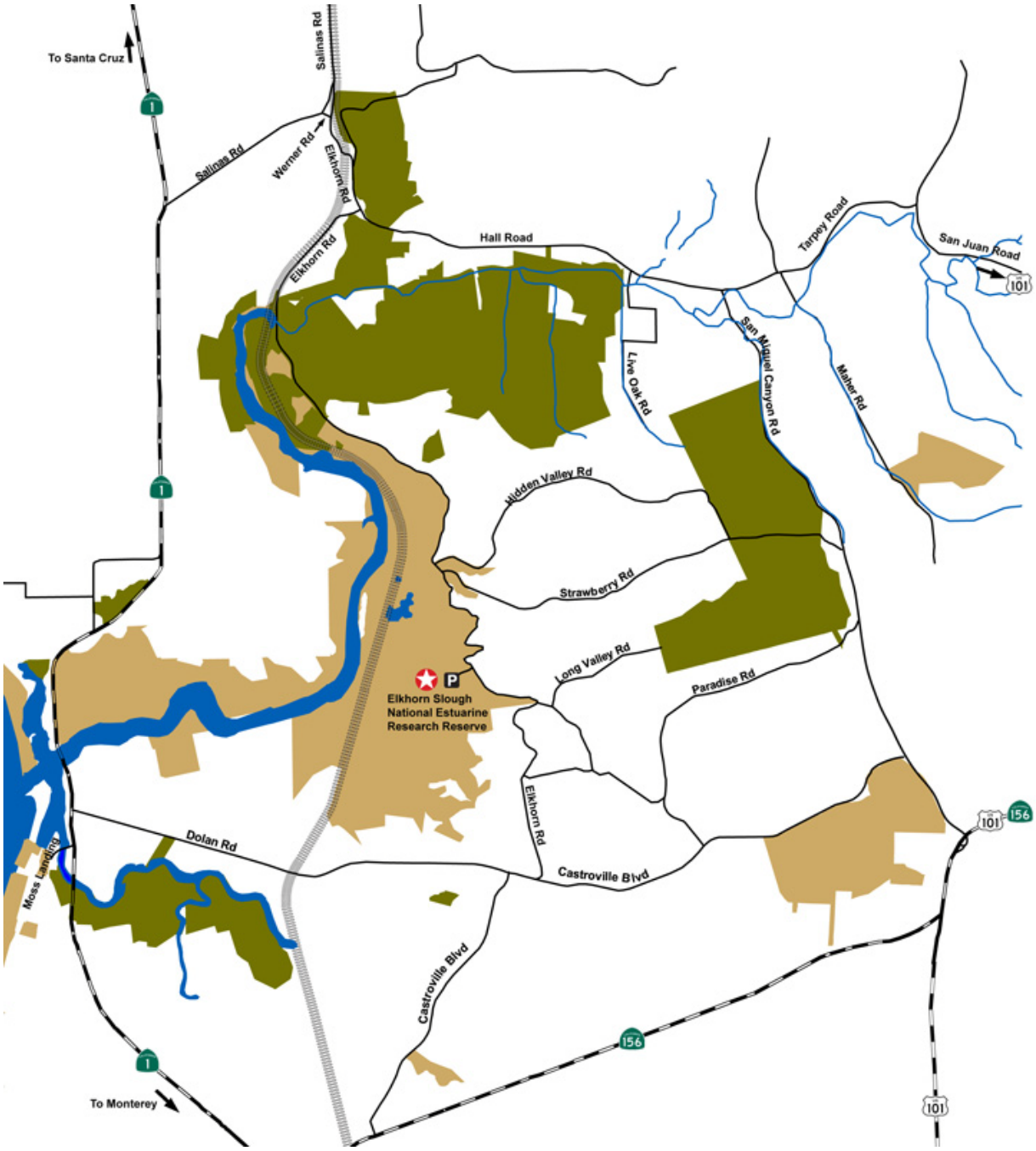

Figure A4.1. Map of Elkhorn Slough.

Surrounding Elkhorn Slough are the upland hills and marine terraces that lie between the Pajaro and Salinas Valleys in Monterey and San Benito Counties (Figure A5.2). Planted in strawberries and other row crops and used for cattle grazing and housing, these areas drain into the slough through Carneros Creek at the head of the estuary and from numerous small, ephemeral creeks.

The slough flows under state Highway 1 into Moss Landing Harbor, a man-made small-craft harbor that supports a commercial fishing fleet, recreational craft, and research vessels. The smaller and largely seasonal Moro Cojo and Tembladero Sloughs also empty into the harbor from the south. During incoming tides the waters from these drainages are mixed with the waters from the Monterey Bay and are transported to the upper reaches of Elkhorn Slough.

Just west of the harbor mouth lies the Monterey Bay Submarine Canyon. Extending 110 kilometers (68 mi) offshore and 3 kilometers (1.8 mi) below the surface, this underwater canyon forms the largest gorge along the west coast of North America—broad and deep enough to hold the Grand Canyon of the Colorado River. Monterey Bay and its surrounding waters make up the 13,700-square-kilometer (5,288 sq mi) Monterey Bay National Marine Sanctuary, administered by the National Oceanic and Atmospheric Administration.

Located near the harbor are marine-related businesses and two marine research organizations, the Monterey Bay Aquarium Research Institute and Moss Landing Marine Laboratories. A power plant owned by the LS Power Group (purchased from Duke Energy in 2006) lies directly inland from the harbor and pumps in harbor water for cooling while discharging heated water into Monterey Bay.

Elkhorn Slough is engaged in a dynamic interaction with the upland areas, the harbor, and the ocean beyond, including both human and natural activities that take place in these systems.

Reserve Lands

As a key component of the Elkhorn Slough watershed, the Reserve is part of a biologically rich system containing a diverse landscape of estuarine habitats, freshwater ponds, and hills containing native upland vegetation. These areas are interspersed with roads, working farms and residential housing.

B. Elkhorn Slough Geology

Lagoons and estuaries such as Elkhorn Slough are relatively rare on the west coast of the United States, due to the influence of plate tectonics on coastal landscape features. The proximity of Elkhorn Slough to the San Andreas Fault—the plate tectonic boundary that defines California geology—is the fundamental control on the landscape, which is then further modified by erosion, deposition, and sea level history as well as by physical processes of wave and current activity (Inman and Norstrom 1971).

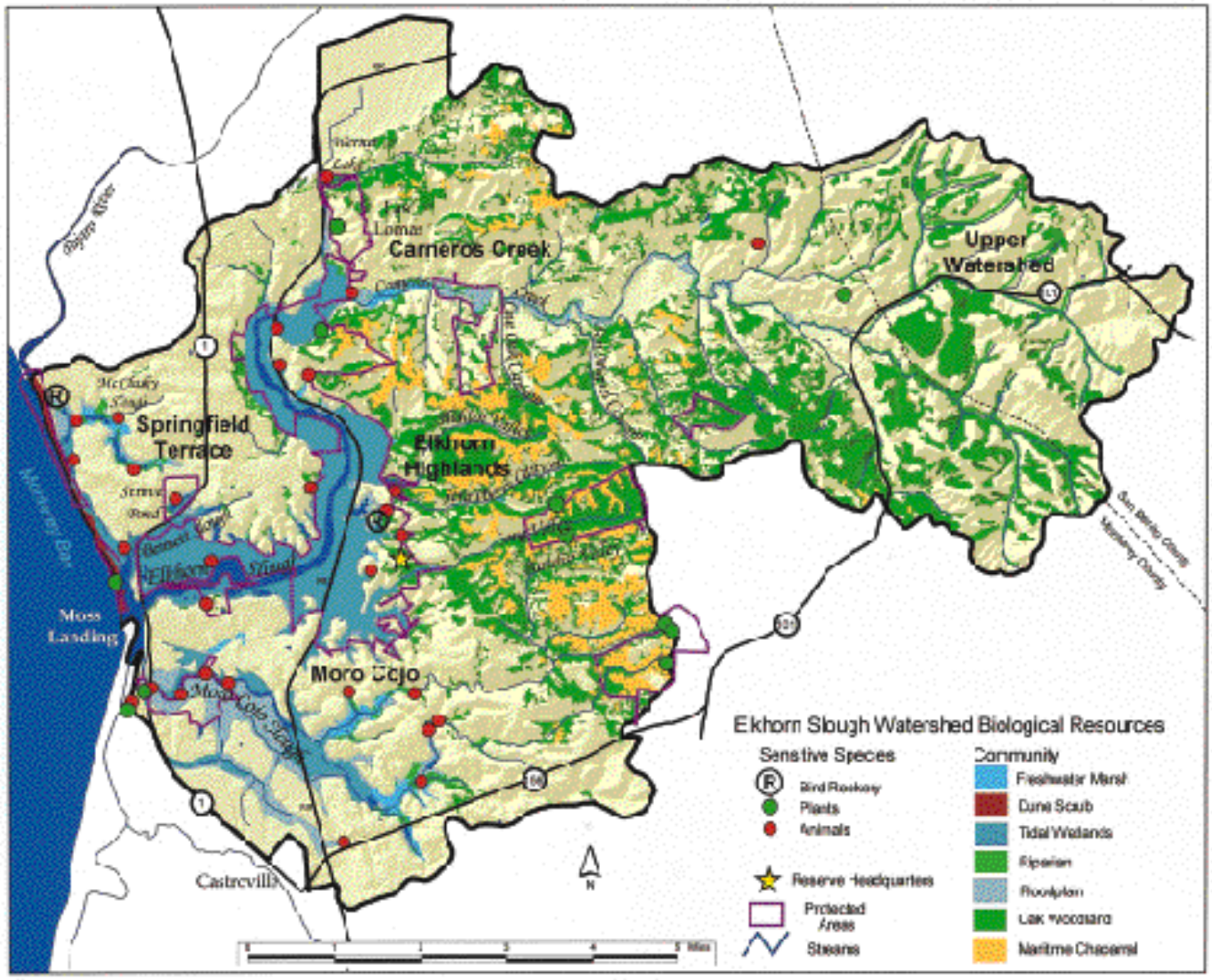

Figure A4.2. The Elkhorn Slough watershed drains 182 square kilometers (70 mi^2) and encompasses a great diversity of habitats.

Elkhorn Valley itself appears to be the westernmost remnant of what was once a much larger river valley. Its headwaters are thought to have originated in either the Santa Clara or Central Valley and flowed into Monterey Bay during the early Pleistocene (1.5 million–500,000 years before present [b.p.]). The headwaters of this ancestral river were apparently cut off by slow, steady movement along the San Andreas Fault zone, resulting in the present anomalous configuration of the Elkhorn Valley: a small stream, without significant headwaters, in a large, broad, deep valley.

Elkhorn Valley lies within the Salinian Block microplate, a wedge of granitic crust that originated south of the Sierra Nevada and was transported to its present location by movement along the San Andreas Fault zone. The Salinian Block is bordered on the east side by the San Andreas Fault zone and on the west by the San Gregorio and Nacimiento Fault zones. Right lateral, strike slip motion along these active fault zones continues to transport the Salinian Block northwestward at a current rate of 27–33 millimeters per year (Vedder, Howell, and McLean 1983).

C. Elkhorn Slough Watershed Soils

Soils in the Elkhorn Slough watershed reflect a relatively young, dynamic setting, with the majority of soils formed from recently stabilized sand dunes and others typical of grasslands that have experienced a fluctuating water table. Soil types range from clay soils in the wetland areas to beach sands near Moss Landing and McCluskey Slough. This variation in soil characteristics influences the distribution of plants and animals, as well as nutrient cycling, water quality, slope stability, and land use, throughout the watershed.

Soils play a vital role in the function of both the upland and wetland Elkhorn Slough ecosystems. They provide the physical substrate for plant roots and habitat for a myriad of organisms, from microorganisms and invertebrates to reptiles, birds, and mammals. Slough and watershed soils also mediate nutrient and moisture availability for plant growth, as well as the processes of organic matter decomposition and accumulation. The watershed's soils control rainwater infiltration, reducing the volume of surface runoff during storms, and store water, releasing it to the atmosphere by evaporation or plant evapotranspiration, to the groundwater by downward movement, or to surface waters such as creeks and wetlands by lateral movement.

Land use, including agricultural and residential development, is also dictated in part by the watershed's soils. For example, the well-drained soils of the Arnold series that dominate much of

the watershed are ideal for strawberry cultivation. In turn, land use practices have a profound impact on soil resources. Human activities ranging from tillage and fertilization for agriculture to road building and vegetation clearing for development affect the soil's ability to modulate nutrient cycles, store water, and maintain slope stability.

Despite their key role in the ecosystem and their importance to land use in the watershed, little research has been done on Elkhorn Slough's soils beyond basic mapping of soil type distribution.

D. Elkhorn Slough Climate

Elkhorn Slough enjoys a mild, Mediterranean climate, thanks to the Pacific Ocean's moderating effects. Because ocean temperatures fluctuate very little, the adjacent land experiences a fairly narrow range of air temperatures. Although air temperatures at a weather station on the Elkhorn Slough National Estuarine Research Reserve (ESNERR) range between 5° and 35°C (41° and 95°F) on a seasonal basis, the monthly means range from only 11.1° to 15.4°C (52° to 60°F). These moderate temperatures combine with distinct seasonal patterns of wind, fog, and rain to create a maritime climate regime limited to a handful of coastal areas around the world.

E. Elkhorn Slough Cultural Features

Watershed

From the pre-Columbian era to the present, human activities have shaped the landscape of Elkhorn Slough and its surrounding watershed. Use of fire by the slough's native inhabitants modified vegetation in ways beneficial to humans. The Spanish and Mexican settlers brought livestock and plants that supplanted native species and permanently changed the region's flora and fauna. Later settlers logged the watershed and diked and drained the slough to create farming and grazing land, eliminating wetlands and altering the slough's hydrography. Populations of native wildlife dwindled and in some cases disappeared under hunting and fishing pressure.

These activities, combined with industrial and residential development, have produced major changes in Elkhorn Slough's natural resources. In recent decades, new attitudes toward the natural landscape have brought a focus on resource conservation and restoration, a change that will in part shape future land use in the Elkhorn Slough watershed.

B. L. Gordon, in his landmark book Monterey Bay Area: Natural History and Cultural Imprints, identifies several waves of people who have moved through the Monterey Bay area, each helping shape the landscape we see today. "Historically the Monterey Bay area has been occupied successively by three major cultural groups: American Indians of the Costanoan group, Spanish-Mexicans, and Americans. The last-named is plainly a very general grouping; it includes diverse elements, each of which has made contributions to the area's development: Americans from the eastern seaboard, Chinese, Italians, Japanese, Portuguese, Yugoslavians, and others. The existing cultural landscape is the cumulative effect of occupancy of the area by these several groups" (Gordon 1996).

Reserve Lands

Recent history of the lands within the Reserve begins at the turn of the century when the Empire Gun Club was established by a group of San Francisco businessmen. The lodge, which no longer exists, was located close to the slough and adjacent to the Southern Pacific (now called Union Pacific) railroad tracks which traverse the Reserve on what is now called Hummingbird Island. The old Del Monte Express maintained a whistle stop at the lodge. The site was subjected to an active management program to augment the numbers of waterfowl. The program included dike and pond construction, water level controls and baiting. When these activities ceased, the stock of waterfowl decreased.

In 1906, J. Henry Meyer, a member of the gun club, bought land around the lodge and built his own hunting lodge. This building is now used as a Reserve staff residence.

In 1915, Meyer increased his holdings to about 1,000 acres and established the Elkhorn Slough Dairy Farm, which operated until 1972. The land was then leased for cattle grazing until 1982.

By 1980 the farm buildings had deteriorated to a significant degree. An archaeological evaluation stated that because of their fairly recent dates of construction, history of modification, purpose, and deteriorated state, the Elkhorn Dairy Farm structures did not qualify for National Register status. In this same archaeological study, twelve Indian sites were also found on the Reserve.

F. References

Caffery, Jane, M. Brown, W.B. Tyler, M. Silberstein (editors). 2002. Changes in a California Estuary, A Profile of Elkhorn Slough. Moss Landing, California: Elkhorn Slough Foundation.

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Inman, D.L. and C.E. Norstrom. 1971. On the tectonic and morphological classification of coasts. *Journal of Geology* 79:1-21.

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Appendix 5.
Watershed Habitats and Species

Text excerpted from: Changes in a California Estuary, *A Profile of Elkhorn Slough*, edited by Jane Caffrey, Martha Brown, W. Breck Tyler, and Mark Silberstein

A. Primary Producers

The Elkhorn Slough watershed and estuary support a rich assemblage of primary producers (see Table 1), those organisms that grow via photosynthesis using sunlight and carbon dioxide to make organic matter. More than 500 species of flowering plants occur in upland (terrestrial), marsh, and subtidal communities, and the estuary supports the seagrass Zostera marina L. (eelgrass) and more than 100 species of macrophytic algae and phytoplankton (DeVogelaere et al. 1998).

Primary producers form the base of the food chain and support the rich diversity of animal life found in Elkhorn Slough and its watershed. Grazers, whether they are zooplankton, clams, voles, or deer, depend on primary producers as their source of food, while grazers, in turn, are a food source for higher trophic levels. The annual cycle of primary production sets the timing of reproduction for many species, so that food is available for their offspring.

As sources of food, all primary producers are not alike. Plant and animal species have co-evolved, sometimes to extreme cases where one grazer is totally dependent on a very small number of plant species. In addition, plants provide habitat and refuge for animal species. The replacement of one primary producer with another can greatly affect the composition of the animal community. Thus, conversions such as salt marsh to mudflats, oak forests to eucalyptus forests, or grasslands to agricultural fields have a greater impact than just the replacement of one primary producer species with another.

In all the communities of Elkhorn Slough, primary production is regulated mostly by seasonal variation in light availability, temperature, and moisture. Terrestrial (nonagricultural) production is determined largely by the duration and extent of the rainy season (November to April). Production peaks in spring (February to June) for many of these communities. Except among some woody perennials, primary productivity is almost nonexistent during the dry summer months. Summer drought also causes early (mid-June) maturation of dominant annual grasses and early dormancy of drought-deciduous perennials. Persistent fog moderates the effects of summer

drought in coastal habitats. Winter frost is rare except in isolated canyon basins where cold air can pool at night. In contrast, marine productivity is highest from late spring through summer, when prevailing northwest winds promote strong upwelling of cold, nutrient-rich water near the coast.

Human activities have caused dramatic changes in the watershed's vegetation communities. Introduced nonnative plants now dominate many habitats and have altered primary production patterns. In addition, intensive livestock grazing, row crop cultivation, and higher housing density all contribute to increased nutrient runoff and higher nitrogen levels in slough waters. Although effects of terrestrial nutrient inputs into Elkhorn Slough are poorly understood, eutrophication can lead to extensive blooms of nuisance algae and phytoplankton. Decomposition of these algae and phytoplankton reduces oxygen concentrations in the water, ultimately killing fish and invertebrates when concentrations get low enough. Such an occurrence at Elkhorn Slough could affect primary productivity in slough waters and severely restrict fish and invertebrate populations. Restoration efforts to reverse habitat loss and degradation and limit nutrient runoff have taken place at the slough and throughout the watershed, and more efforts are currently underway.

B. Marine Invertebrates

The diverse and sometimes bizarre marine invertebrates of Elkhorn Slough (see Table 2) have long delighted locals, as tasty meals or subjects of study. Giant gaper clams and other delicious molluscs have been harvested by humans for thousands of years. Invertebrates also support tens of thousands of shorebirds and waterbirds that stop to feed in the slough as they migrate along the Pacific flyway, and help sustain local breeding populations of birds such as Great Egrets and Great Blue Herons. Many fish, including leopard sharks, prey on invertebrates, as do the sea otters that have recently become abundant in the slough.

Beginning in the 1920s, Elkhorn Slough's invertebrates caught the attention not only of predators but also of fine naturalists. Classic studies of the fat innkeeper worm, familiar to zoologists worldwide, were based at the slough. For decades, students and researchers have become mired in deep mud while attempting to acquaint themselves with the slough's invertebrate communities.

Invertebrates at the slough are also critical from a conservation perspective. Few extensive tidal wetlands remain on the Pacific Coast, and many mudflat species are nowhere else as abundant as

in Elkhorn Slough. Drastic declines in the populations of some key species documented over the past decades are thus of serious concern. Various human activities in the Elkhorn Slough watershed have the potential to negatively affect invertebrates, and more research is needed to devise the best management strategies to protect them. Conservation efforts in the area should include explicit focus on these permanent slough residents, both for their own sake and to better protect more familiar but often transient visitors to the slough such as shorebirds, marine mammals, and sharks.

C. Freshwater & Terrestrial Invertebrates

Very little is known about the freshwater and terrestrial invertebrates of Elkhorn Slough. Not even a complete list of locally occurring species is available. Taking these animals into account would surely double the invertebrate species richness of the slough area. Here we will just briefly mention important freshwater and terrestrial habitats and what little is known about their invertebrate communities.

A key freshwater habitat is Carneros Creek, which flows into the upper slough. A student searched for aquatic arthropods there and found a variety of species, including crayfish, beetles, mayflies, and dragonflies, water boatmen, whirligigs, backswimmers, and midges (J. Jones, pers. comm.). Other freshwater areas near the mouth of Elkhorn Slough, such as the old Salinas River channel and McClusky Slough, have yet to be surveyed for invertebrates.

The slough's upper marshes support a diverse community of terrestrial invertebrates (see Tables 3 & 4). As part of a pickleweed trampling study, Woolfolk (1999) assessed the diversity of terrestrial invertebrates in experimental plots as an indicator of marsh health. Further work on the insects and other invertebrates of the slough's marshes and salt pans would surely be fruitful.

The grasslands, oak woodlands, and other uplands of the slough certainly host a rich fauna of invertebrates, including insects, spiders, isopods, earthworms, and snails. However, virtually nothing is known about the occurrence or ecology of these species at

the slough. Some 23 species of butterflies occur in the Elkhorn Slough area (P. Johnson, pers. comm.; J. Lane, pers. comm.) and over 50 species of moths have been collected (S. Fork, pers. comm.). Over 100 additional species of other insects have been collected on the ESNERR and are curated in the reserve's collection (S. Fork, per. comm.). Representatives of eight spider families are known from the area (F. Sala, pers. comm.). Four species of earthworms have been identified from areas around Elkhorn Slough, one of them native and three introduced species common in disturbed soils (Silberstein et al. 1997).

D. Fishes

Fishes are among the most conspicuous and best-studied inhabitants of Elkhorn Slough. Long a source of food and recreation, they are of special interest to humans and—as both predator and prey—play a critical role in the slough ecosystem.

The fish fauna in Elkhorn Slough (see Table 5) is abundant, diverse, and dominated by marine and estuarine species (Cailliet et al. 1977; Yoklavich et al. 1991; Yoklavich, Stevenson, and Cailliet 1992). The slough provides critical habitat not only for year-round residents, but also for marine species from nearshore waters that enter sloughs to feed, mate, and spawn. Many marine fishes, including a number of economically important species, inhabit the slough's relatively warm, calm waters as juveniles before moving to nearshore coastal waters.

Early studies on the slough's fish populations provided baseline information critical to long-term monitoring of Elkhorn Slough's fish assemblages, their response to potential environmental changes, and their contribution to the nearshore fishery resources of Monterey Bay. More recent studies reveal that human impacts on Elkhorn Slough have fundamentally changed available fish habitat, resulting in changes to fish assemblages and an overall decline in diversity of both fishes and their prey.

E. Birds & Mammals

The diversity of habitats within the Elkhorn Slough watershed largely explains the vast number of bird and mammal species (see Tables 6 & 7) that use this region as year-round residents or seasonal visitors. One may encounter denizens of channel waters, coastal dunes and beaches,

intertidal mudflats, salt marsh, oak woodlands, and grasslands. The moderate central coast climate allows for a diverse assemblage of species throughout the year.

Elkhorn Slough is recognized as a Globally Important Bird Area by the American Bird Conservancy. More than 265 bird species (73% of the California total) have been recorded in the Elkhorn Slough area (Roberson 1991). Most are seasonal visitors, but approximately 40 are year-round residents. Aquatic birds—shorebirds, seabirds, herons, and waterfowl—account for much of the slough's avian diversity. Roberson (1991) lists 137 aquatic species, including 57 that are common at some time each year. Many of these species are migrants. In fact, as one of the largest estuaries in California, Elkhorn Slough is a major stopover for birds migrating along the Pacific flyway. More than 20,000 sandpipers, plovers, and their relatives may be present at the peak of migration (Senner and Howe 1984; Ramer, Page, and Yoklavich 1991; Page et al. 1992). A number of these aquatic species nest in the Elkhorn Slough watershed: Great Egrets, Great Blue Herons, and Double-crested Cormorants nest in a grove of pines and eucalyptus in the Elkhorn Slough National Estuarine Research Reserve (ESNERR); Caspian Terns nest on man-made islands on the ESNERR; and threatened Snowy Plovers nest at the salt ponds and on beaches.

Fifty-nine species of mammals are believed to occur in the Elkhorn Slough watershed, five of which are marine (Schafer 1986). The sea otter (Enhydra lutris) returned to its historic range in the slough in the early 1980s, and the number using the slough has increased gradually since then. Harbor seal (Phoca vitulina) populations have also increased in recent years. California sea lion (Zalophus californianus), harbor porpoise (Phocoena phocoena), and juvenile gray whale (Eschrichtius robustus) are sighted infrequently in the lower reaches of the slough (Richman 1997).

F. Reserve Species Lists

1. Terrestrial Plants Found in the Elkhorn Slough Watershed

Family	Species	Common Name	Status
Aizoaceae	Carpobrotus edulis	Hottentot Fig	Non-native
Aizoaceae	Tetragonia tetragonioides	New Zealand Spinach	Non-native
Alismataceae	Alisma plantago-aquatica	Water-Plantain	Native
Anacardiaceae	Toxicodendron diversilobum	Poison Oak	Native
Apiaceae	Anthriscus caucalis	Bur Chervil	Non-native
Apiaceae	Cicuta spp.	Water Hemlock	Native
Apiaceae	Conium maculatum	Poison Hemlock	Non-native
Apiaceae	Foeniculum vulgare	Fennel	Non-native
Apiaceae	Hydrocotyle sp.	Marsh Pennywort	Unknown
Apiaceae	Lomatium caruifolium	Caraway Leaf Lomatium	Native
Apiaceae	Lomatium parvifolium	Small-leaved Lomatium	Native
Apiaceae	Perideridia gairdneri	Yampah	Native
Apiaceae	Sanicula bipinnatifida	Purple Sanicle	Native
Apiaceae	Sanicula crassicaulis	Gamble Weed	Native
Apiaceae	Torilis sp.	Hedge-parsley	Non-native
Apocynaceae	Vinca major	Periwinkle	Non-native
Araceae	Zantedeschia aethiopica	Calla Lily	Non-native
Araliaceae	Hedera helix	English Ivy	Non-native
Asteraceae	Achillea millefolium	Yarrow	Native
Asteraceae	Ambrosia chamissonis	Beach-bur	Native
Asteraceae	Ambrosia psilostachya	Western ragweed	Native
Asteraceae	Anaphalis margaritacea	Pearly Everlasting	Native
Asteraceae	Anthemis cotula	Dog Fennel	Non-native
Asteraceae	Artemisia californica	California Sagebrush	Native
Asteraceae	Artemisia douglasiana	Mugwort	Native
Asteraceae	Artemisia pycnocephala	Beach Sagewort	Unknown
Asteraceae	Aster chilenses	California Aster	Native
Asteraceae	Baccharis douglasii	Salt Marsh Baccharis	Native
Asteraceae	Baccharis pilularis	Coyote Brush	Native
Asteraceae	Baccharis salicifolia	Mule Fat	Native
Asteraceae	Baccharis viminea	Mule fat	Native
Asteraceae	Bidens laevis	Bur-marigold	Native
Asteraceae	Carduus pycnocephalus	Italian Thistle	Non-native

Asteraceae	Centaurea cyanus	Bachelor's Button	Non-native
Asteraceae	Centaurea melitensis	Tocolote	Non-native
Asteraceae	Chamomilla suaveolens	Pineapple Weed	Non-native
Asteraceae	Cichorium intybus	Chicory	Non-native
Asteraceae	Cirsium vulgare	Bull Thistle	Non-native
Asteraceae	Conyza bonariensis	Bonaire horseweed	Non-native
Asteraceae	Conyza canadensis	Horseweed	Native
Asteraceae	Conyza sp.	Horseweed	Varies
Asteraceae	Cotula coronopifolia	Brass-buttons	Non-native
Asteraceae	Delairea odorata	Cape Ivy	Non-native
Asteraceae	Ericameria ericoides	Mock Heather	Native
Asteraceae	Euthamia occidentalis	Western Goldenrod	Native
Asteraceae	Filago gallica	Filago	Non-native
Asteraceae	Gnaphalium californicum	California Everlasting	Native
Asteraceae	Gnaphalium luteo-album	Weedy Cudweed	Non-native
Asteraceae	Gnaphalium ramosisimum	Pink Everlasting	Native
Asteraceae	Gnaphalium stramineum	Cudweed	Native
Asteraceae	Grindelia stricta	Coast Gum Plant	Native
Asteraceae	Hedypnois cretica	Hedypnois	Non-native
Asteraceae	Hemizonia congesta	Hayfield Tarweed	Native
Asteraceae	Hemizonia corymbosa	Coast Tarweed	Native
Asteraceae	Heterotheca grandiflora	Telegraph Weed	Native
Asteraceae	Hypochaeris glabra	Smooth Cat's Ear	Non-native
Asteraceae	Hypochaeris radicata	Hairy Cat's Ear	Non-native
Asteraceae	Jaumea carnosa	Jaumea	Native
Asteraceae	Lactuca serriola	Prickly Lettuce	Non-native
Asteraceae	Lasthenia californica	Gold Fields	Native
Asteraceae	Layia platyglossa	Tidy-tips	Native
Asteraceae	Lessingia filaginifolia	California Aster	Unknown
Asteraceae	Madia sativa	Coast Tarweed	Native
Asteraceae	Picris echioides	Bristly Ox-tongue	Non-native
Asteraceae	Senecio vulgaris	Common Groundsel	Non-native
Asteraceae	Silybum marianum	Milk Thistle	Non-native
Asteraceae	Solidago californica	California Goldenrod	Native
Asteraceae	Solidago canadensis	Canada Goldenrod	Native

Asteraceae	Soliva sessilis	Common soliva	Non-native
Asteraceae	Sonchus asper	Prickly Sow Thistle	Non-native
Asteraceae	Sonchus oleraceus	Common Sow Thistle	Non-native
Asteraceae	Stylocline gnaphaloides	Everlasting Neststraw	Native
Asteraceae	Taraxacum oficinale	Common Dandelion	Non-native
Asteraceae	Tragopogon porrifolius	Salsify	Non-native
Asteraceae	Wyethia angustifolia	Mule-ears	Native
Asteraceae	Wyethia helenioides	Gray Mule-ears	Native
Asteraceae	Xanthium spinosum	Spiny Cocklebur	Native
Asteraceae	Xanthium strumarium	Cocklebur	Native
Azollaceae	Azolla filiculoides	Mosquito Fern	Native
Betulaceae	Alnus rhombifolia	White Alder	Native
Betulaceae	Corylus cornuta var. californica	Western Hazelnut	Native
Boraginaceae	Amsinckia menziesii var. intermedia	Intermediate Fiddleneck	Native
Boraginaceae	Cryptantha leiocarpa	Coast Cryptantha	Native
Boraginaceae	Heliotropium curassavicum	Seaside Heliotrope	Native
Boraginaceae	Myosotis latifolia	Forget-me-not	Non-native
Boraginaceae	Plagiobothrys chorisianus var. hickmanii	Popcorn Flower	Native
Brassicaceae	Arabis glaba	Rock Cress	Non-native
Brassicaceae	Brassica nigra	Black Mustard	Non-native
Brassicaceae	Brassica rapa	Field Mustard	Non-native
Brassicaceae	Cakile maritima	Sea Rocket	Non-native
Brassicaceae	Capsella bursa-pastoris	Shepherd's Purse	Non-native
Brassicaceae	Cardamine oligosperma	Few-seeded Bitter Cress	Non-native
Brassicaceae	Cardaria draba	Hoary Cress	Non-native
Brassicaceae	Hirschfeldia incana	Summer Mustard	Non-native
Brassicaceae	Lobularia maritima	Sweet Alyssum	Non-native
Brassicaceae	Raphanus raphanistrum	Jointed charlock	Non-native
Brassicaceae	Raphanus sativus	Wild Radish	Non-native
Brassicaceae	Rorippa nasturtium-aquaticum	Water Cress	Native
Brassicaceae	Sisymbrium officinale	Hedge Mustard	Non-native
Caprifoliaceae	Lonicera hispidula var. vacillans	Hairy honeysuckle	Native
Caprifoliaceae	Lonicera involucrata	Twinberry	Native

Caprifoliaceae	Sambucus mexicana	Blue Elderberry	Native
Caprifoliaceae	Symphoricarpos albus var. laevigatus	Snowberry	Native
Caprifoliaceae	Symphoricarpos mollis	Snowberry	Native
Caryophyllaceae	Silene gallica	Common Catchfly	Non-native
Caryophyllaceae	Spergula arvensis	Spurrey	Non-native
Caryophyllaceae	Spergularia bocconii	Boccone's Sand Spurrey	Non-native
Caryophyllaceae	Spergularia marina	Sand Spurry	Native
Caryophyllaceae	Stellaria media	Common Chickweed	Non-native
Chenopodiaceae	Atriplex patula	Spear Oracle	Native
Chenopodiaceae	Atriplex semibaccata	Australian Saltbush	Non-native
Chenopodiaceae	Atriplex triangularis ssp. Hastata	Salt Bush	Native
Chenopodiaceae	Chenopodium album	Lamb's Quarters	Non-native
Chenopodiaceae	Chenopodium californicum	California Goosefoot	Native
Chenopodiaceae	Chenopodium macrospermum var. halophilum	Coast Goosefoot	Non-native
Chenopodiaceae	Chenopodium rubrum	Red Goosefoot	Native
Chenopodiaceae	Salicornia virginica	Pickleweed	Native
Chenopodiaceae	Salsola tragus	Russian Thistle	Non-native
Chenopodiaceae	Suaeda moquinii	California Sea-blite	Native
Chlorophyta	Enteromorpha intestinalis	Enteromorpha	Native
Convolvulaceae	Calystegia soldanella	Beach Morning-glory	Native
Convolvulaceae	Convolvulus arvensis	Bindweed	Non-native
Convolvulaceae	Cressa truxillensis	Alkali Weed	Native
Cornaceae	Cornus sp.	Creek Dogwood	Native
Crassulaceae	Crassula connata	Pygmy weed	Native
Cucurbitaceae	Marah fabaceus	Wild Cucumber	Native
Cucurbitaceae	Marah sp.	Wild Cucumber	Unknown
Cupressaceae	Cupressus macrocarpa	Monterey Cypress	
Cuscutaceae	Cuscuta salina var. major	Salt Marsh Dodder	Native
Cyperaceae	Carex barbarae	Santa Barbra Sedge	Native
Cyperaceae	Carex obnupta	Slough Sedge	Native
Cyperaceae	Carex sp.	Sedge	
Cyperaceae	Cyperus eragrostis	Tall Umbrella Sedge	Native
Cyperaceae	Cyperus sp.	Sedge	Native

Cyperaceae	Eleocharis sp.	Spike Rush	Unknown
Cyperaceae	Scirpus americanus	Olney's Bulrush	Native
Cyperaceae	Scirpus californicus	California Bulrush	Native
Cyperaceae	Scirpus robustus	Prairie Bulrush	Native
Cyperaceae	Scirpus sp.	Tule	Unknown
Dennstaetiaceae	Pteridium aquilinum var. pubescens	Bracken Fern	Native
Dryopteridaceae	Dryopteris arguta	Coastal Wood Fern	Native
Dryopteridaceae	Polystichum munitum	Sword Fern	Native
Ericaceae	Arctostaphylos pajaroensis	Pajaro Manzanita	Native - rare
Ericaceae	Vaccinium ovatum	Huckleberry	Native
Fabaceae	Acacia spp.	Wattle	Non-native
Fabaceae	Genista monspessulana	French Broom	Non-native
Fabaceae	Lathyrus vestitus	Pacific Pea	Native
Fabaceae	Lotus corniculatus	Bird's Foot Lotus	Non-native
Fabaceae	Lotus scoparius	California Broom	Native
Fabaceae	Lotus wrangelianus	Chile Trefoil	Native
Fabaceae	Lupinus albifrons	Silver Bush Lupine	Native
Fabaceae	Lupinus arboreus	Yellow Bush Lupine	Native
Fabaceae	Lupinus bicolor	Miniature Lupine	Native
Fabaceae	Lupinus nanus	Sky Lupine	Native
Fabaceae	Lupinus sp.	Lupine	Native
Fabaceae	Lupinus succulentus	Succulent Lupine	Native
Fabaceae	Medicago hispida	Bur Clover	Non-native
Fabaceae	Medicago polymorpha	California Burclover	Non-native
Fabaceae	Melilotus alba	White Sweet Clover	Non-nativeb
Fabaceae	Melilotus indica	Yellow Sweet Clover	Non-native
Fabaceae	Melilotus indicus	Yellow Sweet Clover	Non-native
Fabaceae	Trifolium angustifolium	Narrow-leaved Clover	Non-native
Fabaceae	Trifolium campestre	Low hop Clover	Non-native
Fabaceae	Trifolium dubium	Shamrock	Unknown
Fabaceae	Trifolium hirtum	Rose Clover	Non-native
Fabaceae	Trifolium incarnatum	Crimson Clover	Non-native
Fabaceae	Trifolium subterraneum	Subterranean Clover	Non-native
Fabaceae	Trifolium wormskyoldii	Cow Clover	Native

Fabaceae	Vicia gigantea	Giant Vetch	Native
Fabaceae	Vicia sativa	Spring Vetch	Non-native
Fabaceae	Vicia villosa	Hairy Vetch	Non-native
Fagaceae	Quercus agrifolia	Coast Live Oak	Native
Frankeniaceae	Frankenia salina	Alkali Heath	Native
Fumariaceae	Dicentra formosa	Bleeding Heart	Native
Garryaceae	Garrya elliptica	Coast Silktassel	Native
Geraniaceae	Erodium botrys	Long Beaked Filaree	Non-native
Geraniaceae	Erodium cicutarium	Red Stemmed Filaree	Non-native
Geraniaceae	Erodium moschatum	White-stemmed Filaree	Non-native
Geraniaceae	Erodium texanum	Filaree	Native
Geraniaceae	Geranium carolinianum	Carolina Geranium	Unknown
Geraniaceae	Geranium dissectum	Cut-leaved Geranium	Non-native
Geraniaceae	Geranium molle	Cranesbill	Non-native
Grossulariaceae	Ribes divaricatum	Straggly Gooseberry	Native
Grossulariaceae	Ribes sanguineum	Red Flowering Currant	Native
Hippocastanaceae	Aesculus californica	California Buckeye	Native
Hydrophyllaceae	Phacelia ciliata	Great Valley Phacelia	Native
Hydrophyllaceae	Phacelia ramosissima var. montereyensis	Branching Phacelia	Native
Hydrophyllaceae	Pholistoma auritum	Fiesta Flower	Native
Iridaceae	Iris douglasiana	Douglas Iris	Native
Iridaceae	Sisyrinchium bellum	Blue-eyed Grass	Native
Juglandaceae	Juglans californica var. hindsii	California Black Walnut	Non-native
Juncaceae	Juncus bufonius	Toad Rush	Native
Juncaceae	Juncus effusus var. pacificus	Pacific Bog Rush	Native
Juncaceae	Juncus lesueurii	Salt Rush	Native
Juncaceae	Juncus occidentalis	Western rush	Native
Juncaceae	Juncus patens	Common Rush	Native
Juncaceae	Juncus phaeocephalus	Brown-headed Rush	Native
Juncaceae	Juncus xiphioides	Iris-leaved Rush	Native
Juncaceae	Luzula comosa	Wood Rush	Native
Juncaginaceae	Triglochin maritima	Seaside Arrow Grass	Native
Lamiaceae	Lamium amplexicaule	Clasping Henbit	Non-native
Lamiaceae	Marrubium vulgare	Horehound	Non-native

Lamiaceae	Mentha pulegium	Pennyroyal	Non-native
Lamiaceae	Monardella villosa	Coyote Mint	Native
Lamiaceae	Salvia mellifera	Black Sage	Native
Lamiaceae	Stachys ajugoides ssp. Rigida	Hedge Nettle	Native
Lamiaceae	Stachys bullata	Hedge Nettle	Native
Lemnaceae	Lemna minima	Least Duckweed	Native
Lemnaceae	Lemna minor	Lemna minor	Native
Liliaceae	Brodiaea elegans	Harvest Brodiaea	Native
Liliaceae	Calochortus luteus	Yellow Mariposa Lily	Native
Liliaceae	Chlorogalum pomeridianum	Wavy Leafed Soap Plant	Native
Liliaceae	Dichelostemma capitatum	Blue Dicks	Native
Liliaceae	Fritillaria lanceolata	Mission Bells	Native
Liliaceae	Muilla maritima	Common Muilla	Native
Liliaceae	Trillium chloropetalum	Giant Trillium	Native
Liliaceae	Triteleia ixiodes	Golden Brodiaea	Native
Liliaceae	Triteleia laxa	Ithuriel's Spear	Native
Lythraceae	Lythrum hyssopifolia	Hyssop Loosestrife	Non-native
Malvaceae	Malva nicaeensis	Bull Mallow	Non-native
Malvaceae	Malva parviflora	Mallow	Non-native
Malvaceae	Sidalcea malvaeflora	Checker Mallow	Native
Myricaceae	Myrica californica	California Wax Myrtle	Native
Myrtaceae	Eucalyptus globulus	Eucalyptus	Non-native
Myrtaceae	Leptospermum laevigatum	Australian Tea Tree	Non-native
Oleaceae	Ligustrum vulgare	Privet	Non-native
Onagraceae	Camissonia cheiranthifolia	Beach Evening Primrose	Native
Onagraceae	Camissonia contorta	Contorted Primrose	Native
Onagraceae	Camissonia micrantha	Primrose	Native
Onagraceae	Camissonia ovata	Suncup	Native
Onagraceae	Clarkia rubicunda	Ruby Chalice Clarkia	Native
Onagraceae	Epilobium canum	California Fuchsia	Native
Onagraceae	Epilobium sp.	Fireweed	Native
Oxalidaceae	Oxalis corniculata	Creeping Oxalis	Non-native
Oxalidaceae	Oxalis pes-caprae	Bermuda Buttercup	Non-native

Oxalidaceae	Oxalis pilosa	Hairy Wood Sorrel	Native
Oxalidaceae	Oxalis sp.	Wood Sorrel	Non-native
Papaveraceae	Eschscholzia californica	California Poppy	Native
Pinaceae	Pinus radiata	Monterey Pine	Non-native to Elkhorn Slough
Plantaginaceae	Plantago coronopus	Cut-leaved Plantain	Non-native
Plantaginaceae	Plantago elongata	Annual Plantain	Native
Plantaginaceae	Plantago lanceolata	English Plantain	Non-native
Plantaginaceae	Plantago major	Common Plantain	Non-native
Plantaginaceae	Plantago subnuda	Mexican Plantain	Native
Poaceae	Agrostis pallens	Bent Grass	Native
Poaceae	Aira caryophyllea	Silver European Hair Grass	Non-native
Poaceae	Alopercurus pratensis	Meadow foxtail	Non-native
Poaceae	Avena barbata	Slender Wild Oat	Non-native
Poaceae	Avena fatua	Wild Oat	Non-native
Poaceae	Briza minor	Little Quaking Grass	Non-native
Poaceae	Bromus carinatus	California Brome	Native
Poaceae	Bromus catharticus	Rescue grass	Non-native
Poaceae	Bromus diandrus	Ripgut	Non-native
Poaceae	Bromus hordeaceus	Soft Cheat Grass	Non-native
Poaceae	Bromus madritensis	Foxtail Chess	Non-native
Poaceae	Bromus stamineus	Chilean brome	Non-native
Poaceae	Bromus trinii	Chilean Chess	Non-native
Poaceae	Cortaderia jubata	Jubata Grass	Non-native
Poaceae	Cynodon dactylon	Bermuda Grass	Non-native
Poaceae	Cynosurus echinatus	Dog-tail Grass	Non-native
Poaceae	Dactylis glomerata	Orchard Grass	Non-native
Poaceae	Danthonia californica	California Oat Grass	Native
Poaceae	Deschampsia caespitosa	Tufted Hairgrass	Native
Poaceae	Deschampsia elongata	Slender Hairgrass	Native
Poaceae	Distichlis spicata	Salt Grass	Native
Poaceae	Ehrharta calycina	Veldt Grass	Non-native
Poaceae	Ehrharta erecta	Panic Veldt Grass	Non-native
Poaceae	Elymus glaucus	Blue Wild Rye	Native

Poaceae	Festuca arundinacea	Reed Fescue	Non-native
Poaceae	Holcus lanatus	Velvet Grass	Non-native
Poaceae	Hordeum brachyantherum	Meadow Barley	Native
Poaceae	Hordeum marinum	Mediterranean Barley	Non-native
Poaceae	Hordeum murinum ssp. leporinum	Hare Barley	Non-native
Poaceae	Hordeum sp.	Barley	
Poaceae	Leymus condensatus	Giant Wild Rye	Native
Poaceae	Leymus mollis	American Dune Grass	Native
Poaceae	Leymus triticoides	Creeping Wild Rye	Native
Poaceae	Lolium multiflorum	Italian Ryegrass	Non-native
Poaceae	Lolium perenne	Perennial Ryegrass	Non-native
Poaceae	Melica imperfecta	Coastrange Melic	Native
Poaceae	Nassella cernua	Nodding Needlegrass	Native
Poaceae	Nassella lepida	Foothill Needlegrass	Native
Poaceae	Nassella pulchra	Purple Needlegrass	Native
Poaceae	Parapholis incurva	Sickle Grass	Non-native
Poaceae	Pennisetum clandestinum	Kikuyu Grass	Non-native
Poaceae	Phalaris aquatica	Harding Grass	Non-native
Poaceae	Poa annua	Annual Bluegrass	Non-native
Poaceae	Polypogon monspeliensis	Rabbit's Foot Grass	Non-native
Poaceae	Vulpia bromoides	Brome Fescue	Non-native
Poaceae	Vulpia microstachys var.pauciflora	Pacific Fescue	Native
Poaceae	Vulpia myuros	Rattail Fescue	Non-native
Poaceae	Vulpia sp.	Fescue	Unknown
Polygonaceae	Chorizanthe sp.	Spineflower	Unknown
Polygonaceae	Eriogonum nudum	Wild Buckwheat	Native
Polygonaceae	Polygonum arenastrum	Dooryard Knotweed	Non-native
Polygonaceae	Polygonum aviculare	Knotweed	Native
Polygonaceae	Polygonum persicaria	Lady's Thumb	Non-native
Polygonaceae	Polygonum punctatum	Water Smartweed	Unknown
Polygonaceae	Rumex acetosella	Sheep Sorrel	Non-native
Polygonaceae	Rumex conglomeratus	Clustered Dock	Non-native
Polygonaceae	Rumex crispus	Curly Dock	Non-native
Polygonaceae	Rumex pulcher	Fiddle dock	Non-native

Polypodiaceae	Polypodium californicum	Resurrection Fern	Native
Portulacaceae	Calandrinia ciliata	Red Maids	Native
Portulacaceae	Claytonia perfoliata	Miner's Lettuce	Native
Potamogetonaceae	Ruppia maritima	Ditch Grass	Native
Primulaceae	Anagallis arvensis	Scarlet Pimpernel	Non-native
Pteridaceae	Pentagramma triangularis	Golden Back Fern	Native
Ranunculaceae	Aquilegia formosa	Red Columbine	Native
Ranunculaceae	Ranunculus californicus	California Buttercup	Native
Rhamnaceae	Ceanothus thyrsiflorus	Blue blossom	Native
Rhamnaceae	Rhamnus californica	Coffeeberry	Native
Rosaceae	Acaena pinnatifida var. californica	California Acaena	Native
Rosaceae	Adenostoma fasciculatum	Chamise	Native
Rosaceae	Cotoneaster pannosa	Cotoneaster	Non-native
Rosaceae	Fragaria sp.	Wild Strawberry	Native
Rosaceae	Heteromeles arbutifolia	Christmas Berry	Native
Rosaceae	Holodiscus discolor	Cream Bush	Native
Rosaceae	Horkelia californica	Horkelia	Native
Rosaceae	Horkelia cuneata	Wedge-leaved Horkelia	Native
Rosaceae	Oemleria cerasiformis	Oso berry	Native
Rosaceae	Potentilla anserina ssp. Pacifica	Pacific Silverweed	Native
Rosaceae	Potentilla sp.	Cinquefoil	Native
Rosaceae	Rosa californica	California Wild Rose	Native
Rosaceae	Rosa gymnocarpa	Wood rose	Native
Rosaceae	Rubus discolor	Himalayan Blackberry	Non-native
Rosaceae	Rubus ursinus	California Blackberry	Native
Rosaceae	Sanguisorba minor ssp. Muricata	Burnet	Non-native
Rubiaceae	Galium aparine	Cleaver's Bedstraw	Non-native
Rubiaceae	Galium sp.	Bedstraw	Unknown
Salicaceae	Salix lasiolepsis	Arroyo Willow	Native
Scrophulariaceae	Castilleja densiflora	Owl's Clover	Native
Scrophulariaceae	Castilleja exserta	Owl's Clover	Unknown
Scrophulariaceae	Castilleja foliolosa	Woolly Painted Cap	Native
Scrophulariaceae	Castilleja sp.	Indian Paintbrush	Native
Scrophulariaceae	Mimulus aurantiacus	Sticky Monkeyflower	Native
Scrophulariaceae	Mimulus guttatus	Large Monkeyflower	Native

Scrophulariaceae	Pedicularis densifiorus	Indian Warrior	Native
Scrophulariaceae	Scrophularia californica	California Figwort	Native
Scrophulariaceae	Triphysaria sp.		Native
Solanaceae	Solanum douglasii	Douglas' nightshade	Native
Solanaceae	Solanum umbelliferum	Blue Witch	Native
Typhaceae	Sparganium eurycarpum	Broad-fruited Bur-reed	Native
Typhaceae	Typha angustifolia	Narrow-leaved Cattail	Non-native
Typhaceae	Typha latifolia	Broad-leaved Cattail	Native
Urticaceae	Urtica dioica ssp. holosericea	Stinging Nettle	Native
Urticaceae	Urtica urens	Dwarf Nettle	Non-native
Verbenaceae	Verbena lasiostachys	Western Verbena	Native

2. Marine & Brackish Water Invertebrates in Elkhorn Slough.

The first reference to the presence of the species at Elkhorn Slough is listed after its name. Additionally, references 1, 2, and/or 3—the only thorough surveys of the slough's invertebrates—are listed if those authors reported the presence of the species. The number of species is listed with each higher taxon name.

Key for References: 1 = MacGinitie 1935; 2 = Nybakken, Cailliet, and Broenkow 1977; 3 = Kvitek et al. 1996 and R. Kvitek, pers. comm.; 4 = Wasson et al. 2001; 5 = DeVogelaere et al. 1998; 6 = J. Pearse, pers. comm.; 7 = Ricketts et al. 1985; 8 = Pace 1978; 9 = M. Silberstein, pers. comm.; 10 = Hsueh 1988; 11 = Wasson, pers. comm.; 12 = Nybakken, pers. comm.; 13 = Kudenov and Blake 1985; 14 = Addicott 1952; 15 = Kellogg 1980; 16 = Byers 1999; 17 = J. Brown, pers. comm.

*indicates species is not native to this bioregion

+means this species is locally extinct, or so rare it has not been found in recent searches for it

PHYLUM PORIFERA (sponges) 9

Cliona ? celata* 1, 2
Halichondria bowerbanki* 4
Haliclona cinera 1
Haliclona loosanoffi* 4
Haliclona permollis 2
Halisarca sacra 1
Hymeniacidon sinapium* 4
Mycale macginitiei 1
Topsentia sp. 4

PHYLUM CNIDARIA 25

CLASS HYDROZOA (hydroids) 11

Abietinaria filicula 1
Aglaophenia struthionides 1
Bougainvillia mertensi 1
Campanularia sp. 1
Cordylophora caspia* 4
Ectopleura crocea* 1
Obelia gracilis 1
Obelia longissima 1, 2
Opercularella lacerata 1
Polyorchis penicillatus 2
Syncoryne mirabilis 1

CLASS SCYPHOZOA (jellyfish) 4

Aurelia aurita* 1
Chrysaora melanaster 17
Pelagia colorata 2
Pelagia noctiluca 2

CLASS ANTHOZOA (sea anemones)10

Anthopleura elegantissima 1, 2
Anthopleura sola 6
Anthopleura xanthogrammica 1, 2
Diadumene franciscana* 4
Diadumene leucolena* 4
Diadumene lineata* 4
Edwardsiella sp. 3
Metridium senile 1, 2
Pachycerianthus fimbriatus 2
Zaolutus actius+ 1

PHYLUM CTENOPHORA 1

Pleurobrachia bachei 1

PHYLUM PLATYHELMINTHES (flatworms) 9

CLASS TREMATODA 4

Cercaria batillariae* 4
Epibdella pacifica 1
Probolitrema californiense 1
Udonella myliobati 1

CLASS POLYCLADIDA 4

Eurylepta aurantiaca 1
Kaburakia excelsa 12
Notoplana sp. 6
Stylochoplana heathi 1

CLASS CESTODA 1
Phyllobothrium sp. 1

PHYLUM NEMERTEA 9
Carcinonemertes sp. 12
Carinoma mutabilis 1, 12
Cerebratulus californiensis 6, 12
Cerebratulus sp. 1 1
Cerebratulus sp. 2 1
Malacobdella grossa 14
Micrura sp. 1
Pantinonemertes californiensis 12
Paranemertes peregrina 1

PHYLUM ECHIURA 2
Listriolobus pelodes 9
Urechis caupo 1, 3
PHYLUM SIPUNCULA 3
Phascolosoma gouldi 1
Siphonosoma ingens 6
Themiste perimeces 1, 12
PHYLUM ANNELIDA 144
CLASS POLYCHAETA 143
Amaeana occidentalis 2
Ampharete labrops 2
Anaitides williamsi 2
Armandia brevis 1, 2, 3
Audouinia tentaculata 1
Axiothella sp. 3
Boccardia columbiana 2
Boccardia hamata 2
Boccardia proboscidea 2
Boccardia redeki 12
Boccardia rou 3
Boccardia sp. 3
Capitella capitata 1, 2, 3
Chaetozone setosa 2
Chone gracilis 2
Chone infundibuliformis 1
Cirratulus cirratus 2
Cirriformia spirabrancha 2
Cistenides brevicoma 7
Ctenodrilus serratus 2
Diopatra ornata 2
Diopatra splendidissima 2
Dispio uncinata 2
Dorvillea articulata 2
Eteone californica 2
Eteone dilatae 2
Eteone sp. 3
Eudistyllia polymorpha 1
Eulalia quadrioculata 2
Eumida bifoliata 2
Eumida sp. 3
Exogone lourei 2, 3
Exogone sp. 3
Ficopomatus enigmaticus* 4
Glycera alba macrobranchiata 1
Glycera convoluta 2
Glycera robusta 1, 2
Glycera rugosa 1
Glycera sp. 3
Glycinde sp. 2, 3
Gyptis brevipalpa 2
Halosydna brevisetosa 1
Haploscoloplos pugettensis 2
Harmothoe lunulata 2
Harmothoe priops 2
Hemipodus borealis 1, 2
Hesionura sp. 2
Hesperonoe adventor 1, 6
Hesperonoe complanata 1
Hesperonoe sp. 1
Heteromastus filiformis* 4
Heteromastus filobranchus 2
Leitoscoloplos elongatus 5
Leodice longicirrata 1
Loimia medusa 1
Lumbrineris cruzensis 2
Lumbrineris japonica index 1
Lumbrineris limicola 2
Lumbrineris luti 2
Lumbrineris sp. 3
Lumbrineris tetraura 1, 2
Lumbrineris zonata 2
Magelona sacculata 2
Malacoceros glutaeus 2
Mediomastus californiensis 2, 3
Mesochaetopterus taylori 7
Microphthalmus sp. 2
Naineris dendritica 2
Neanthes brandti 7
Neanthes virens 1, 2
Neoamphitrite robusta 1
Nephtys caeca ciliata 1
Nephtys caecoides 1, 2
Nephtys californiensis 3
Nephtys cornuta franciscana 2, 3
Nereis dumerilii agassizi 1
Nereis grubei 2
Nereis procera 1, 2
Nereis sp. 3
Nereis vexillosa 1, 6
Nereis virens 1
Nereis virens brandti 1
Nerinides acuta 2
Northia elegans 1, 2
Notomastus giganteus 1
Notomastus magnus 2
Notomastus sp. 3
Notomastus tenuis 1, 2, 3
Onuphis eremita 1, 2

Owenia collaris 2
Owenia sp. 2
Paleanotus bellis 2
Pareurythoe californica 1, 2
Pectinaria auricoma 1
Pectinaria californiensis 2
Perinereis monterea 1
Pherusa plumosa 5
Pholoe glabra 2
Phyllodoce muscosa 2
Pilargis berkeleyi 1
Pilargis maculata 2
Pista elongata 1
Platynereis bicanaliculata 2
Platynereis sp. 3
Polycirrus sp. 2
Polydora brachycephala 2
Polydora citrona 2
Polydora ligni * 2
Polydora socialis 2
Polydora sp. 3
Prionospio cirrifera 2
Prionospio pinnata 2
Prionospio pygmaea 2
Protodorvillea gracilis 2
Pseudeurythose reducta 13
Pseudopolydora paucibranchiata* 2
Pseudopolydora sp. 3
Pygospio elegans 2
Rhynchospio glutaea 5
Schistomeringos longicornis 5
Schistomeringos rudolphi 2
Scololepis tridentata 2
Scoloplos armiger 2
Scoloplos sp. 2
Serpula vermicularis 6
Sigambra tentaculata 2
Spiochaetopterus costarum 2
Spiophanes berkeleyorum 2
Spiophanes bombyx 2, 3
Spiophanes missionensis 2, 3
Spriorbis sp. 6
Sthenelais fusca 1
Sthenelais tertiaglabra 5
Sthenelais verruculosa 2
Streblospio benedicti* 2, 3
Styllaroides plumosa 1
Syllides sp. 2
Tharyx monilaris 2
Tharyx parvus 2
Tharyx sp. 3
Travisia sp. 3
Trochochaeta multisetosum 2
Typosyllis armillaris 2

CLASS HIRUDINEA (leeches) 1
Branchellion sp. 1

PHYLUM ARTHROPODA 161
CLASS PYCNOGONIDA
(sea spiders) 3
Ammothea hilgendorfi 2
Phoxichilidium femoratum 2
Pycnogonum stearnsi 2

CLASS CRUSTACEA 158
Subclass Cirripedia (barnacles) 11
Balanus crenatus 11
Balanus glandula 6
Balanus improvisus* 4
Balanus nubilis 1
Chthamalus sp. 6
Lepas hilli 1
Megabalanus californicus 1, 6
Pollicipes polymerus 6
Sacculina sp. 1
Semibalanus cariosus 5
Tetraclita rubescens 6

Subclass Branchiura (fish lice) 1
Argulus melanostictus 1

Subclass Branchiopoda 2
Evadne nordmanni 2
Podon leuckarti 2

Subclass Copepoda 15
Acartia californiensis 8
Acartia clausii 8
Acartia longiremis 8
Acartia tonsa 8
Calanus pacificus 2
Eucalanus bungi 2
Eurytemora hirundoides 2
Hemicyclops callianassae 1
Hemicyclops thysanotus 1
Microcalanus sp. 2
Modiolicola gracilis 1
Mytilicola orientalis* 4
Oithona spinifera 2
Tortanus discaudatus 2
Trebius caudatus 1

Subclass Ostracoda 3
Euphilomedes carcharodonta 2
Euphilomedes longiseta 2
Euphilomedes oblonga 2

Subclass Malacostraca 126
Order Isopoda (Pill Bugs) 15
Austrosignum tillerae 12

Exosphaeroma inornata	5
Exosphaeroma media	2
Gnorimosphaeroma oregone	3
Iais californica*	4
Ianiropsis montereyensis	2
Idotea resecata	1
Idotea wosnesenskii	2
Limnoria lignorum	1, 2
Limnoria quadripunctata*	2
Lironeca vulgaris	1
Munna ubiquita	2
Phyllodurus abdominalis	1
Portunion conformis	2
Sphaeroma quoyanum*	4
Order Tanaidacea	6
Anatanais normani	2
Leptochelia dubia	2, 3
Leptognathia sp.	12
Sinelobus sp.	4
Tanais carolinii	2
Tanais sp.	12
Order Cumacea	5
Cumella vulgaris	3
Cyclaspis sp.	2, 3
Cyclaspis nubila	2
Hemilamprops californiensis	2
Lamprops sp.	2
Order Amphipoda (sand hoppers)	54
Allorchestes angusta	2
Allorchestes sp.	3
Ampithoe lacertosa	1
Ampithoe valida*	4
Anisogammarus confervicolus	1, 2
Aoroides columbiae	1, 2
Aoroides sp.	3
Argissa hamatipes	2
Atylus tridens	2
Caprella acutifrons	1
Caprella equilibria	1
Caprella brevirostris	2
Caprella californica	2, 3
Caprella ferrea	2
Caprella gracilior	2
Caprella mendax	2
Caprella mutica*	4
Caprella natalensis	2
Caprella penantis	2
Caprella scaura	1
Caprella sp.	3
Caprella verrucosa	5
Corophium acherusicum*	2
Corophium insidiosum*	2
Corophium salmonis	1
Corophium sp.	3
Corophium spinicorne	1, 2
Corophium uenoi*	2
Dulichia sp.	2
Eohaustorius sencillus	2
Erichthonius sp.	3
Gammaropsis sp.	3
Grandidierella japonica*	3
Grandidierella sp.	3
Ischyrocerus pelagops	2
Jassa marmorata*	4
Jassa sp.	2
Listriella diffusa	2
Maera sp.	2
Melita nitida*	4
Melita sp.	2
Metopa sp.	2
Monoculodes spinipes	2
Orchestia traskiana	2
Parapleustes derzhavini*	4
Photis sp.	2
Podocerus sp.	2
Pontogeneia sp.	3
Protomedeia articulata	2
Rhepoxynius daboius	2
Rhepoxynius variatus	2
Synchelidium shoemakeri	2
Tiron biocellata	2
Tritella laevis	2
Order Mysidacea (opossum shrimps)	1
Acanthomysis sp.	2
Order Leptostraca	1
Nebalia pugettensis	2
Order Decapoda (shrimps and crabs)	43
Betaeus longidactylus	1
Callianassa californiensis	1, 2
Callianassa gigas	1
Callianassa sp.	3
Cancer antennarius	1, 2
Cancer anthonyi	1, 2
Cancer gibbosulus	1
Cancer gracilis	1, 2
Cancer jordani	1, 2
Cancer magister	1
Cancer productus	1, 2
Carcinus maenas*	4
Crangon nigricauda	1, 2
Crangon nigromaculata	17
Hemigrapsus nudus	1
Hemigrapsus oregonensis	1, 2
Heptacarpus paludicola	1, 2

Heptacarpus stichensis 1
Hippolyte californiensis 1
Isocheles pilosus 2
Lophopanopeus bellus 10
Loxorhynchus grandis 2
Opisthopus transversus 1
Pachycheles rudis 1
Pachygrapsus crassipes 1, 2
Pagurus granosimanus 5
Pagurus hirsutiusculus 1
Pagurus samuelis 1
Palaemon macrodactylus* 7
Petrolisthes cinctipes 1
Pinnixa faba 1
Pinnixa franciscana 1, 2
Pinnixa longipes 1
Pinnixa schmitti 1
Pinnixa sp. 3
Pinnixa tomentosa 1
Pinnixa tubicola 1, 2
Pinnixa weymouthi 10
Pugettia producta 1, 2
Randallia ornate 2
Scleroplax granulata 1, 2
Synalpheus lockingtoni 2
Upogebia pugettensis 1, 2

Order Euphausiacea (krill) 1
Euphausia pacifica 2

PHYLUM BRACHIOPODA 1
Glottidia albida 2

PHYLUM PHORONIDA 1
Phoronopsis viridis+ 1, 2

PHYLUM KAMPTOZOA (=ENTOPROCTA) 2
Barentsia benedeni* 4
Barentsia gracilis* 1, 12

PHYLUM BRYOZOA (=ECTOPROCTA) **18**
Amathia vidovici* 4
Bowerbankia gracilis* 1, 4
Bugula "neritina"* 4
Bugula californica 12
Bugula sp. 6
Bugula stolonifera* 4
Buskia seriata 4
Celleporaria brunnea 6
Conopeum tenuissimum* 4
Crisia occidentalis 12
Cryptosula pallasiana* 4
Dendrobeania lichenoides 12
Membranipora membranacea1
Reginella hippocrepis 11
Schizoporella unicornis* 4
Tricellaria occidentalis 12
Tricellaria sp. 12
Watersipora "subtorquata"*4

PHYLUM MOLLUSCA 160
CLASS POLYPLACOPHORA (chitons) 7
Lepidochitona dentiens 5
Lepidochitona raymondi 1
Lepidozona sinudentata 1
Mopalia ciliata 1
Mopalia hindsii 1, 6
Mopalia muscosa 1, 6
Nuttallina californica 6

CLASS BIVALVIA 62
Adula diegensis 1
Bankia setacea 1, 2
Chaceia ovoidea 1
Clinocardium nuttallii 1, 2
Cooperella sp. 3
Cooperella subdiaphana 2
Crassadoma giganteus 1, 6
Crassostrea virginica 1
Cryptomya californica 2, 3
Gemma gemma* 2, 3
Hiatella arctica 1, 2
Leptopecten latiauratus 12
Lithophaga plumula 1
Lyonsia californica 2
Lyrodus pedicellatus* 1, 4
Macoma acolasta 2
Macoma balthica 2, 3
Macoma dolabriformis 1
Macoma inquinata 1, 2, 14
Macoma nasuta 1, 2, 3
Macoma secta 1, 2
Mactra sp. 2
Modiolus capax 1
Modiolus rectus 1, 2
Musculista senhousia* 4
Musculus sp. 2
Mya arenaria*+ 1, 2
Mysella aleutica 2
Mysella sp. 2, 3
Mytilus californianus 6
Mytilus trossulus/
galloprovincialis* 1, 2
Naeromya compressa 5
Nuttallia nuttallii* 1
Orobitella rugifera 1
Ostrea conchaphila 1, 2
Panopea generosa 1, 2
Pecten hindsii 1
Penitella penita 1
Petricola carditoides 1
Platyodon cancellatus 1

Pododesmus cepio 1
Protothaca sp. 3
Protothaca staminea 1, 2, 3
Protothaca tenerrima 1, 2
Pseudochama exogyra 1
Pseudopythina compressa 1
Saxidomus nuttalli 1, 2, 3
Siliqua lucida 1, 2
Solen sicarius 1, 2
Tagelus californianus 1, 6
Tellina bodegensis 1
Tellina meropsis 2
Tellina modesta 1, 2, 3
Tellina nuculoides 2
Tivela stultorum 1
Trachycardium quadragenarium2
Transennella tantilla 2
Tresus capax 5
Tresus molli 3
Tresus nuttallii 1, 2
Venerupis philippinarum* 4
Zirfaea pilsbryi 1, 2

CLASS GASTROPODA 88
Subclass Prosobranchia 40
Acanthina spirata 1, 2
Alia carinata 2
Alia gausapata 5
Alia gouldii 2
Alia sp. 3
Alvinia compacta 2
Asperiscala bellastriata 5
Assiminea californica 2
Batillaria attramentaria* 2
Carinaria sp. 2
Cerithidea californica+ 16
Crepidula nummaria 1
Diodora aspersa 1
Epitonium bellastriatum 2
Kellia laperousii 1, 2
Kurtziella plumbea 2
Lacuna porrecta 1
Lacuna unifasciata 1
Littorina plena/scutulata 1, 6
Lottia digitalis/austrodigitalis 6
Lottia gigantea 6
Lottia limatula 1, 6
Lottia paradigitalis 6
Macclintockia scabra 1, 2
Marseniopsis sharonae 6
Nassarius fossatus 1, 6
Nassarius mendicus 2
Nassarius rhinetes 2, 3
Nucella emarginata 2
Olivella biplicata 1, 2
Olivella pycna 2, 3
Olivella sp. 3
Polinices draconis 1
Polinices lewisii 1, 2
Polinices pallidus 5
Tectura persona 1
Tegula funebralis 1, 2
Tryonia imitator 15
Urosalpinx cinerea* 4
Vitrinella sp. 2

Subclass Pulmonata 2
Myosotella myosotis* 2
Onchidella borealis 2

Subclass Opisthobranchia 46
Acanthodoris lutea 2
Acanthodoris pilosa 2
Acanthodoris rhodoceras 2
Aeolidia papillosa 1, 2
Aglaja diomedea 2
Alderia modesta 2
Ancula lentiginosa 2
Ancula pacifica 2
Anisodoris nobilis 17
Aplysia californica 1, 2
Aplysiopsis smithi 2
Archidoris montereyensis 2
Bulla gouldiana 2
Catriona alpha 2
Chelidonura inermis 1, 2
Coryphella cooperi 2
Coryphella sp. 1, 2
Cumanotus beaumonti 2
Cylichna attonsa 2
Dendronotus frondosus 2
Dendronotus iris 2
Dendronotus sp. 1
Dendronotus subramosus 17
Diaulula sandiegensis 2
Doto amyra 2
Doto sp. 1
Elysia hedgpethi 2
Emarcusia morroensis 2
Eubranchus rustyus 2
Flabellina trilineata 2
Galvina sp. 1
Haminoea vesicula 1, 2
Melibe leonina 2
Okenia angelensis 2
Okenia plana* 4
Onchidoris bilamellata 2
Onchidoris hystricina 2
Phidiana crassicornis 1, 2
Philine ?auriformis* 4
Philine sp. 1
Phyllaplysia taylori 1, 2

Polycera atra	2	
Polycera hedgpethi		2
Stiliger fuscovittatus		2
Tenellia adspersa*		4
Trinchesia albocrusta		2
CLASS CEPHALOPODA		3
Loligo opalescens		12
Octopus rubescens		17
Paroctopus apollyon	1	

PHYLUM ECHINODERMATA 7

Amphiodia occidentalis	1
Dendraster excentricus	1, 2
Leptosynapta albicans	1

3. Invertebrate insects of the Elkhorn Slough

Families of insects known from Elkhorn Slough National Estuarine Research Reserve

Order: **Coleoptera** Family	Order: **Lepidoptera** Family	Order: **Diptera** Family	Order: **Hymenoptera** Family	Order: **Hemiptera** Family	Order: **Homoptera** Family	Order: **Orthoptera** Family	Order: **Neuroptera** Family	Order: **Psocoptera** Family	Order: **Dermaptera** Family
Bostrichidae	Arctiidae	Anthomyiidae	Anthophoridae	Corixidae	Aphididae	Acrididae	Hemerobiidae	Psocidae	Forficulidae
Cantharidae	Dioptidae	Calliophoridae	Apidae	Largidae	Cercopidae	Gryllacrididae	Raphidiidae		
Carabidae	Geometridae	Carnidae	Braconidae	Miridae	Cixiidae	Stenopelmatidae			
Cerambycidae	Hesperiidae	Hippoboscidae	Formicidae	Pentatomidae	Membracidae				
Chrysomelidae	Lycaenidae	Milichiidae	Halictidae	Reduviidae					
Coccinellidae	Lymantridae	Muscidae	Ichneumonidae	Saldidae					
Curculionidae	Noctuidae	Syrphidae	Pompilidae						
Dermestidae	Nolidae	Tachnidae	Vespidae						
Elateridae	Nymphalidae	Tephritidae							
Endomychidae	Pieridae	Tipulidae							
Hydrophiliidae	Pterophoridae	Torymidae							
Melyridae	Pyralidae								
Phengodidae	Saturniidae								
Scarabaeidae	Sesiidae								
Silphidae	Sphingidae								
Staphylinidae									
Tenebrionidae									
Trogositidae									
Total = 18	Total = 15	Total = 11	Total = 8	Total = 5	Total = 4	Total = 3	Total = 2	Total = 1	Total = 1

Total number of families = 69

4. Terrestrial Invertebrates

	agri lands	beach/dunes	coast waters	estuarine	fresh marsh	grasslands	residential	riparian	woodlands	abundance	status
CLASS AMPHIBIA											
Order Caudata (salamanders)											
Family Ambystomatidae (mole salamanders)											
California tiger salamander											
Ambystoma tigrinum californiense				x	x		x	x	x	U	
Santa Cruz long-toed salamander											
Ambystoma macrodactylum croceum				x	x		x	x	x	U	1,3,4
Family Salamandridae (newts)											
Coast range newt											
Taricha torosa torosa				x	x		x	x		P	
Family Plethodontidae (lungless salamanders)											
Monterey salamander											
Ensatina eschscholtzii eschscholtzii							x	x	x	C	
Arboreal salamander											
Aneides lugubris							x	x	x	C	
Pacific slender salamander											
Batrachoseps pacificus	x	x					x	x	x	C	
Order Salientia (Frogs and Toads)											
Family Bufonidae (true toads)											
California toad											
Bufo boreas halophilus	x						x	x	x	C	
Family Hylidae (treefrogs)											
Pacific treefrog											
Hyla regilla	x						x	x	x	C	
Family Ranidae (true frogs)											
California red-legged frog											
Rana aurora draytonii				x	x			x	x	U	2
Foothill yellow-legged frog											
Rana boylii								x	x	P	
Bullfrog											
Rana catesbeiana				x	x			x	x	C	5
CLASS REPTILIA											
Order Testudines (turtles)											
Family Emydidae (water and box turtles)											
Southwestern pond turtle											
Clemmys marmorata marmorata	x				x	x		x	x	C	
Order Squamata (lizards and snakes)											
Family Iguanidae (iguanids)											
Northwestern fence lizard											
Sceloporus occidentalis occidentalis	x					x	x		x	C	
Coast horned lizard											
Phrynosoma coronatum						x			x	U	
Family Scincidae (skinks)											
Skilton skink											
Eumeces skiltonianus skiltonianus	x					x		x	x	C	
Family Anguidae (alligator lizards)											
California alligator lizard											
Gerrhonotus multicarinatus multicarinatus	x					x	x		x	C	
San Francisco alligator lizard											
Gerrhonotus coeruleus coeruleus		x				x	x		x	P	
Family Anniellidae (California legless lizards)											
Black legless lizard											
Anniella pulchra nigra		x				x		x	x	C	
Family Boidae (boas)											
Pacific rubber boa											
Charina bottae bottae						x		x	x	U	
Family Colubridae (colubrids)											
Monterey ringneck snake											
Diadophis punctatus vandenburghi	x					x	x		x	C	
Sharp-tailed snake											
Contia tenuis							x		x	P	
Western yellow-bellied racer											
Coluber constrictor mormon	x						x		x	C	
Alameda whipsnake											
Masticophis lateralis lateralis							x			U	
Pacific gopher snake											
Pituophis melanoleucus catenifer	x						x	x		C	
California kingsnake											
Lampropeltis getulus californiae	x					x			x	C	
California red-sided garter snake											
Thamnophis sirtalis parietalis	x					x	x	x		C	
Coast garter snake											
Thamnophis elegans terrestris	x	x			x		x			C	
Santa Cruz garter snake											
Thamnophis couchi atratus						x			x	C	
Family Viperidae (vipers)											
Northern Pacific rattlesnake											
Crotalus viridis oreganus					x		x	x	x	U	
CLASS MAMMALIA											
Order Marsupialia (pouched animals)											
Family Didelphidae (opossums)											
Opossum											
Didelphis marsupialis	x	x						x	x	C	5
Order Insectivora (insect eaters)											
Family Soricidae (shrews)											
Trowbridge shrew											
Sorex trowbridgei									x	P	
Vagrant shrew											
Sorex vagrans						x	x		x	P	
Ornate shrew											
Sorex ornatus		x		x	x				x	P	
Family Talpidae (moles)											
Shrew-mole											
Neurotrichus gibbsi						x			x	U	
Broad-handed mole (California mole)											
Scapanus latimanus	x	x				x	x		x	C	
Order Chiroptera (bats)											
Family Vespertilionidae (evening bats and plainnose bats)											
Little brown myotis											
Myotis lucifugus							x		x	P	
Yuma myotis											
Myotis yumanensis							x		x	P	
Long-eared myotis											
Myotis evotis							x		x	P	
Fringed myotis											
Myotis thysanodes							x		x	P	
Long-legged myotis (hairy-winged myotis)											
Myotis volans							x		x	U	
California myotis											
Myotis californicus							x	x		C	
Small-footed myotis											
Myotis leibii									x	P	
Western pipistrel											
Pipistrellus hesperus							x			C	
Big brown bat											
Eptesicus fuscus	x						x	x		C	
Red bat											
Lasiurus borealis	x								x	P	
Hoary bat											
Lasiurus cinereus	x							x		C	
Western big-eared bat (Lump-nosed bat)											
Plecotus townsendi							x		x	P	
Pallid bat											
Antrozous pallidus						x	x		x	C	
Family Molossidae (freetail bats)											
Brazilian freetail bat (Mexican freetail bat)											
Tadarida brasiliensis							x		x	P	
Order Carnivora (flesh-eaters)											
Family Procyonidae (raccoons)											
Raccoon											
Procyon lotor	x	x		x	x		x	x	x	C	
Family Bassariscidae (ringtails)											
Ringtail											
Bassariscus astutus						x		x	x	P	4
Family Mustelidae (weasels and skunks)											
Longtail weasel											
Mustela frenata	x	x				x	x		x	C	
Sea otter											
Enhydra lutris			x	x					C		2,4
Badger											
Taxidea taxus						x			x	U	
Spotted skunk											
Spilogale putorius							x	x		P	
Striped skunk											
Mephitis mephitis				x	x	x	x	x		C	
Family Canidae (dogs, wolves, and foxes)											
Coyote											
Canis latrans	x					x	x		x	U	
Red fox											
Vulpes fulva							x	x	C		5
Gray fox											
Urocyon cinereoargenteus		x				x			x	U	
Family Felidae (cats)											
Mountain lion											
Felis concolor						x			x	U	4
Bobcat											
Lynx rufus		x				x			x	U	
Order Pinnipedia (seals and sea lions)											
Family Otariidae (sea lions and eared seals)											
California sea lion											
Zalophus californianus			x	x						C	
Family Phocidae (hair seals and earless seals)											
Harbor seal											
Phoca vitulina			x	x						C	
Order Rodentia (gnawing mammals)											
Family Sciuridae (squirrels)											
California ground squirrel											
Spermophilus beecheyi	x					x				C	
Western gray squirrel											
Sciurus griseus								x	x	C	
Eastern gray squirrel											
Sciurus carolinensis								x	x	P	5
Fox squirrel											
Sciurus niger								x	x	P	5
Family Geomyidae (pocket gophers)											
Valley pocket gopher											
Thomomys bottae	x	x			x	x			x	C	
Family Heteromyidae											
(pocket mice and kangaroo rats)											
California pocket mouse											
Perognathus californicus								x		C	
Heermann kangaroo rat											
Dipodomys heermanni								x		P	
Santa Cruz kangaroo rat											
Dipodomys venustus								x		P	
Family Castoridae (beavers)											
Beaver											
Castor canadensis								x	x	P	
Family Cricetidae (rats and mice)											
Western harvest mouse											
Reithrodontomys megalotis	x	x		x	x	x				C	
California mouse											
Peromyscus californicus									x	C	
Deer mouse											
Peromyscus maniculatus	x	x				x	x		x	C	
Piñon mouse											
Peromyscus truei									x	C	
Dusky-footed woodrat											
Neotoma fuscipes								x	x	C	
California meadow mouse (California vole)											
Microtus californicus	x	x		x	x	x				C	
Muskrat											
Ondatra zibethica					x			x		U	5
Family Muridae (Old World rats and mice)											
House mouse											
Mus musculus		x		x				x		C	5
Norway rat											
Rattus norvegicus		x		x				x		C	5
Black rat											
Rattus rattus								x		C	5
Order Lagomorpha (hares and rabbits)											
Family Leporidae (hares and rabbits)											
Blacktail jackrabbit											
Lepus californicus	x	x		x		x				U	
Audubon cottontail (Desert cottontail)											
Sylvilagus audubonii	x							x	x	C	
Brush rabbit											
Sylvilagus bachmani								x		C	
Order Artiodactyla (even-toed ungulates)											
Family Cervidae (deer)											
Mule deer (Blacktail deer)											
Odocoileus hemionus	x	x						x		C	
Order Cetacea (whales)											
Family Eschrichtiidae (gray whale)											
Gray whale											
Eschrichtius robustus			x							C	1
Family Delphinidae											
Harbor porpoise											
Phocoena phocoena			x							C	
Locally extinct (gone but not forgotten)											
California coast grizzly											
Ursus horribilis											
Tule elk											
Cervus elaphus nannodes											

5. Marine Fish

Species of finfish (alphabetically ordered by Family) collected from Elkhorn Slough, California and adjacent areas (Moss Landing Harbor, Jetties and Bennett Slough).

Life style (M = marine, MI = marine immigrant, R = resident, PR = partial resident, and F = freshwater)
Life stage (A = adult, J = juvenile, L = larva, E = egg) '?' indicates that species or life stage were not verified.
NN indicates non-native species.
Common and scientific names follow Robins et al. (1991) and Robert N. Lea (pers. comm.).

Family	Species	Common Name	Life style	Life stage
Acipenseridae	Acipenser medirostris	green sturgeon	MI	A
Ammodytidae	Ammodytes hexapterus	Pacific sand lance	M	L, A
Anarhichadidae	Anarrhichthys ocellatus	wolf-eel	M	A
Atherinopsidae	Atherinops affinis	topsmelt	PR	L, J, A
	Atherinopsis californiensis	jacksmelt	PR	L, J, A
	Leuresthes tenuis	California grunion	M	A
Aulorhynchidae	Aulorhynchus flavidus	tubesnout	M	J, A
Bathylagidae	Leuroglossus stilbius	California smoothtongue	M	L
Batrachoididae	Porichthys notatus	plainfin midshipman	MI	J, A
Blenniidae	Hypsoblennius gentilis	bay blenny	M	J
Bothidae	Citharichthys stigmaeus	speckled sanddab	MI	E, L, J

	Paralichthys californicus	**California halibut**	**MI**			**L, J, A**				
Carangidae	**Trachurus symmetricus**	**jack mackerel**		**M**			**J, A**			
Carcharhinidae	**Mustelus californicus**	**gray smoothhound**		**M**			**J, A**			
	Mustelus henlei	**brown smoothhound**	**M**			**J, A**				
	Triakis semifasciata	**leopard shark**	**PR**			**J, A**				
Clinidae	**Gibbonsia metzi**	**striped kelpfish**	**M**			**L, A**				
	Heterostichus rostratus	**giant kelpfish**	**M**			**J, A**				
	Neoclinus uninotatus	**onespot fringehead**		**M**			**L, J, A**			
Clupeidae	**Alosa sapidissima (NN)**	**American shad**			**F**			**J, A**		
	Clupea pallasi	**Pacific herring**			**MI**			**L, J, A**		
	Dorosoma petenense	**threadfin shad**					**F**			**A, ?**
	Sardinops sagax	**Pacific sardine**		**M**			**J, A**			
Cottidae	**Artedius harringtoni**	**scalyhead sculpin**	**M**			**A, ?**				
	Clinocottus sp.	**sculpin**			**M**			**L**		
	Cottus asper	**prickly sculpin**		**F**			**?**			
	Leptocottus armatus	**Pacific staghorn sculpin**	**R**			**L, J, A**				
	Scorpaenichthys marmoratus	**cabezon**		**MI**			**J, A**			
Cyclopteridae	**Liparis sp.1**	**snailfish**	**M**			**?**				
Embiotocidae	**Amphistichus argenteus**	**barred surfperch**	**M**			**A**				
	Amphistichus koelzi	**calico surfperch**	**M**			**A**				
	Amphistichus rhodoterus	**redtail surfperch**		**M**			**A**			
	Cymatogaster aggregata	**shiner surfperch**		**PR**			**J, A**			
	Embiotoca jacksoni	**black surfperch**		**R**			**J, A**			

	Embiotoca lateralis	**striped surfperch**	**M**			**A**						
	Hyperprosopon anale	**spotfin surfperch**		**M**			**A**					
	Hyperprosopon argenteum	**walleye surfperch**	**MI**			**J, A**						
	Hyperprosopon ellipticum	**silver surfperch**	**M**			**A**						
	Hypsurus caryi	**rainbow surfperch**		**M**			**A**					
	Micrometrus minimus	**dwarf surfperch**		**MI**			**J, A**					
	Phanerodon furcatus	**white surfperch**		**PR**			**J, A**					
	Rhacochilus toxotes	**rubberlip surfperch**	**M**			**J, A**						
	Rhacochilus vacca	**pile surfperch**	**MI**			**A**						
Engraulidae	**Engraulis mordax**	**northern anchovy**	**MI**			**E, L, J, A**						
Gadidae	**Microgadus proximus**	**Pacific tomcod**			**M**				**J, ?**			
Gasterosteidae	**Gasterosteus aculeatus**	**threespine stickleback**			**F**				**J, A**			
Gobiidae	**Acanthogobius flavimanus (NN)**	**yellowfin goby**		**R**			**J, A**					
	Clevelandia ios	**arrow goby**	**R**			**L, J, A**						
	Eucyclogobius newberryi	**tidewater goby**		**R**			**L, J, A**					
	Gillichthys mirabilis	**longjaw mudsucker**	**R**			**L, J, A**						
	Lepidogobius lepidus	**bay goby**		**R**			**L?, J?, A**					
	Rhinogobiops nicholsii	**blackeye goby**			**M**				**L, J**			
	Tridentiger trigonocephalus (NN)	**chameleon goby**	**M**			**?**						
Hexagrammidae	**Hexagrammos decagrammus**	**kelp greenling**			**M**				**J, A**			
	Hexagrammos lagocephalus ?	**rock greenling**			**M**				**?**			
	Ophiodon elongatus	**lingcod**	**M**			**J, A**						
	Oxylebius pictus	**painted greenling**	**M**			**J, A**						
Kyphosidae	**Girella nigricans**	**opaleye**	**M**			**A**						

Labridae	**Oxyjulis californica**	**señorita**	**M**	**L, A**
Mugilidae	**Mugil cephalus**	**striped mullet**	**MI**	**A**
Myctophidae	**Stenobrachius leucopsarus**	**northern lampfish**	**M**	**L**
Myliobatidae	**Myliobatis californica**	**bat ray**	**PR**	**J, A**
Ophichthidae	**Ophichthus triserialis**	**Pacific snake eel**	**M**	**A**
Ophidiidae	**Chilara taylori**	**spotted cusk-eel**	**M**	**J, A**
Osmeridae	**Hypomesus pretiosus**	**surf smelt**	**M**	**L, A**
	Spirinchus starksi	**night smelt**	**M**	**A**
Percichthyidae	**Morone saxatilis (NN)**	**striped bass**	**F**	**J, A**
Pleuronectidae	**Eopsetta exilis**	**slender sole**	**M**	**L, A**
	Hypsopsetta guttulata	**diamond turbot**	**MI**	**J, A**
	Platichthys stellatus	**starry flounder**	**MI**	**L, J, A**
	Parophrys vetulus	**English sole**	**MI**	**J**
	Pleuronichthys coenosus	**C-O sole**	**M**	**E**
	Pleuronichthys decurrens	**curlfin turbot**	**M**	**E, J, A**
	Pleuronichthys ritteri ?	**spotted turbot**	**M**	**J, A**
	Pleuronichthys verticalis	**hornyhead turbot**	**M**	**E, L**
	Psettichthys melanostictus	**sand sole**	**M**	**L, J, A**
Poeciliidae	**Gambusia affinis (NN)**	**western mosquitofish**	**F**	**L, J, A**
Rhinobatidae	**Platyrhinoidis triseriata**	**thornback**	**M**	**A**

	Rhinobatos productus	**shovelnose guitarfish**	**M**	**A**
Salmonidae	**Oncorhynchus mykiss**	**rainbow trout (steelhead)**	**M**	**A**
	Oncorhynchus tshawytscha	**chinook salmon**	**M**	**A**
Sciaenidae	**Seriphus politus**	**queenfish**	**MI**	**J, A**
	Genyonemus lineatus	**white croaker**	**M**	**E, L, A**
Scorpaenidae	**Sebastes atrovirens**	**kelp rockfish**	**M**	**J**
	Sebastes auriculatus	**brown rockfish**	**M**	**J, A ?**
	Sebastes carnatus	**gopher rockfish**	**M**	**J**
	Sebastes caurinus	**copper rockfish**	**M**	**J**
	Sebastes chrysomelas	**black-and-yellow rockfish**	**M**	**J**
	Sebastes dallii	**calico rockfish**	**M**	**J**
	Sebastes flavidus 2	**yellowtail rockfish**	**M**	**J**
	Sebastes melanops	**black rockfish**	**M**	**J**
	Sebastes mystinus	**blue rockfish**	**M**	**J**
	Sebastes paucispinis	**bocaccio**	**M**	**L, J**
	Sebastes rastrelliger	**grass rockfish**	**M**	**J, A**
	Sebastes saxicola	**stripetail rockfish**	**M**	**J**
Soleidae	**Symphurus atricauda**	**California tonguefish**	**MI**	**E, J, A**
Squalidae	**Squalus acanthias**	**spiny dogfish**	**M**	**A**
Stichaeidae	**Cebidichthys violaceus**	**monkeyface prickleback**	**M**	**L, A**
Stromateidae	**Peprilus simillimus**	**Pacific pompano**	**M**	**A**
Syngnathidae	**Syngnathus californiensis**	**kelp pipefish**	**M**	**A**

	Syngnathus exilis	**barcheek pipefish**	**M**	**A**
	Syngnathus leptorhynchus	**bay pipefish**	**R**	**L, J, A**
Synodontidae	**Synodus lucioceps**	**California lizardfish**	**M**	**J, A**
Torpedinidae	**Torpedo californica**	**Pacific electric ray**	**M**	**A**
Urolophidae	**Urolophus halleri**	**round stingray**	**M**	**J, A**

6. Birds of Elkhorn Slough

Seasons: Winter, November–February; Spring, (February) March–May; Summer, June–July; Fall, (July) August–October

Abundance: c: common, almost certain to be seen in suitable habitat; u: uncommon, present but not certain to be seen; o: occasional, seen only a few times during a season; r: rare, not present every year; x: extraordinary, 1 or 2 records

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Loons — Family Gaviidae					
Red-throated Loon	Gavia stellata	c	u	o	u
Pacific Loon	Gavia pacifica	o	o	–	o
Common Loon	Gavia immer	c	c	o	c
Yellow-billed Loon	Gavia adamsii	x	–	–	–
Grebes — Family Podicipedidae					
Horned Grebe	Podiceps auritus	u	o	o	u
Eared Grebe	Podiceps nigricollis	c	u	x	u
Pied-billed Grebe	Podilymbus podiceps	c	u	u	u
Red-necked Grebe	Podiceps grisegena	o	o	–	o
Clark's Grebe	Aechmophorus clarkii	u	u	u	u
Western Grebe	Aechmophorus occidentalis	c	c	u	c
Pelicans — Family Pelecanidae					
American White Pelican	Pelecanus erythrorhynchos	r	r	r	r
Brown Pelican	Pelecanus occidentalis	u	u	c	c
Cormorants — Family Phalacrocoracidae					
Double-crested Cormorant	Phalacrocorax auritus	c	c	o	c
Brandt's Cormorant	Phalacrocorax penicillatus	c	c	u	c
Pelagic Cormorant	Phalacrocorax pelagicus	u	u	u	u
Herons, Bitterns — Family Ardeidae					
American Bittern	Botaurus lentiginosus	r	r	o	r
Black-crowned Night-Heron	Nycticorax nycticorax	r	o	–	r
COMMON NAME	**SCIENTIFIC NAME**	**Winter**	**Spring**	**Summ.**	**Fall**
Green Heron	Butorides virescens	u	o	r	u

Reddish Egret	Egretta rufescens	–	–	–	x
Cattle Egret	Bubulcus ibis	o	r	–	r
Snowy Egret	Egretta thula	c	c	u	c
Great Egret	Ardea alba	c	c	c	c
Great Blue Heron	Ardea herodias	c	c	c	c

Ibises — Family Threskiornithidae

White-faced Ibis	Plegadis chihi	r	–	r	r

Ducks, Geese, Swans — Family Anatidae

Tundra Swan	Cygnus columbianus	r	–	–	–
Greater White-fronted	Goose Anser albifrons	o	–	–	r
Snow Goose	Chen caerulescens	r	–	–	r
Ross's Goose	Chen rossii	r	–	–	r
Emperor Goose	Chen canagica	x	–	–	–
Canada Goose	Branta canadensis	o	r	–	r
Brant	Branta bernicla	o	u	r	u
Wood Duck	Aix sponsa	o	–	–	o
Mallard	Anas platyrhynchos	c	c	c	c
Gadwall	Anas strepera	c	c	c	c
Green-winged Teal	Anas crecca	c	u	–	c
American Wigeon	Anas americana	c	u	–	u
Eurasian Wigeon	Anas penelope	x	x	–	–
Northern Pintail	Anas acuta	c	c	u	c
Northern Shoveler	Anas clypeata	c	c	u	c
Blue-winged Teal	Anas discors	r	u	x	u
Cinnamon Teal	Anas cyanoptera	r	c	u	u
Canvasback	Aythya valisineria	c	u	–	u
Redhead	Aythya americana	r	r	–	r
Ring-necked Duck	Aythya collaris	u	r	–	r
Tufted Duck	Aythya fuligula	x	–	–	–
Greater Scaup	Aythya marila	c	u	o	u
Lesser Scaup	Aythya affinis	c	u	o	u
King Eider	Somateria spectabilis	x	x	x	–
Black Scoter	Melanitta nigra	o	r	–	r
COMMON NAME	**SCIENTIFIC NAME**	**Winter**	**Spring**	**Summ.**	**Fall**
White-winged Scoter	Melanitta fusca	c	u	o	u

Surf Scoter	Melanitta perspicillata	c	c	c	c
Harlequin Duck	Histrionicus histrionicus	o	x	–	–
Long-tailed Duck	Clangula hyemalis	o	r	x	–
Barrow's Goldeneye	Bucephala islandica	x	–	–	–
Common Goldeneye	Bucephala clangula	c	u	–	c
Bufflehead	Bucephala albeola	c	u	–	c
Common Merganser	Mergus merganser	x	x	x	x
Red-breasted Merganser	Mergus serrator	c	u	o	u
Hooded Merganser	Lophodytes cucullatus	r	–	–	–
Ruddy Duck	Oxyura jamaicensis	c	c	c	c

New World Vultures — Family Cathartidae

Turkey Vulture	Cathartes aura	r	c	u	u

Hawks, Kites, Eagles — Family Accipitridae

Osprey	Pandion haliaetus	o	o	x	o
White-tailed Kite	Elanus leucurus	u	u	u	u
Northern Harrier	Circus cyaneus	u	u	o	u
Golden Eagle	Aquila chrysaetosu	u	u	u	
Bald Eagle	Haliaeetus leucocephalus	x	–	–	–
Sharp-shinned Hawk	Accipiter striatus	u	u	–	u
Cooper's Hawk	Accipiter cooperii	u	u	o	u
Red-shouldered Hawk	Buteo lineatus	u	u	u	u
Red-tailed Hawk	Buteo jamaicensis	c	c	c	c
Rough-legged Hawk	Buteo lagopus	r	–	–	–
Ferruginous Hawk	Buteo regalis	r	–	–	–
American Kestrel	Falco sparverius	c	c	u	c
Merlin	Falco columbarius	o	r	–	r
Prairie Falcon	Falco mexicanus	r	r	x	r
Peregrine Falcon	Falco peregrinus	o	r	r	r

New World Quail — Family Odontophoridae

California Quail	Callipepla californica	c	c	c	c

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Wild Turkey — Family Phasianidae					
Wild Turkey	Meleagris gallopavo	r	r	r	r
Rails, Coots — Family Rallidae					
*Clapper Rail	Rallus longirostris	?	?	?	?
Virginia Rail	Rallus limicola	u	o	–	o
Sora	Porzana Carolina	u	o	–	o
Common Moorhen	Gallinula chloropus	r	r	–	r
American Coot	Fulica Americana	c	c	c	c
Plovers — Family Charadriidae					
Black-bellied Plover	Pluvialis squatarola	c	c	u	c
Pacific Golden-Plover	Pluvialis fulva	x	x	–	r
American Golden-Plover	Pluvialis dominica	x	–	–	o
Snowy Plover	Charadrius alexandrinus	u	u	u	u
Semipalmated Plover	Charadrius semipalmatus	u	c	x	c
Mongolian Plover	Charadrius mongolus	–	–	–	x
Killdeer	Charadrius vociferus	c	c	c	c
Stilts, Avocets — Family Recurvirostridae					
American Avocet	Recurvirostra americana	c	c	c	c
Black-necked Stilt	Himantopus mexicanus	c	c	c	c
Sandpipers, Phalaropes — Family Scolopacidae					
Willet	Catoptrophorus semipalmatus	c	c	u	c
Greater Yellowlegs	Tringa melanoleuca	c	c	r	c
Lesser Yellowlegs	Tringa flavipes	o	o	–	u
Wandering Tattler	Heteroscelus incanus	x	x	–	x
Spotted Sandpiper	Actitis macularia	u	u	o	u
Whimbrel	Numenius phaeopus	u	c	r	c
Long-billed Curlew	Numenius americanus	c	c	o	c
Marbled Godwit	Limosa fedoa	c	c	u	c
Ruddy Turnstone	Arenaria interpres	c	c	r	c

*The clapper rail has not been seen since 1980

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Black Turnstone	Arenaria melanocephala	–	r	x	r
Surfbird	Aphriza virgata	–	x	–	x
Red Knot	Calidris canutus	o	u	x	u
Sanderling	Calidris alba	c	c	u	c
Dunlin	Calidris alpina	c	c	x	c
Semipalmated Sandpiper	Calidris pusilla	–	–	–	o
Western Sandpiper	Calidris mauri	c	c	x	c
Least Sandpiper	Calidris minutilla	c	c	r	c
Baird's Sandpiper	Calidris bairdii	–	–	–	u
Little Stint	Calidris minuta	–	–	–	x
Pectoral Sandpiper	Calidris melanotos	–	–	–	u
Sharp-tailed Sandpiper	Calidris acuminata	–	–	–	r
Buff-breasted Sandpiper	Tryngites subruficollis	–	–	–	x
Ruff	Philomachus pugnax	x	–	–	x
Short-billed Dowitcher	Limnodromus griseus	c	c	x	c
Long-billed Dowitcher	Limnodromus scolopaceus	c	c	–	c
Stilt Sandpiper	Calidris himantopus	–	–	–	r
Common Snipe	Gallinago gallinago	u	u	–	u
Wilson's Phalarope	Phalaropus tricolor	x	u	o	u
Red-necked Phalarope	Phalaropus lobatus	x	u	r	c
Red Phalarope	Phalaropus fulicaria	r	r	x	o
Jaegers, Gulls, Terns — Family Laridae					
Parasitic Jaeger	Stercorarius parasiticus	–	–	–	o
Heermann's Gull	Larus heermanni	u	o	c	c
Franklin's Gull	Larus pipixcan	x	x	x	r
Laughing Gull	Larus atricilla	x	–	–	–
Bonaparte's Gull	Larus philadelphia	c	c	o	c
Ring-billed Gull	Larus delawarensis	c	c	u	c
Mew Gull	Larus canus	u	o	–	o
California Gull	Larus californicus	c	c	u	c
Herring Gull	Larus argentatus	c	o	–	o
Glaucous Gull	Larus hyperboreus	r	x	–	–
Thayer's Gull	Larus thayeri	c	o	–	o
Western Gull	Larus occidentalis	c	c	c	c
Glaucous-winged Gull	Larus glaucescens	c	c	o	c

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Black-legged Kittiwake	Rissa tridactyla	x	x	–	x
Sabine's Gull	Xema sabini	–	–	–	x
Swallow-tailed Gull	Creagrus furcatus	–	–	x	–
Elegant Tern	Sterna elegans	x	r	c	c
Royal Tern	Sterna maxima	–	–	–	x
Caspian Tern	Sterna caspia	x	c	c	c
Forster's Tern	Sterna forsteri	u	c	c	c
Common Tern	Sterna hirundo	–	u	r	u
Arctic Tern	Sterna paradisaea	–	o	–	o
Least Tern	Sterna antillarum	–	o	r	o
Black Tern	Chlidonias niger	–	o	–	o
Black Skimmer	Rynchops niger	–	x	–	x
Auks, Murres — Family Alcidae					
Common Murre	Uria aalge	r	r	r	r
Thick-billed Murre	Uria lomvia	x	–	–	–
Pigeon Guillemot	Cepphus columba	–	–	–	r
Craveri's Murrelet	Synthliboramphus craveri	–	–	–	x
Ancient Murrelet	Synthliboramphus antiquus	x	–	–	–
Cassin's Auklet	Ptychoramphus aleuticus	r	–	–	–
Rhinoceros Auklet	Cerorhinca monocerata	o	–	–	r
Pigeons, Doves — Family Columbidae					
Band-tailed Pigeon	Columba fasciata	u	c	u	u
Rock Dove	Columba livia	c	c	c	c
Mourning Dove	Zenaida macroura	c	c	c	c
White-winged Dove	Zenaida asiatica	–	–	–	x
Roadrunners — Family Cuculidae					
Greater Roadrunner	Geococcyx californianus	–	x	–	x
Owls — Families Tytonidae and Strigidae					
Barn Owl	Tyto alba	u	u	u	u
Short-eared Owl	Asio flammeus	r	r	r	r
Long-eared Owl	Asio otus	x	–	–	–
Great Horned Owl	Bubo virginianus	c	c	c	c

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Burrowing Owl	Athene cunicularia	u	u	u	u
Swifts — Family Apodidae					
Vaux's Swift	Chaetura vauxi	–	o	–	o
White-throated Swift	Aeronautes saxatalis	–	x	–	–
Hummingbirds — Family Trochilidae					
Anna's Hummingbird	Calypte anna	c	c	c	c
Rufous Hummingbird	Selasphorus rufus	–	o	–	o
Allen's Hummingbird	Selasphorus sasin	–	c	c	–
Kingfishers — Family Alcedinidae					
Belted Kingfisher	Ceryle alcyon	u	u	u	u
Woodpeckers — Family Picidae					
Acorn Woodpecker	Melanerpes formicivorus	u	u	u	u
Northern Flicker	Colaptes auratus	c	c	u	c
Red-breasted Sapsucker	Sphyrapicus ruber	o	o	–	o
Nuttall's Woodpecker	Picoides nuttallii	c	c	c	c
Downy Woodpecker	Picoides pubescens	u	u	u	u
Hairy Woodpecker	Picoides villosus	u	u	u	u
Tyrant Flycatchers — Family Tyrannidae					
Olive-sided Flycatcher	Contopus cooperi	–	u	u	–
Western Wood-Pewee	Contopus sordidulus	–	–	–	u
Pacific-slope Flycatcher	Empidonax difficilis	x	c	c	u
Black Phoebe	Sayornis nigricans	c	c	c	c
Say's Phoebe	Sayornis saya	u	r	–	u
Ash-throated Flycatcher	Myiarchus cinerascens	x	u	u	r
Western Kingbird	Tyrannus verticalis	–	r	x	r
Tropical Kingbird	Tyrannus melancholicus	x	–	–	r
Scissor-tailed Flycatcher	Tyrannus forficatus	–	x	–	–
Shrikes — Family Laniidae					
Loggerhead Shrike	Lanius ludovicianus	u	u	u	u

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Vireos — Family Vireonidae					
Hutton's Vireo	Vireo huttoni	c	c	c	c
Red-eyed Vireo	Vireo olivaceus	–	–	–	x
Warbling Vireo	Vireo gilvus	–	c	u	c
Crows, Jays — Family Corvidae					
Steller's Jay	Cyanocitta stelleri	r	r	–	–
Western Scrub-Jay	Aphelocoma californica	c	c	c	c
American Crow	Corvus brachyrhynchos	c	c	c	c
Common Raven	Corvus corax	r	r	r	r
Larks — Family Alaudidae					
Horned Lark	Eremophila alpestris	u	r	–	u
Swallows — Family Hirundinidae					
Tree Swallow	Tachycineta bicolor	u	c	c	c
Violet-green Swallow	Tachycineta thalassina	r	c	c	c
Bank Swallow	Riparia riparia	x	r	r	r
Cliff Swallow	Petrochelidon pyrrhonota	–	c	c	c
Northern Rough-winged Swallow	Stelgidopteryx serripennis	x	o	r	r
Barn Swallow	Hirundo rustica	x	c	c	c
Babblers — Family Timaliidae					
Wrentit	Chamaea fasciata	c	c	c	c
Chickadees, Titmice — Family Paridae					
Oak Titmouse	Baeolophus inornatus	c	c	c	c
Chestnut-backed Chickadee	Poecile rufescens	c	c	c	c
Bushtits — Family Aegithalidae					
Bushtit	Psaltriparus minimus	c	c	c	c
Creepers — Family Certhiidae					
Brown Creeper	Certhia americana	u	u	u	u

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Nuthatches — Family Sittidae					
Red-breasted Nuthatch	Sitta Canadensis	o	–	–	o
Pygmy Nuthatch	Sitta pygmaea	u	u	u	u
Wrens — Family Troglodytidae					
House Wren	Troglodytes aedon	x	u	–	u
Winter Wren	Troglodytes troglodytes	u	r	–	r
Bewick's Wren	Thyromanes bewickii	c	c	c	c
Marsh Wren	Cistothorus palustris	c	c	c	c
Kinglets — Family Regulidae					
Ruby-crowned Kinglet	Regulus calendula	c	c	–	c
Thrushes — Family Turdidae					
Western Bluebird	Sialia mexicana	u	r	–	–
Townsend's Solitaire	Myadestes townsendi	x	–	–	–
Swainson's Thrush	Catharus ustulatus	–	c	u	r
Hermit Thrush	Catharus guttatus	u	u	–	u
Varied Thrush	Ixoreus naevius	u	r	–	r
American Robin	Turdus migratorius	c	c	u	c
Mockingbirds, Thrashers — Family Mimidae					
Northern Mockingbird	Mimus polyglottos	u	u	u	u
California Thrasher	Toxostoma redivivum	o	o	o	o
Starlings — Family Sturnidae					
European Starling	Sturnus vulgaris	c	c	c	c
Wagtails, Pipits — Family Motacillidae					
White Wagtail	Motacilla alba	x	–	–	–
American Pipit	Anthus rubescens c	u	–	c	
Red-throated Pipit	Anthus cervinus	–	–	–	x
Waxwings — Family Bombycillidae					
Cedar Waxwing	Bombycilla cedrorum	c	c	–	c

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Wood-Warblers — Family Parulidae					
Orange-crowned Warbler	Vermivora celata	u	c	c	c
Nashville Warbler	Vermivora ruficapilla	x	r	–	r
Yellow-rumped Warbler	Dendroica coronata	c	c	–	c
Black-throated Gray Warbler	Dendroica nigrescens	–	o	–	o
Townsend's Warbler	Dendroica townsendi	c	u	–	u
Yellow Warbler	Dendroica petechia	–	u	o	u
MacGillivray's Warbler	Oporornis tolmiei–	o	–	o	
Wilson's Warbler	Wilsonia pusilla	–	c	c	c
Northern Waterthrush	Seiurus noveboracensis	x	–	–	–
Common Yellowthroat	Geothlypis trichas	u	u	u	u
American Redstart	Setophaga ruticilla	x	–	–	–
Tanagers — Family Thraupidae					
Western Tanager	Piranga ludoviciana	–	u	–	u
Emberizids (Towhees, Sparrows) — Family Emberizidae					
California Towhee	Pipilo crissalis	c	c	c	c
Spotted Towhee	Pipilo maculates	c	c	c	c
Brewer's Sparrow	Spizella breweri	–	x	–	–
Grasshopper Sparrow	Ammodramus savannarum	r	–	–	r
Saltmarsh Sharp-tailed Sparrow	Ammodramus caudacutus	–	–	–	x
Fox Sparrow	Passerella iliaca	u	u	–	u
Lark Bunting	Calamospiza melanocorys	–	–	–	x
Savannah Sparrow	Passerculus sandwichensis c	c	c	c	
Lincoln's Sparrow	Melospiza lincolnii	u	u	–	u
Song Sparrow	Melospiza melodia	c	c	c	c
Swamp Sparrow	Melospiza georgiana	o	–	–	o
White-throated Sparrow	Zonotrichia albicollis	x	–	–	–
White-crowned Sparrow	Zonotrichia leucophrys	c	c	c	c
Golden-crowned Sparrow	Zonotrichia atricapilla	c	c	–	c
Dark-eyed Junco	Junco hyemalis	c	c	u	c
Smith's Longspur	Calcarius pictus	–	–	–	x

COMMON NAME	SCIENTIFIC NAME	Winter	Spring	Summ.	Fall
Cardinals (Grosbeaks) — Family Cardinalidae					
Black-headed Grosbeak	Pheucticus melanocephalus	–	u	u	u
Blackbirds — Family Icteridae					
Bobolink	Dolichonyx oryzivorus	–	–	–	r
Western Meadowlark	Sturnella neglectac	c	c	c	
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	x	o	–	o
Red-winged Blackbird	Agelaius phoeniceus	c	c	c	c
Tricolored Blackbird	Agelaius tricolor c	u	o	c	
Rusty Blackbird	Euphagus carolinus	x	–	–	–
Brewer's Blackbird	Euphagus cyanocephalus	c	c	c	c
Brown-headed Cowbird	Molothrus ater	u	u	u	u
Bullock's Oriole	Icterus bullockii	r	u	–	u
Finches — Family Fringillidae					
Purple Finch	Carpodacus purpureus	c	c	c	c
House Finch	Carpodacus mexicanus	c	c	c	c
Red Crossbill	Loxia curvirostra r	–	–	–	
Pine Siskin	Carduelis pinus	c	c	u	c
American Goldfinch	Carduelis tristis	c	c	c	c
Lesser Goldfinch	Carduelis psaltria	c	c	c	c
Lawrence's Goldfinch	Carduelis lawrencei	–	r	–	–
Old World Sparrows — Family Passeridae					
House Sparrow	Passer domesticus	c	c	c	c

7. Mammals of the Elkhorn Slough

List compiled by E. Schafer (1986) for the Elkhorn Slough National Estuarine Research Reserve. Little information is available regarding occurrence and abundance of mammal species in this region and therefore is not presented in this appendix. Known information is included in the text. This list represents both known and potential presence at the slough.

Marsupials — Order Marsupialia

Virginia opossum	Didelphis virginiana

Shrews and Moles — Order Insectivora

Trowbridge's shrew	Sorex trowbridgii
vagrant shrew	Sorex vagrans

ornate shrew	Sorex ornatus
shrew-mole	Neurotrichus gibbsii
broad-footed mole	Scapanus latimanus

Bats — Order Chiroptera

little brown bat	Myotis lucifugus
Yuma bat	Myotis yumanensis
long-eared bat	Myotis evotis
fringed bat	Myotis thysanodes
long-legged bat	Myotis volans
California bat	Myotis californicus
western small-footed bat	Myotis ciliolabrum
western pipistrel	Pipistrellus hesperus
big brown bat	Eptesicus fuscus
western red bat	Lasiurus blossevillii
hoary bat	Lasiurus cinereus
pallid bat	Antrozous pallidus
guano bat	Tadarida brasiliensis

Carnivores — Order Carnivora

raccoon	Procyon lotor
ringtail	Bassariscus astutus
long-tailed weasel	Mustela frenata
sea otter	Enhydra lutris
badger	Taxidea taxus
spotted skunk	Spilogale putorius
striped skunk	Mephitis mephitis
coyote	Canis latrans
red fox	Vulpes vulpes
gray fox	Urocyon cinereoargenteus
mountain lion	Felis concolor
bobcat	Lynx rufus

Sea Lions and Seals — Order Pinnipedia

California sea lion	Zalophus californianus
harbor seal	Phoca vitulina

Rodents — Order Rodentia

California ground squirrel	Spermophilus beecheyi
western gray squirrel	Sciurus griseus
eastern gray squirrel	Sciurus carolinensis
fox squirrel	Sciurus niger
Botta's pocket gopher	Thomomys bottae
California pocket mouse	Chaetodipus californicus
Heermann's kangaroo rat	Dipodomys heermanni
narrow-faced kangaroo rat	Dipodomys venustus
beaver	Castor canadensis
western harvest mouse	Reithrodontomys megalotis
parasitic mouse	Peromyscus californicus
deer mouse	Peromyscus maniculatus
piñon mouse	Peromyscus truei
dusky-footed woodrat	Neotoma fuscipes
California meadow vole	Microtus californicus
muskrat	Ondatra zibethica
house mouse	Mus musculus
Norway rat	Rattus norvegicus
black rat	Rattus rattus

Rabbits — Order Lagomorpha

black-tailed jackrabbit	Lepus californicus
Audubon's cottontail	Sylvilagus audubonii
brush rabbit	Sylvilagus bachmani

Ungulates — Order Artiodactyla

black-tailed deer	Odocoileus hemionus

Whales — Order Cetacea

gray whale	Eschrichtius robustus
harbor porpoise	Phocoena phocoena

8. Critical Biological Resources

Sensitive Communities and Species in the Elkhorn Slough Watershed– July 2006

Species	Federal Status	State	CDFG or CNPS	G-Rank	S-Rank	Occurrence	Habitat	Located on Reserve?
Sensitive Plant Species								
Arctostaphylos hookeri ssp *hookeri* Hooker's Manzanita			1B.2	G3T2	S2	K	Chaparral	
Arctostaphylos pajaroensis Pajaro Manzanita			1B.1	G2	S2.1	K	Chaparral	
Castilleja latifolia Monterey Indian Plant			4.3	G3	S3.3	K	Coastal Dune	
Ceanothus cuneatus var. rigidus Monterey Ceanothus			4.2	G5T3	S3.2	K	Chaparral	
Centromadia parryi ssp. *congdonii* Congdon's tarplant			1B.2	G4T2	S3.2	K	Grassland	
Chorizanthe pungens var pungens Monterey Spineflower	Threatened		1B.2	G2T2	S2.2	K	Coastal Dune	
Chorizanthe robusta var *robusta* Monterey Spineflower	Endangered		1B.1	G2T1	S1.1	K	Coastal Dune	
Ericameria fasciculata Eastwood's Goldenbush			1B.1	G2	S2.1	K	Maritime Chaparral	
Fritillaria liliacea Fragrant Fritillary			1B.2	G2	S2.2	K	Grasslands	
Gilia tenuiflora	Endangered	Threatened	1B.2	G3G4T2	S2.2	K	Coastal	

Species	Federal Status	State	CDFG or CNPS	G-Rank	S-Rank	Occurrence	Habitat	Located on Reserve?
ssp. arenaria Sand Gilia							Dune	
Holocarpha macradenia Santa Cruz Tarplant	Threatened	Endangered	1B.1	G1	S1.1	K	Coastal Prairie	
Lomatium parvifolium Small-leaved Lomatium			4.2	G3	S3.2	K	Chaparral Coastal scrub Riparian woodland	
Perideridia gairdneri spp. *gairdneri* Gairdner's Yampah			4.2	G5T3	S3.2	K	Grasslands, Chaparral	
Piperia yadonii Yadon's Piperia	Endangered		1B.1	G2	S2.1	K	Maritime Chaparral	
Plagiobothrys chorisianus var. *chorisianus* Artist's popcorn-flower			1B.2	G3T2Q	S2.2			
Rosa pinetorum Pine Rose			1B.2	G2Q	S2.2	K	Closed-cone Coniferous Forest	
Trifolium buckwestiorum Santa Cruz Clover			1B.1	G1	S1.1	K	Coastal Prairie	
Trifolium depauperatum var. hydrophilum Saline Clover			1B.2	G5T2?	S2.2?	K	Grassland, Salt Marsh	
Sensitive Animal Species								
Agelaius tricolor (nesting colony) Tricolored Blackbird			California Special Concern species	G2G3	S2	K	Grasslands, Freshwater Ponds, Brackish and Freshwater Marsh	
Ambystoma californiense California Tiger Salamander	Threatened		California Special Concern species	G2G3	S2S3	K	Freshwater Ponds and Wetlands, Brackish	

Species	Federal Status	State	CDFG or CNPS	G-Rank	S-Rank	Occurrence	Habitat	Located on Reserve?
							and Salt Marsh, Grasslands	
Ambystoma macrodactylum croceum Santa Cruz Long-Toed Salamander	Endangered	Endangered	Fully Protected	G5T1	S1	K	Freshwater Ponds, Grasslands, Willow Riparian, Chaparral	X
Anniella pulchra nigra Black Legless Lizard			California Special Concern species	G3G4T2T3Q	S2	K	Sand Dunes	
Aquila chrysaetos (nesting and wintering) Golden Eagle			California Special Concern species and Fully Protected	G5	S3	K	Grassland and Oak Savanna	
Asio flammeus (nesting) Short-eared Owl			California Special Concern species	G5	S3	K	Brackish and Freshwater Marsh, Grasslands	
Athene cunicularia (burrow sites) Burrowing Owl			California Special Concern species	G4	S2	K	Grasslands	
Charadrius alexandrinus nivosus (nesting) Western Snowy Plover	Threatened		California Special Concern species	G4T3	S2	K	Sandy Beaches, Salt Pond Levees	
Circus cyaneus (nesting) Northern harrier			Special Concern species	G5	S3			
Danaus plexippus (wintering sites) Monarch Butterfly				G4	S3	K	Eucalyptus Groves	X
Elanus leucurus (nesting) White-tailed Kite			Fully Protected	G5	S3	K	Nesting - Scattered Oaks Or Marshes Next To Woodland	X

Species	Federal Status	State	CDFG or CNPS	G-Rank	S-Rank	Occurrence	Habitat	Located on Reserve?
Emys (=Clemmys) marmorata pallida Southwestern Pond Turtle			California Special Concern species	G3G4T2T3	S2	K	Freshwater Ponds	X
Enhydra lutris nereis Southern Sea Otter	Threatened		Fully protected	G4T2	S2		Slough Channels	X
Eucyclogobius newberryi Tidewater Goby	Endangered		California Special Concern species	G3	S2S3	K	Brackish Water	
Falco columbarius (wintering) Merlin			California Special Concern species	G5	S3	K - winter	Salt Marsh	
Pelecanus occidentalis californicus (communal roosts) California Brown Pelican	Endangered	Endangered	Fully protected	G4T3	S1S2	K	Non-breeding Roosts on Salt Ponds, Marsh	X
Phalacrocorax auritus (rookery site) Double-crested Cormorant			California Special Concern species	G5	S3	K	Nests On Coastal Cliffs & Along Lake Margins	**X**
Rallus longirostris obsoletus California Clapper Rail	Endangered	Endangered	Fully Protected	G5T1	S1	Likely extirpated: Documented prior to 1980s	Salt marsh	Extirpated
Rana aurora draytonii California Red-legged Frog	Threatened		California Special Concern species	G4T2T3	S2S3	K	Freshwater Ponds, Riparian, Chaparral	X
Reithrodontomys megalotis distichlis Salinas Harvest Mouse				G5TH	SH	K	Fresh And Brackish Water Wetlands And Adjacent Uplands	X
Riparia riparia		Threatened		G5	S2S3	K	Riparian	

Species	Federal Status	State	CDFG or CNPS	G-Rank	S-Rank	Occurrence	Habitat	Located on Reserve?
Bank Swallow								
Sorex ornatus salarius Monterey / Salinas Ornate Shrew			California Special Concern species	G5T1T2	S1S2	K	Freshwater Marsh	Potentially
Sterna antillarum browni (nesting colony) California Least Tern	Endangered	Endangered	Fully Protected	G4T2T3	S2S3	Formerly nested in watershed	Salt Marsh and Beaches	
Tryonia imitator California Brackishwater Snail				G2G3	S2S3	K	Estuary	

Species include those:
Listed as Federally Endangered by the Federal Government
Listed as Federally Threatened by the Federal Government
Listed as Endangered by the State of California
Listed as Threatened by the State of California
Described by the California Dept. Of Fish and Game as Fully Protected or Species of Special Concern
Or Described as Rare or Endangered in CA and Elsewhere ("1B")

Occurrence: K = known, P = potential

Additional rankings include:

G-rank - Global ranking
The global rank (G-rank) is a reflection of the overall condition of an element throughout its global range.

Species or Community Level
G1 = Less than 6 viable element occurrences (EOs) OR less than 1,000 individuals OR less than 2,000 acres.
G2 = 6-20 EOs OR 1,000-3,000 individuals OR 2,000-10,000 acres.
G3 = 21-80 EOs OR 3,000-10,000 individuals OR 10,000-50,000 acres.
G4 = Apparently secure; this rank is clearly lower than G3 but factors exist to cause some concern; i.e., there is some threat, or somewhat narrow habitat.
G5 = Population or stand demonstrably secure to ineradicable due to being commonly found in the world.

Subspecies Level
Subspecies receive a T-rank attached to the G-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global situation of just the subspecies or variety. For example: Chorizanthe robusta var. hartwegii. This plant is ranked G2TI. The G-rank refers to the whole species range i.e., Chorizanthe robusta. The T-rank refers only to the global condition of var. hartwegii.

S-rank - State Ranking
The state rank (S-rank) is assigned much the same way as the global rank, except state ranks in California often also contain a threat designation attached to the S-rank.

S1 = Less than 6 EOs OR less than 1,000 individuals OR less than 2,000 acres
- S1.1 = very threatened
- S1.2 = threatened
- S1.3 = no current threats known

S2 = 6-20 EOs OR 1,000-3,000 individuals OR 2,000-10,000 acres
- S2.1 = very threatened
- S2.2 = threatened
- S2.3 = no current threats known

S3 = 21-80 EOs or 3,000-10,000 individuals OR 10,000-50,000 acres
- S3.1 = very threatened
- S3.2 = threatened
- S3.3 = no current threats known

S4 = Apparently secure within California; this rank is clearly lower than S3 but factors exist to cause some concern; i.e. there is some threat, or somewhat narrow habitat. NO THREAT RANK.
S5 = Demonstrably secure to ineradicable in California. NO THREAT RANK

California Native Plant Society List

1A – Presumed extinct in California
1B – Rare or endangered in California and elsewhere
2 – Rare/endangered in California, more common elsewhere
3 – Need more information
4 – Plants of limited distribution

CNPS code extensions and their meanings:
.1 - Seriously endangered in California (over 80% of occurrences threatened / high degree and immediacy of threat)
.2 – Fairly endangered in California (20-80% occurrences threatened)
.3 – Not very endangered in California (<20% of occurrences threatened or no current threats known)

G. References

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Appendix 6.
Elkhorn Slough Research Project Ideas

The following are some of the many possible questions student researchers are encouraged to attempt to answer at Elkhorn Slough. Some are well-suited to short-term projects, others would require longer efforts, such as thesis research.

We at the Elkhorn Slough National Estuarine Research Reserve particularly encourage projects that examine threats to Slough ecosystems and how best to minimize them. The questions below are organized first by habitat type, then mostly by threats to each. While these questions represent priorities for informing conservation, we're curious and interested in all aspects of the Slough. Feel free to contact Kerstin Wasson (research@elkhornslough.org) for advice about a project at the Slough. If you would like to conduct research on the Elkhorn Slough Reserve (northeast portion of Slough), you will also need to contact her to apply for a research permit.

1) ESTUARINE HABITATS

- **TIDAL RESTRICTION**

What mechanisms are responsible for differences in assemblages between sites with full and restricted tidal exchange?
We have data suggesting that birds, fish, invertebrates, and marsh plants differ, but manipulative experiments are needed to get at the processes behind these patterns. Mechanisms might include active habitat selection, differential transport, or differential mortality in response to biotic or abiotic conditions.

How do water quality and estuarine assemblages change with distance from tide control structures?
For large sites with water control structures that restrict tidal exchange (e.g., North Marsh or Moro Cojo), do water quality and biotic diversity decline with increasing distance from these structures?

- **TIDAL EROSION**

What are the major causes of salt marsh degradation in undiked areas?
The proximate cause of current rapid decline in salt marsh appears to be subsidence of the marsh plain, which in turn appears likely to have resulted from death of marsh plants (which halted the sediment generation and trapping that marshes provide). But what killed the marsh plants in the first place? And why are patterns of salt marsh loss spatially variable in the Slough? The key driver is likely to be related to longer inundation times resulting from opening of the harbor mouth, but there may also be other key contributing factors, such as increased *Ulva* mats or decreased sediment inputs. Factorial experiments could attempt to separate the role of individual factors and examine interactions between them.

How have South Marsh assemblages changed in 20 years?

Repeat sampling done in first years after this area was opened to tidal exchange, to assess how assemblages have changed. Constructed islands have shrunk due to bank erosion and channels have deepened, so there are likely to be significant effects of tidal erosion that could be documented here.

- **HISTORICAL BASELINES**

What range of environmental conditions were typical at the Slough for the past 5000 years?

Use modern isotope techniques to re-examine fish otoliths and mollusc shells to determine relative marine vs. terrestrial inputs to Slough systems. Or examine sediment cores for indicators of paleosalinity.

Which Slough wetlands today most resemble conditions before major human alterations?

Compare indicator assemblages (e.g. forams) at sites with varying amounts of tidal and freshwater influence today, and take cores at these same sites to assess past assemblages. Is today's main channel foram assemblage most similar to that of the main channel 1000 years ago, or most similar to that of a brackish system like Moro Cojo?

How have eelgrass invertebrate assemblages changed since the 1920s?

Repeat MacGinitie's sampling of eelgrass fauna and look for broad changes (missing species? new invaders?).

- **REGIONAL PATTERNS**

What are patterns of estuarine habitat loss and conversion in California's estuaries?

In order to set regional conservation goals, we are sorely missing a synthesis of overall acres of salt marsh, brackish marsh, intertidal mudflat, and subtidal channels today vs. 100-200 years ago (before major human influences). A broadscale GIS analysis would help inform restoration planning.

How do shorebird numbers at Elkhorn compare to those at other wetlands in the region?

Convert shorebird abundance data at Elkhorn into Slough-wide total estimates, and then compare these to numbers from monitoring programs at Morro Bay, San Francisco Bay, Bolinas Lagoon, etc.

- **RESTORATION**

Does increasing elevation in degraded marsh areas lead to sustainable salt marsh recovery?

Small scale experiments would begin to shed light on whether salt marsh cover would be stable if the elevation of the marsh plain is increased substantially in subsided areas.

Can small-scale measures decrease bank erosion?

Small scale experiments with structures to reduce velocities (e.g., anchored Christmas trees) could reveal whether bank erosion could be slowed by such mechanisms.

Might native *Spartina foliosa* be a viable alternative or addition to hydrological management strategies to combat tidal erosion?
The Slough has no native (or non-native) *Spartina* marshes. Introducing the native species into intertidal mudlfats (degraded former pickleweed marshes and bank edges) might increase sediment deposition and decrease bank loss. Carry out literature review and simple modeling to determine where *Spartina* beds could potentially survive at Slough (maximum and minimum estimates of extent), given what is known about elevation and salinity tolerances of the species from elsewhere. Make predictions about effects on tidal erosion / depositional process at the Slough, under maximum and minimum estimates of distribution, based on sediment trapping studies elsewhere.

How does salt tolerance influence competition in the upper marsh?
In areas that have been disturbed by cattle grazing or diking, is it possible to increase marsh plant abundance and decrease non-native weed abundance in the ecotone by salt addition? If so, how persistent are these effects?

- **ECOSYSTEM SERVICES AND FUNCTION**

What is the habitat value of vegetated vs. unvegetated estuarine habitats?
Compare larval settlement, fish abundance, etc. in paired areas with and without dense pickleweed (intertidal) or eelgrass (subtidal). Or, using isotopes, compare marsh plant vs. algal sources of N and C in key indicator species (such as commercially harvested fish).

What is the relationship between tidal erosion and habitat use by key target species?
Are degraded marshes that have converted to high mudflats useful to migratory shorebirds (relative to other Slough mudflats)? Are eroded subtidal habitats in the channel useful to commercially valuable fish species or sea otters (relative to depositional subtidal areas in other estuaries)?

- **POLLUTION**

Does water quality correlate with adjacent land uses?
Use our 15 year database of water quality around the Slough, and pick specific case history sites to carry out GIS analysis of links between changed land practices and adjacent water quality.

What sort of vegetated buffer strips most effectively reduce polluted run-off from entering estuarine wetlands?
Not well known for Mediterranean region; some experiments with annual grasses found these were not effective barrier.

Are Elkhorn Slough habitats eutrophic?
What are the direct (e.g., toxicity) and indirect (e.g., changes in species assemblages due to macroalgal production or hypoxia) effects of high nutrient concentrations documented in the Slough?

Is the distribution of algal mats related to nutrient levels?

Correlate algal density with nutrient levels measured by monthly volunteer water quality monitoring program.

Has the abundance of *Ulva* mats increased over time?
Examine aerial photographs; extrapolate from increase in nutrient levels. Algal mats can have big effects on community dynamics, so knowing how historical levels have changed is important.

How do dense algal mats influence the distribution and abundance of infaunal invertebrates?
Compare invertebrate diversity and abundance in areas with and without dense algal mats (naturally occuring, or manipulate). Map distributions of dense algal mats to identify areas where invertebrates might be influenced most.

How do dense algal mats influence bird distributions?
Map bird distribution and abundance as a function of algal cover; experimentally change or look at natural variation. Presumably birds cannot access invertebrates through dense blanket of algae.

Are pesticides accumulating in Slough organisms?
Are pesticide concentrations causing chronic toxicity to organisms low in the food web at Elkhorn Slough, and is this resulting in bioaccumulation in birds and mammals?

Are ghost shrimp sensitive to polluted run-off?
Collect ghost shrimp from beds on the Reserve and grow them in Reserve water vs. water from Tembladero Slough and other polluted areas to test R. Kvitek hypothesis that decline of ghost shrimp near mouth may be due to polluted run-off.

What is the role of groundwater and atmospheric sources of nitrogen relative to freshwater run-off?
Use isotopes or other tools to determine relative importance of different sources of nutrient loading.

What are the main sources of fecal coliform bacteria in the Slough?
Concentrations are highest in areas receiving the most freshwater input, but it is not clear whether sources are residential septic tanks or agricultural.

- **INVASIONS BY NON-NATIVE SPECIES**

What are the effects of the introduced Japanese mudsnail *Batillaria* on diatom communities and macroalgal mats?
Assess diatom diversity & abundance and/or *Ulva* mats in areas with differing (naturally varying or experimentally manipulated) *Batillaria* densities. Interesting because enormous densities must be changing food webs in Slough, but effect hasn't been documented.

What factors influence *Batillaria* distribution and abundance?

The mudsnails appear to be densest in low elevation intertidal mudflats, particularly in subsided (formerly diked) areas; they are rare along the Slough's main channel. Is this due to patterns of spread from initial introduction sites? Or increased population growth in the subsided mudflats? Or lower predation (by crabs, shorebirds?) there than along the main channel?

How does the introduced gem clam (*Gemma gemma*) influence the abundance of other infaunal invertebrates?
Set up enclosures with and without gem clams, with otherwise normal invert community; examine changes in abundance over time. These clams are incredibly abundant, but no one has ever shown what sort of community effect they have.

Which invertebrate invaders are transported to the Slough on boat bottoms?
Examination of boats in Moss Landing Harbor, esp. those which have recently arrived from San Francisco Bay or other places with established populations of invaders; demonstration of local boat traffic as an important mechanism of transport might lead to boat-cleaning regulations.

Do non-native species fare better under human-altered conditions than natives?
Test a particular guild with natives and non-natives, such as fouling community, for survival and reproductive success in different pollution conditions, artificial vs. natural substrates, etc.

What are the competitive dynamics between the native long-jawed mudsucker and the non-native yellowfin goby?
Anecdotally, it appears that the former is becoming rare with the latter is becoming abundant.

- **RARE ESTUARINE ENDEMICS**

What are the microhabitat correlates of the threatened brackish snail *Tryonia imitator* and/or tidewater goby?
Fieldwork to map small-scale and large-scale distribution of these rare species at Slough; correlate to environmental factors (nutrients, pickleweed cover, predators). For the snail (which is not listed), manipulative mesocosm or laboratory experiments could confirm the role of putative environmental factors.

What are the current environmental correlates of oyster distribution and mortality?
Assess turbidity, depth, nitrates, etc. as possible factors affecting the distribution and mortality (ratio of dead/live shells) of native oysters at Elkhorn Slough. Results would inform potential restoration experiments.

Why have green phoronids become so rare?
In terms of native estuarine biodiversity, the dramatic declines of the green phoronid (formerly a mudflat dominant near the mouth, now virtually absent) are concerning, especially since there are only about a dozen species in this animal phylum. Carry out multi-estuary study to determine microhabitat requirements and environmental tolerances

of green phoronids, assess the distribution of such microhabitats at Elkhorn Slough. Could carry out manipulative experiments at sites where they still are abundant (Bodega) to test role of possible limiting factors at Elkhorn (burial with *Ulva*, etc.).

How does species diversity of salt pannes differ from adjacent habitats?
Salt pannes elsewhere have been shown to host various threatened species (e.g., tiger beetles) adapted to the extreme hypersaline conditions; the fauna of Elkhorn Slough salt pannes (e.g., in the North Marsh area) has never been examined; these habitats may be of high value to these rare communities.

- **RECREATIONAL USES**

How do kayakers influence marine mammal and bird behavior?
Observations to determine whether recreational visitors influence behavior of resident animals; results could lead to management recommendations.

What is the intensity of mudflat harvesting, and what are the effects?
Intensity could easily be assessed by visiting common clamming sites in lower Slough; effects would require controlled expert with fenced take and no-take zones.

2) FRESHWATER AND RIPARIAN HABITATS

- **THREATENED AMPHIBIANS AND REPTILES**

What mosquito control treatment is best at decreasing mosquito populations while supporting threatened amphibians, and the aquatic arthropods they eat?
Compare Bt, mosquitofish, native predators as control mechanisms in 18 Reserve water tanks (guzzlers).

What are the patterns of habitat use by southwestern pond turtles in the Elkhorn watershed?
Explore aquatic habitats and adjacent areas on the Reserve to locate nesting/breeding sites, count numbers of adults, and track their movements.

What strategies can improve water quality in Reserve freshwater wetlands?
Bioretention pits or heavy mulch to improve quality of freshwater inputs coming from adjacent agricultural fields? Annual dry down and removal of sediments? Bubbling stations to increase dissolved oxygen?

- **GROUNDWATER DYNAMICS**

How are the links between groundwater and surface water?
Have past changes to the Slough's tidal prism (e.g., return of tidal exchange to Parsons complex) affected local groundwater (saltwater intrusion)? How would future changes to the tidal prism of different wetlands (moderate decreases at Parsons, slight increases at South Azevedo, etc.) affect adjacent groundwater? Does surface impoundment of freshwater (e.g. in Moro Cojo area wetlands) help to restore groundwater and decrease saltwater intrusion?

3) COASTAL PRAIRIE

- **GRAZING AND OTHER RESTORATION TECHNIQUES**

What tools are effective for increasing native biodiversity in a very degraded grassland?
Compare various techniques (variants of grazing, mowing, planting, etc.) on the highly invaded Reserve grasslands, and determine effects on key targets (native grasses, annual forbs, perennial forbs).

Which native grasses should be planted on what parts of the Reserve?
Fieldwork to permit GIS mapping of soil types and microclimates; match to different plant optima; native grass should be better at resisting invasion if planted in ideal physical conditions.

What is the effect of species diversity on invasibility?
Do grassland restoration with multiple species, singly and in combinations, to look at whether species mixes are more effective than single species at preventing invasion by non-native species.

What is the effect of patch size on restoration success?
Plant natives in degraded grasslands in patches of varying sizes to determine whether bigger areas resist invasion better than do smaller ones.

- **SPATIAL PATTERNS OF PRAIRIE DISTRIBUTION**

Where are remaining stands of intact coastal prairie, and what do they correlate with?
Fieldwork to find remaining native grasses stands, and GIS work to determine whether land use history, slope, surrounding vegetation type, proximity to wetlands, etc. explain distribution.

- **HABITAT USE OF PRAIRIES**

What is the distribution and habitat use of the listed Salinas Harvest Mouse and Salt Marsh Ornate Shrew?
These species are endemic to a small area around Elkhorn Slough, and haven't been studied since the 1950s; their taxonomy and ecology should be revisited so that their small populations can be wisely managed.

How does poison hemlock influence community composition?
Examine diversity and abundance of some native plants or animals (e.g., songbirds; grasshoppers in areas with hemlock and areas where hemlock has been removed.

Which large predators occur in Elkhorn grasslands and surrounding landscape?
Which large predators are present? Are their populations viable? What movement pathways are they using, and how large is their range?

4) MARITIME CHAPARRAL

- **HABITAT LOSS AND CONSERVATION**

Explore the value of conservation easements and model effectiveness of mitigation banking strategies.
Map current conservation easements, document their past and present condition, and evaluate their ecological value. Help design baseline characterization and monitoring programs for chaparral easements. Or, evaluate the benefits of a maritime chaparral mitigation banking program in the watershed.

- **RESTORATION DYNAMICS**

Carry out experiments to test treatments to improve *Manzanita* recruitment.
Alteration of the natural disturbance regime (lack of burning) has lead to decline in recruitment by *Manzanita* and other key chaparral species, and a trend towards gradual conversion of chaparral to oak woodland. Small scale alternatives to burning (soil scrapes, mulching, shading, etc.) could be attempted in controlled experiments to increase recruitment.

5) COAST LIVE OAK

- **HABITAT VALUE RELATIVE TO EUCALYPTUS**

How do ecosystem processes differ in oak woodlands vs. eucalyptus groves?
For instance, how does water usage differ between the two tree species? How does nutrient cycling differ?

What is the value of oak vs. eucalyptus groves for native bird species?
Preliminary work has shown similar bird species composition in oak vs. eucalyptus groves. It would be interesting to track fitness parameters (nesting success, survival, etc.) to see whether the two woodland types are different or equivalent for particular bird species.

- **OAK RESTORATION**

Under what conditions do planted acorns do best?
Experiments evaluating various types of protection from predation and various water and soil parameters to figure out how oak restoration can best be accomplished.

How can invasive Cape Ivy best be controlled?
Experiments to determine optimum treatment times and methods to resolve conflicts in literature (e.g., whether to spray before or after flowering has commenced).

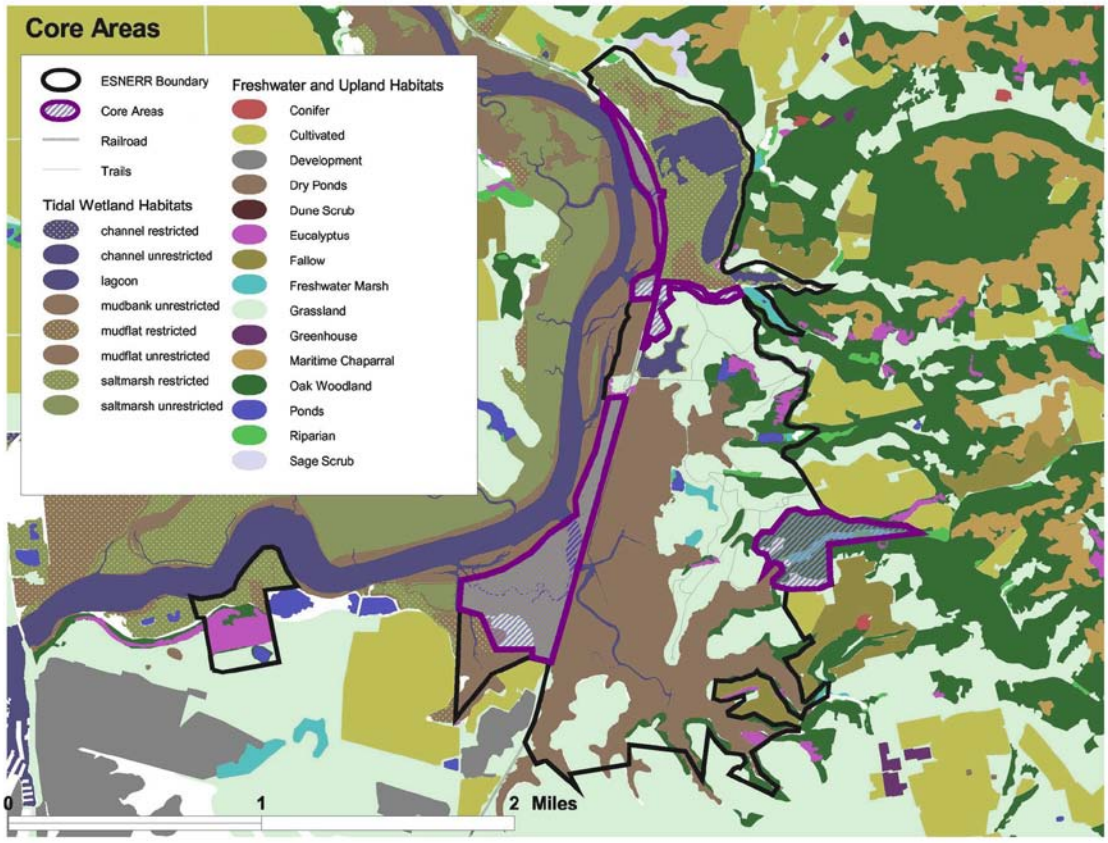
How can native oak understory be enhanced?
Experiments with various methods to initially remove and then to discourage re-establishment of non-natives. Include comparison of areas with varying canopy cover and proximity to edge to determine where long-term success is most likely.

- **WOODLAND CAVITY NESTERS**

What are the effects of providing nestboxes to cavity nesters?
We have 150 nestboxes used mostly by chestnut-backed chickadees (CBCH). Does providing nestboxes increase CBCH densities? (can compare woodlots with and without nestboxes). Does providing nestboxes increase CBCH reproductive success (have to find

natural nests in cavities to make this comparison). Does neotropical migrant density correlate with CBCH density (it has been suggested that neotropical migrants are attracted to CBCH and preferentially flock with them).

Appendix 7.
Elkhorn Slough Core/Buffer Areas



Appendix 8.
California Department of Fish & Game Outreach Messages

STATE OF CALIFORNIA - THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, *Governor*

DEPARTMENT OF FISH AND GAME
OFFICE OF COMMUNICATION, EDUCATION AND OUTREACH
1416 NINTH ST, ROOM 117, SACRAMENTO, CA 95814
(916) 653 - 6420

DFG Outreach Messages

DFG management objectives:
Responsible Recreation
Safe Human/Wildlife Interaction
Conservation and Protection of Wildlife and Habitat

Why resource management matters:
Valuing Our Natural Heritage
The Importance of Biodiversity

Responsible Recreation

DFG objectives:

- Promote fishing, hunting, and wildlife-dependent recreational opportunities to connect Californians to the most diverse natural resource heritage in the nation.
- Provide sustainable opportunities for hunting, fishing, wildlife viewing and other recreational uses of habitat as part of managing for viable, healthy populations.
- DFG wildlife areas, ecological reserves, and marine protected areas offer opportunities for different kinds of wildlife-dependent recreation.

Citizen Participation:

- A variety of conservation and recreation groups continue to play an important role in ensuring the protection of habitats and associated recreational opportunities.
- Compliance with fish and wildlife laws is an essential component of natural resource management.

Safe Human / Wildlife Interaction

DFG objectives:

- Promote co-existence with California's wildlife. This includes expanding awareness about responsible behaviors for the safety of the public and health of wildlife.
- Educate the public about use of fish and wildlife management strategies that recognize all species (including humans) live interdependently.

Citizen Participation:

- ♦ People are part of nature. What we do in our cities, towns, and rural areas affects wildlife habitats no matter where we live and work.
- ♦ Citizens need to know about *what to do* and *what not to do* to co-exist with California wildlife. This requires an understanding of wildlife behaviors including the need for movement and migration patterns.

Conservation and Protection of Wildlife and Habitat

DFG objectives:

- ♦ Maintain native fish, wildlife, plant species and natural communities through a broad range of activities such as: scientific monitoring of native and introduced species; enforcement of laws regarding the taking of wildlife; management of lands and facilities; technical assistance on resource management to landowners; review of streambed alteration and timber harvest plans; and rapid response to oil spills.
- ♦ Conserve critical habitat areas to safeguard terrestrial, fresh water aquatic and marine ecosystems. This includes protection of wildlife corridors connecting areas of viable habitat and critical for providing access to food, water, shelter.
- ♦ Maintain ecological reserves and marine protected areas intended to conserve unique, fragile habitats and which can function to protect and restore rare and threatened native species.

Citizen Participation:

- ♦ Californians only protect fish and wildlife resources they know about and value.
- ♦ Education of a citizenry to the mission of DFG and the breadth of its work is an important means to gain the public support needed to achieve many objectives.
- ♦ Individual personal actions in partnership with local community and combined agency efforts are critical to the long-term maintenance and survival of wildlife and the habitats upon which they depend.
- ♦ The needs of a growing human population can be balanced with those of wildlife. Use of the land, waterways, and living resources should be planned and implemented to minimize the impact on wildlife and ensure long-term sustainability of habitat.

Why resource management matters:

Valuing Our Natural Heritage

- ♦ California's wildlife and habitat represent critical resources maintained in public trust

for future generations.

- ♦ People and wildlife share a common need for clean water, clean air, and a habitable place to live.
- ♦ Each of us shares the responsibility to conserve and protect California's natural heritage.
- ♦ Public and private partnership effort to sustain natural resource viability within the matrix of California landscapes invites the growth of a stewardship ethic. The balance of ecological, economic, recreational, and aesthetic values to be gained is a long-term benefit to our quality of life.

Why resource management matters:

The Importance of Biodiversity

- ♦ Biodiversity is a measure of the biological richness of an area. California is one of the top 'hotspots' for biodiversity in the world (ref. DFG Biodiversity Atlas).

[*Numerous areas in California are considered biologically irreplaceable (significant for conservation of biodiversity) having relatively high concentrations of rare species found nowhere else.*]

- *For a regional landscape or entire state: biodiversity is the diversity of species, habitats, and vegetation types.*
- *For a habitat or vegetation type: biodiversity is the diversity of life forms within it.*
- *For a species: biodiversity is the genetic variation within a population or among populations.*

- ♦ Living organisms, including humans, survive interdependently in the "web of life". High biodiversity, or a complex web, is generally considered more stable because it is more adaptable to change.
- ♦ Biodiversity is being lost due to destruction of habitat by an expanding range of human activities and competition from introduced species.
- ♦ Maintaining a rich biodiversity is important on many different levels. In California, biodiversity is an incentive for job growth and greater economic prosperity. California's living resources have much future potential including value in the fields of medicine, energy, tourism, and others.

Appendix

The following are some examples of how these messages could be applied:

Responsible Recreation—
Practice responsible outdoor recreation.

***** Conserve our wild heritage now, and enjoy it always.

***** Take no more than what you can use in a reasonably short period of time, but never more than your limit when fishing or hunting. You don't always have to take your limit.

Safe Human / Wildlife Interaction—
Wild animals are naturally wary of people. Let's keep it that way.
***** Humans can unintentionally attract wildlife and change them to become dependent on humans.
***** It's humans that can change their actions. Educate others to wildlife awareness.

Conservation and Protection of Wildlife and Habitat—
We All Live in a Watershed
And California's native fish & wildlife are part of our community

Yet, did you know…
The #1 threat to California fish, plants, and wildlife is loss of their habitats

Natural areas can become fragmented and unable to support healthy native plant and animal populations

~ Human needs CAN be balanced with those of wildlife ~

***** Wildlife corridors are critical for providing access to food, water, shelter, and play an important role in wildlife migration.

***** Maintaining protected and linked networks of terrestrial and aquatic habitat with clean air and clean water is essential to building sustainable communities for wildlife and people.

Find out about local opportunities to enhance and restore habitat…
…because California's fish and wildlife are depending on you.

Valuing Our Natural Heritage—
Your Home...is Bigger Than you Think…

***** Most Californians share a desire to protect the environment. And their

attitudes affect what they do: such as, avoiding the use of toxic products where possible and making certain that soaps, paints, and oil don't wash into street gutters and storm drains.

***** Keep creeks and other wild habitats clean and healthy places for fish, wildlife, and people.

***** We hold in "public trust" California's natural heritage of fish and wildlife.

The Importance of Biodiversity—
When the rich web of life is cut back, we are all poorer for it.

***** California is one of the top 'hotspots' of biodiversity identified worldwide…but that diversity is being lost.

***** Do your part to protect wildlife habitat and prevent the spread of invasive and non-native species that threaten California's natural heritage.
***** Maintenance of California's rich biological diversity requires careful land use planning so that plants, fish, and wildlife resources may be sustained for future generations.