Laguna Watershed Research Plan
2008 – 2012

Building a Scientific Knowledgebase to Restore and Preserve the Laguna de Santa Rosa Watershed in a Changing Environmental and Economic World

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I. Executive Summary

The Laguna de Santa Rosa watershed spans 256 square miles and represents a complex of unique and threatened aquatic and terrestrial ecosystems. The Laguna de Santa Rosa is one of the largest floodplains in California, directly and indirectly affected by the many impacts from the largest concentration of urban centers in Sonoma County: Cotati, Rohnert Park, Sebastopol, Santa Rosa, and Windsor. Within the last century, urban, agricultural, and other land uses have resulted in highly fragmented landscapes and critically endangered wetland ecosystems throughout the watershed. Much of the natural processes within the Laguna de Santa Rosa and its watershed tributaries were altered and now reflect these human caused modifications. This has rendered the watershed ecosystem functions impaired, with negative impacts to natural hydrology, sedimentation, flood capacity, water quality and to valuable ecosystem services for humans, such as for example flood storage, nutrient cycling, and recreation. After agricultural conversion and urbanization, the watershed's Santa Rosa Plain region now contains only remnants of the distinctive and formerly vast vernal pool seasonal wetlands. This irreplaceable wetland ecosystem contains several unique rare and endangered species in need of recovery found only in this corner of the world.

The Laguna de Santa Rosa watershed typifies the environmental and economic challenges faced by the surrounding communities in the larger San Francisco Bay Area and elsewhere in California- sustaining agricultural production, developing alternative solutions to expanding human populations and urbanization, and promoting watershed and wetland conservation and restoration. Historically extremely rich and diverse, the degraded watershed ecosystems now perform at sub-optimal levels, and active restoration and effective long-term conservation and management are needed to re-establish their appropriate functioning.

In order to guide these important processes of watershed restoration, conservation and appropriate long-term management a sound and objective methodology of inquiry and evaluation based in science is crucial to an adaptive strategy leading to lasting success. A science-based approach will ensure that

appropriate methods are tested and used in the restoration of ecosystems, and objective decisions are made regarding the approaches to long-term conservation and management of threatened and endangered species and their habitats.

With the guidance of the Laguna Science Advisory Council (LSAC), a group of 28 local and regional academic and agency scientists, the Laguna Foundation Science Program has developed this five-year research plan to effectively guide the conservation and restoration in the Laguna de Santa Rosa watershed. This plan will focus research and information that will help to develop appropriate techniques to protect and enhance the quality of remaining natural areas, identify and evaluate effective restoration methods and management techniques for recovery of threatened and endangered species, to identify threats associated with continued habitat loss or degradation, non-native invasive species, pollution, and climate change with special emphasis on the Laguna de Santa Rosa waterway, its tributaries, the Santa Rosa Plain, and montane upper watershed regions.

We have identified six broad components to focus our research efforts over the next five years, and include a listing of the specific related research projects:

1. **Long-term Ecological & Biodiversity Assessments in the Face of Climate Change** – Creation of a field data set to base conservation and regional climate change modeling and restoration efforts on**.**

   Research Questions: What is the current status of biodiversity in Laguna ecosystems? Where are the areas of highest biotic value to restore and protect? What Laguna areas and habitats constitute the major wildlife corridors connecting important habitats at a variety of scales?

   1.1 Establishment of historic, contemporary and long-term ecological & biodiversity status baselines of Laguna natural systems and their connectivity and related threats;

   1.1.1. Aquatic community surveys to establish current species diversity levels and target species status; to investigate aquatic food web trophic level dynamics for potential biomanipulation to help restore water quality.

   1.1.2. Mammal surveys on City of Santa Rosa Laguna farms to establish mammal diversity and patterns of distribution to reassess land use practices and identify and evaluate wildlife corridors.

   1.1.3. Development of a regional (County-wide) GIS layer of major vegetation types to support conservation planning.

   1.1.4. Regional wildlife corridor survey to evaluate corridor habitat function.

   1.1.5. Laguna Watershed mega-transect or 'Bio Blitz' (National Geographic Society) project to involve citizen scientists in biotic assessmenst of Laguna biodiversity spanning across several habitats.

2. Historical Ecology Analysis - Evaluation of the historical versus current status of Laguna human and natural systems, including trends in land use, resource economics and related perils to Laguna ecosystems.

Research Questions: How do our current levels of land use and biodiversity compare to historic levels? How do current impairments reflect historic land use activities?

2.1. Laguna oral history – to create a historic knowledgebase of the ways the Laguna has served locals and has been impacted within the last 50 to 80 years. This will help in better understanding land use history and the related mind-set of Laguna long-term residents.
2.2. Historic Laguna hydrology evaluation in order to better understand impacts of changed conditions and to inform restoration strategy.
2.3. Historic vegetation communities and wildlife assessment to evaluate the dynamics of historic ecosystem function and to inform the restoration of current ecosystem function.
2.4 Historical oak ecology – to elucidate the history of land use and temporal changes in vegetation stages of watershed habitats and around the use and historical abundance of a Laguna keystone species (Valley oak – *Quercus lobata*).

3. Conservation Planning – Evaluation of existing habitats and land use to identify important conservation areas and to implement their conservation.

Research Questions: Where are the areas of highest biotic value in the watershed? How can we best achieve their recognition and protection?

3.1. Evaluation of Laguna ecological baseline and land use to establish prioritization for conservation land acquisition within the watershed;
3.1.1. Conceptual Area Acquisition Plan (CAAP) – using historic and expanded knowledgebase, and conservation models to prioritize the acquisition of lands for long-term conservation & management.
3.2 Establishment of Laguna as recognized wetland complex of national and international significance under the Ramsar Convention.

4. **Restoration Efficacy & Conservation Management Appraisal** - Creation/expansion of a scientific knowledgebase to inform the implementation of effective restoration and appropriate long-term management of conservation areas.

Research Questions: How can we measure the long-term success of restoration projects and conservation management techniques? How can we improve restoration and management techniques to minimize negative side-effects and to maximize efficacy?

4.1 Development and appraisal of methods to improve the long-term efficacy of restoration and conservation management;
4.1.1. Long-term bird surveys to assess impacts of planned trail system (point counts) & to evaluate riparian restoration success (area searches).
4.1.2. Pepperweed (*Lepidium latifolium*) tarping to test the efficacy of this technique to control/eradicate this invasive plant.
4.1.3. Establishment and testing of conservation management techniques for the endangered Sebastopol meadowfoam (*Limnanthes vinculans*) in a floodplain seasonal wetland.
4.1.4. Investigation of grazing as effective management tool of endangered vernal pool grasslands on conservation lands and as economically viable opportunity for local ranchers.
4.1.5. Establishment of citizen science program for invasive species detection & rapid control at an early stage of infestation
4.1.6. Cooper Road Preserve vegetation study – Evaluation of changes in vernal pool vegetation 12 years after cessation of grazing – evaluation of appropriate long-term management methods to restore to previous diversity levels.

5. **Endangered, Threatened or Special Status Species Recovery –** Investigation into the status of declining species in order to inform recovery decisions.

Research Questions: What are the ecological needs of the declining species to better understand underlying causes and to implement the appropriate recovery actions?

5.1. Assessment of the status and conservation ecology of endangered, threatened and other special status species within the watershed and related threats to recovery;
5.1.1. Adopt a vernal pool long-term endangered plant survey to establish a record of the threats, status and natural fluctuations of endangered annual vernal pool plant species and their community and pollinators.

5.1.2. Endangered vernal pool plant pollination and reproductive ecology to identify the identity and abundance of vernal pool plant main pollinators and to compare the seed set of these endangered plants across site quality (degraded or not; pollinators present at high or low levels) and history (natural or created).

5.1.3. CTS larval community survey to determine the main larval food sources and trophic relationships within larval pools.

5.1.4. Determination of the status, demography & diet of declining Western Pond turtles in the Laguna watershed in order to inform decisions to restore and conserve population numbers and appropriate habitats.

6. **Water Quality Improvement -** Investigation of landscape level dynamics of Laguna ecosystems affecting water quality.

Research Questions: What are landscape scale or regional dynamics of factors influencing Laguna water quality? How can these dynamics be influenced to effect substantial water quality improvement?

6.1. Appraisal of the landscape level dynamics, and evaluation of implemented methods for improvement of seasonal and permanent aquatic system water quality and function;

6.1.1. Scientific inquiry to inform the Laguna Wildlife Area restoration

6.1.2. Determination of the role of vernal pools (and their fauna & flora) in landscape scale water storage and nutrient cycling

To assure the dissemination of the information gathered through our research efforts we have launched an online digital library called the 'Laguna Knowledgebase' (http://www.lagunadesantarosa.org/knowledgebase/). To further effectively share our data and discuss findings, implications, potential actions and new ideas and directions with the local and regional community we are holding science symposia at the biennial State of the Laguna Conference to bring together the scientific and resource management community as well as other stakeholders. We area also working on compiling a biennial Laguna report card detailing the results of our investigations to the public through a simple scoring system based on several indicators. Throughout our research efforts we are involving students from regional and national academic institutions and local schools as well as citizen scientists. We strongly believe in a collaborative inter-disciplinary approach and can so count on the partnership of many academic and resource management institutions, as reflected by our LSAC membership.

The primary expected outcomes of this five-year research plan include:
- Effective long-term restoration, conservation and management of Laguna watershed conservation lands.
- Better understanding of ecological needs and causes of native endangered, threatened and special status species in order to successfully inform their recovery and conservation.
- Increased understanding of the historical Laguna ecology and its relevance to restoration and conservation decisions today.
- Empirical data on current biodiversity dynamics in the watershed to help identify important areas for restoration and to use in local and regional climate change modeling and conservation planning.
- Knowledge of the major (& minor) wildlife corridors within the watershed and their local and regional connectivity.
- Increased area and connectivity of important conservation lands within the watershed.
- Peer-reviewed scientific publications discussing research efforts in the Laguna within a regional, national, and international context.
- Increased collaborations with academic institutions and local High Schools resulting in student research projects within the Laguna.
- A next generation of researchers educated to use tools such as GIS, genetic tools, etc. in practical "place based" long-term field research studies.
- Updated Best Management Practice guidelines for vernal pool grassland grazing.
- Demonstrated partnerships between Laguna stakeholders (e.g. increased grazing agreements between ranchers and natural resource managers)
- Increased availability to the public of documents relevant to the Laguna.
- An engaged local community that enjoys the myriad services and richness offered by the Laguna.
- Effective management of vernal pool grasslands.
- Updated Best Management Practice guidelines for vernal pool grassland grazing.

II. Introduction

A. The Purpose of this Research Plan

The Laguna de Santa Rosa Foundation Science Program (LFSP) developed this five-year research plan to help identify, address and resolve critical local environmental problems - providing information to assist local, regional and national agencies in resource management decision making, restoration of degraded habitats, and long-term conservation, management and recovery of listed species.

The purpose of this research plan is to:
- Respond to the resource conservation, restoration and management needs of the local watershed community;
- Establish a current ecological knowledgebase at the species, population, community, and landscape levels to be used in conservation planning and policy decisions;
- Improve communication and flow of information regarding the status of and threats to Laguna watershed ecosystems;
- Implement effective restoration and early invasive species detection and control programs;
- Collaborate with other academic and scientific institutions, and resource management agencies;
- Provide an excellent academic and research learning experience for students;
- Raise public awareness and involvement by engaging citizen scientists;
- Provide a clear, concise timeline of research projects within the Laguna de Santa Rosa

This plan includes a clearly defined body of work, which can be summarized as a problem statement, clearly defined research questions, and the projects that will address the research questions over a five-year period. The Laguna research plan development was guided by the Laguna Research Advisory Council (LSAC), which includes representatives from government, research and academic institutions, non-profits and local stakeholders.

B. Background

i. The Laguna de Santa Rosa

The Laguna de Santa Rosa is a complex of waterways and associated wetlands draining a 240 square mile watershed in Sonoma County, California. The Laguna watershed wetland complex (Laguna) consists of a 14-mile main channel flowing to the Pacific Ocean via the Russian River as well as associated tributaries, wetlands, floodplain, and uplands (Fig. 1). The Laguna de Santa Rosa is one of the largest freshwater wetlands remaining in California facing many threats within a matrix of direct and indirect human impacts. Home to an increasing number of

threatened and endangered species and habitats, the Laguna is an important hotspot of biological diversity and ranks as one of the highest-priority areas for conservation and preservation in California.

Decline of wetlands in Mediterranean-type areas around the world has become an alarming trend, and California wetlands have been hit especially hard. California has witnessed more than a 90% wetland loss - more than any other state in the country. Soon to be officially recognized as a Wetland of International Importance under the Ramsar Convention, a section of the Laguna will join a short list of 24 other wetlands in the United States to earn this designation, recognizing the Laguna as critical wetland habitat in a global context. The Laguna is globally significant mainly as one of the few remaining large freshwater wetland systems in the Mediterranean-type ecosystems. Mediterranean type ecosystems have recently been identified as the second most at-risk biome worldwide, second only to the grassland biome.

The Laguna is home to 120 endangered, threatened, or special status species, including the California tiger salamander (*Ambystoma californiense*), western pond turtle (*Emys marmorata*), California freshwater shrimp (*Syncaris pacifica*), Steelhead trout (*Oncorhynchus mykiss*), Coho salmon (*Oncorhynchus kisutch*), long-eared myotis (*Myotis evotis*) and several other bats, ringtail (*Bassaricus astutus*), bald eagle (*Haliaetus leucocephalus*), willow flycatcher (Empidonax trailii), and several plant species, including white sedge (*Carix albida*), Vine Hill clarkia (*Clarkis imbricata*), Sebastopol meadowfoam (*Limnanthes vinculans*), Sonoma sunshine (*Blennosperma bakeri*), Burke's goldfields (*Lasthenia burkei*), and many-flowered Navarretia (*Navarretia leucocephala-plieantha*).

A complex of a variety of wetland environments near growing urban centers, the Laguna has undergone profound anthropogenic changes resulting from the pressures of expanding cities. Once supporting large dairy ranches, the Laguna has become increasingly fragmented by encroaching urban and suburban boundaries and conversion to vineyards, each of which have led to soaring land prices and diminishing lands for habitat for native wildlife, low-impact agriculture, and recreation, and changes in related ecosystem functions and their services.

While catastrophes such as the devastating hurricanes Katrina and Rita brought into sharp public focus the importance of conserving wetlands to dampen deadly storm surges, overall recognition of the many important services provided by wetlands is still lacking. Conserving wetland habitat for one endangered species can often protect an entire ecosystem at many trophic levels. For example, decreasing sediment inputs to support Salmonids improves clarity of water benefiting other wildlife, as well as recreation and so promoting tourism. The Laguna de Santa Rosa and adjacent Santa Rosa plain are recognized as important native species habitat also providing a wealth of ecosystem services to the local economy including water storage, flood protection, food, fuel, and fiber production, recreation, and tourism. It is productive agricultural land and becomes increasingly complex with biking and hiking trails to foster human enjoyment.

Urbanization of the watershed resulted in significant nutrient and sediment loading of the Laguna via indirect storm runoff from city streets and direct discharge of treated wastewater. In 2002, the Laguna was added to the Clean Water Act

303(d) list for impairments regarding phosphorus, nitrogen, low dissolved oxygen, elevated temperature, and excessive sediment. In 2007, the watershed was also listed for elevated mercury. Construction of the Geysers pipeline to divert and discharge treated wastewater outside of the watershed to recharge a depleted aquifer has drastically reduced regular nutrient additions into the Laguna in recent years. This and other efforts reflect growing public concern about the state of one of Sonoma County's richest wildlife areas.

Figure 1a Map of Sonoma County and Laguna de Santa Rosa watershed (only major tributaries are depicted).
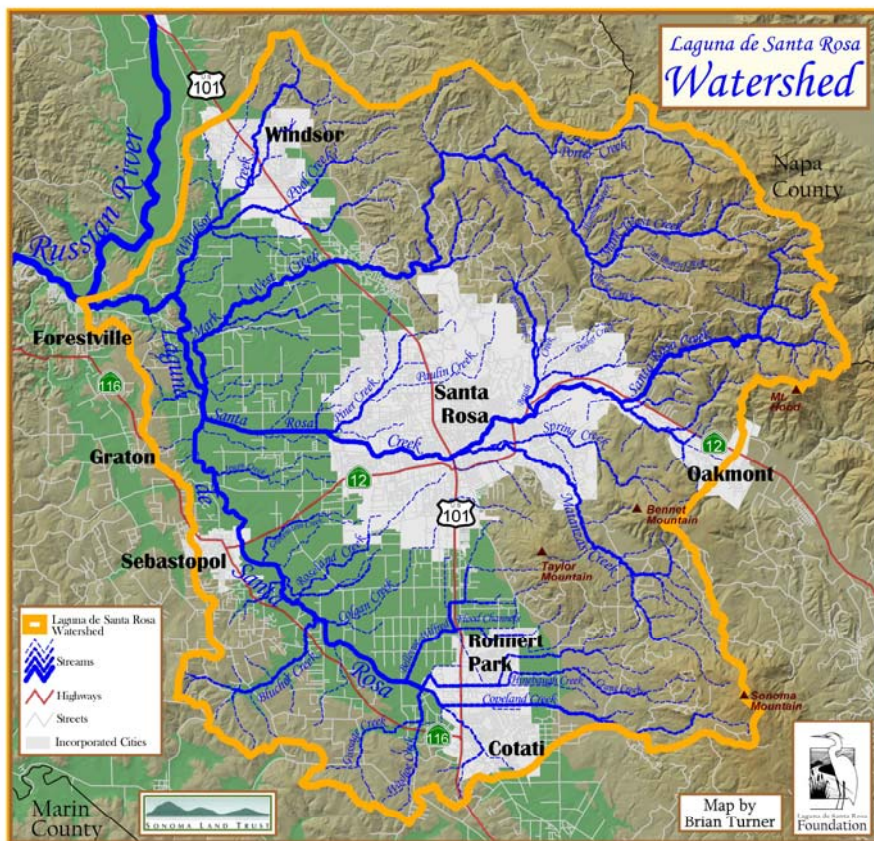
Figure 1b: Detailed map of Laguna de Santa Rosa watershed.

ii. The Laguna Foundation

It is the mission of the Laguna de Santa Rosa Foundation to "preserve, restore and enhance the Laguna de Santa Rosa, and to inspire greater public appreciation and understanding of this magnificent natural area." Established in 1989, the Laguna Foundation is a nonprofit organization providing education for school children and adults, collaborating with local landowners and public agencies, managing control efforts of major invasive species infestations, implementing restoration plantings in large degraded riparian areas along the Laguna de Santa Rosa, and guiding the restoration and conservation of the watershed's natural resources via scientific research.

Despite its recognized importance, the Laguna to date has not received the necessary support required to achieve regional conservation goals. The Laguna Foundation has played a vital role in building broader support for this unique area. The Foundation's programs restore and enhance wildlife habitat, provide classroom and outdoor learning experiences, conduct scientific research to inform restoration, conservation and management practices and public policy, and create opportunities for the public to experience the Laguna.

Within the Foundation, it is the specific goal of the Science Program to conduct relevant, targeted research to promote science-based, cost-effective choices that will positively affect the Laguna in a local, regional, national, and international

context, adding valuable information to the scientific knowledgebase to aid restoration, natural resource management, and conservation. Our program scientists collaborate with colleges and universities, natural resource managers, and citizen scientists to collect, analyze, and share data that will ultimately enhance restoration, conservation and management efforts.

The Role of Science

In order to guide the important processes of watershed restoration, conservation and appropriate long-term management we recognize that a sound and objective methodology of inquiry and evaluation based in science is crucial to an adaptive strategy leading to lasting success. After our first biennial Laguna science symposium at Sonoma State University in 2007 the LFSP and LSAC established the need for a comprehensive and collaborative Laguna research plan to guide short-term scientific study over the next five years as well as implement long-term ecological surveys to inform future resource management and policy decisions in the face of climate change and other scientific questions relative to long-range ecological dynamics.

The role of science in implementing and evaluating conservation and restoration strategies cannot be underestimated. For example, throughout California during the 1990's livestock grazing in native and often threatened vernal pool habitats was determined to be detrimental. Cattle were viewed as destructive because they trample and graze on endangered plants and defecate in pools. As a result of mere anecdotal observations, cattle were systematically removed from public vernal pool conservation lands 10 – 15 years ago. Recent scientific studies however, demonstrate that grazing can have a positive impact to preserve vernal pool and other grassland community types (Hayes, 2003, Marty 2005). These studies showed that cattle graze on non-native invasive plant competitors allowing the native plants to increase in cover and species richness in grazed compared to ungrazed sites. Resulting from this research, livestock grazing is being re-implemented as a tool to preserve native plants in the landscape. However, other studies have indicated that grazing regimes have to be evaluated very closely with regard to their effects on grassland type and specific management goals. Therefore, scientific methods must be implemented on a localized scale to closely evaluate the best practices for grazing in Santa Rosa Plain vernal pool lands to preserve native species.

iii. Laguna Science Advisory Committee

The Laguna Science Advisory Committee (LSAC) was established to support the Laguna Foundation Science Program (LFSP) in developing, coordinating and conducting research, and helping us to monitor the success of this research plan. The Laguna Foundation research program consults with LSAC to ensure that we are engaging in the best possible and most relevant research projects and use the most appropriate methodologies in our inquiries. The LSAC is composed of local natural resource professionals, researchers, and stakeholders within the Laguna. The relationships between the many partners involved in the implementation of this Research Plan and their roles are seen in Figure 2.
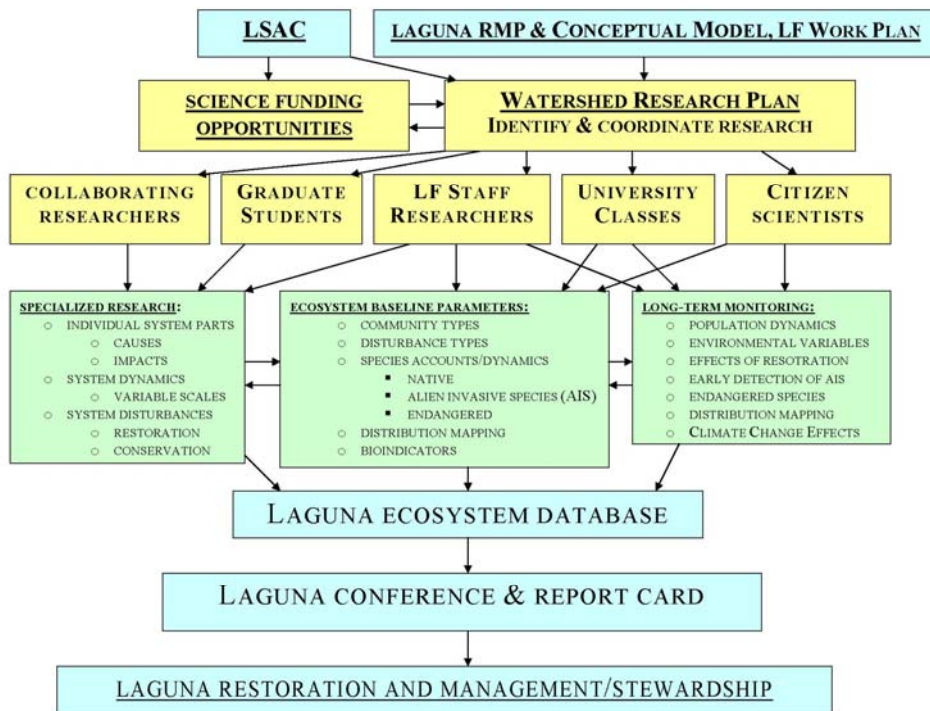

Figure 2. A conceptual model of research partnerships, and components, and related outcomes.

Table 1: Laguna Science Advisory Council (LSAC) Membership since 2007.

Name	Title	Affiliation
Dr. Michael Barbour	Professor	UC Davis
Stephen Barnhart	Education Director	Pepperwood Preserve
Dr. Shawn Brumbaugh	Professor	Santa Rosa Junior College
Denise Cadman	Natural Resource Specialist	City of Santa Rosa
Dr. Caroline Christian	Assistant Professor	Sonoma State University
Dr. Mateo Clark	Assistant Professor	Sonoma State University
David Cook	Biologist	Sonoma County Water Agency
Gene Cooley	Botanist	California Department of Fish & Game
Clayton Creager	Scientist	North Coast Regional Water Quality Control Board
Kit Crump	Biologist	NOAA Fisheries
Dr. Heather Davis	Post-Doctoral Researcher	Sonoma State University
Deanne DiPietro	Research & Information Systems Program Manager	Sonoma Ecology Center
Dr. Lorraine Flint	Scientist	USGS
Karen Gaffney	Land Stewardship Manager	Sonoma County Agricultural Preservation and Open Space District
Tom Gardali	Avian Ecologist	PRBO Conservation Science
Dr. Nick Geist	Professor	Sonoma State University
Dr. Mark Herzog	Avian Ecologist	PRBO Conservation Science
Rebecca Lawton	Geologist	Sonoma Ecology Center
David Lewis	Biologist	UC Cooperative Extension
Stacy Martinelli	Wildlife Biologist	California Department of Fish & Game
Dr. Lisa Micheli	Geomorphologist	Sonoma Ecology Center
Dr. Phil Northen	Professor Emeritus	Sonoma State University
Charles Patterson	Biological Consultant	
Dr. Christopher Potter	Scientist	NASA/Ames
Dr. Nathan Rank	Professor	Sonoma State University
Dr. Edmund Smith	Scientist	Bodega Marine Lab
Dr. Ayzik Solomeshch	Botanist	UC Davis
Chuck Striplen	Historical Ecologist	San Francisco Estuary Institute
Kate Symonds	Biologist	U.S. Fish and Wildlife Service
Dr. Steven Talley	Biological Consultant	

iv. Laguna Stakeholders

The community of stakeholders in the Laguna watershed is vast and diverse, encompassing subsections of potentially opposite interests. Within the overarching goal of enhancing and restoring the Laguna wetland complex we have been successful in working together with all types of Laguna stakeholders and have successfully engaged opposing factions. We have instituted regular Laguna stakeholder meetings, where stakeholders come together to learn about and discuss issues, current projects and potential opportunities. We see this as an extremely important part of our work to implement appropriate restoration, conservation, research and education projects. The Laguna stakeholder community generally consists of the following constituencies:

- Laguna Agricultural Community
    - o Dairy Farmers

- o Sheep Ranchers
- o Wine Growers
- o Nurseries
- Other Private Landowners
- Sonoma County Water Agency
- Municipalities
  - o City of Santa Rosa
  - o City of Sebastopol
  - o City of Cotati
  - o City of Rohnert Park
  - o City of Windsor
- Sonoma County PRMD
- California Department of Fish & Game
- North Coast Regional Water Quality Control Board
- U.S. Fish and Wildlife Service
- Sonoma State University
- Santa Rosa Junior College
- Public

v. Problem Statements

Challenges Facing the Laguna

1) Increasing level of urbanization, and land use history in the Laguna caused:
- Significant loss and fragmentation of critical wildlife habitat within the watershed.
- Loss and decline of threatened and endangered and special concern species.
- Continued inputs via runoff and sediment from urban centers surrounding the Laguna.
- Mobilization of historic inputs within the Laguna.
- Conversion of dairy and livestock grazing lands to housing and vineyards.

2) Local community members are under-informed of the importance of the Laguna.
- Limited public awareness of the ecosystem services provided by the Laguna.
- Lack of knowledge regarding the current state of Laguna ecology.
  - o Pollutant levels
  - o Biodiversity
  - o Endangered species recovery
  - o Non-native invasive species impacts
  - o Impacts from habitat loss and fragmentation
  - o Impacts from climate change

3) Public agencies tasked with maintaining public land holdings in the Laguna lack the monetary resources to effectively manage conservation lands.

- Current conservation lands are degrading in the absence of appropriate management
- Existence of large data gaps to adequately guide the implementation of restoration and conservation management.

Challenges of conducting research and restoration in the Laguna
- Private landowners are often reluctant to allow restoration and scientific monitoring for fear that finding threatened or endangered species or habitat will limit their land use options.
- Lack of understanding of funding agencies of the importance of science-based restoration and conservation projects –a scientific component to every restoration or conservation management project is crucial in order to evaluate the need, the appropriate methodology and the efficacy and success over the short and long term.
- Deficient knowledge about the efficacy of restoration methods and the success of restoration efforts in the Laguna including matrices by which to measure a project as successful or not.
- Lack of historical knowledgebase, i.e. available baseline data for comparison.
- Restoration efforts are expensive and take a long time to show success.
- Research and restoration efforts must not damage the critical habitat they take place in.

III. Research Components and Projects

Research projects under each research component are listed below, including in each case an overarching goal relative to the problems facing the Laguna that the research addresses, the specific research question, potential collaborators, and the ways to conduct research toward the goal.

Research Component 1:
Long-term Ecological & Biodiversity Assessments in the Face of Climate Change

Priority: **1-3** (Rank 1-5, with 1 being top priority)
Opportunity: **B-C** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, North Coast Regional Water Quality Control Board, Sonoma Ecology Center, USGS, Cal Academy of Science, Sonoma State University, UC Berkeley Extension, National Geographic Society, Sonoma County Agricultural Preservation and Open Space District, Sonoma Land Trust, Resource Conservation Districts (Sotoyome & Goldridge).*

Research Questions: What is the current status of biodiversity in Laguna ecosystems? Where are the areas of highest biotic value to restore and protect? What Laguna areas and habitats constitute the major wildlife corridors connecting important habitats at a variety of scales?

Research Goal: Establishment of historic, contemporary and long-term ecological and biodiversity status baselines of Laguna natural systems and their connectivity and related threats; Creation of a field data set to inform restoration, conservation and regional climate change modeling efforts**:**

1.1 **Aquatic community surveys** to establish current species diversity levels and target species status and to investigate aquatic food web trophic level dynamics for potential biomanipulation to help restore water quality.

- Following standardized protocols twice annually for three years tested in a 2008 pilot survey to sample abundance and diversity of fish, macro-invertebrates, plankton, periphyton and water chemistry at four-six sites along the Laguna de Santa Rosa floodplain.

Priority: **1**
Opportunity: **C**; North Coast Regional Water Quality Control Board, NOAA Fisheries, Mary A. Crocker Trust.
Integration: **R & E**; Restoration of Laguna water quality, Education of students and professionals in aquatic survey methods

Collaboration: North Coast Regional Water Quality Control Board TMDL program, Community Clean Water Institute, Sonoma State University, Sotoyome Resource Conservation District, Pepperwood Preserve.

1.2 **Mammal surveys** on City of Santa Rosa Laguna farms to establish mammal diversity and patterns of distribution to reassess land use practices and identify wildlife corridors.
- Following establish mammal survey protocols to survey different habitats within different land use areas on City of Santa Rosa farmlands.

Priority: **1**
Opportunity: **B**; City of Santa Rosa, Marisla Foundation
Integration: **R & E**; Restoration of Laguna wildlife corridor habitats, Education of students and professionals in mammal survey methods
Collaboration: City of Santa Rosa, Department of Fish & Game, Sonoma State University, Pepperwood Preserve.

1.3 **Regional (county-wide) GIS vegetation type layer development** to aid in conservation planning and in determining likely biological hot spots and potential wildlife corridors.
- Using GIS aerial photograph interpretation techniques to establish a fine-scale vegetation-type layer throughout the watershed.
- Using analysis of vegetation layer and additional existing GIS layers on established conservation parcels to determine corridor habitats and biological hot spots in the watershed and beyond.

Priority: **1**
Opportunity: **C**; Sonoma County Agricultural Preservation and Open Space District, Marisla Foundation
Integration: **R**; Restoration of Laguna wildlife corridor habitats.
Collaboration: Sonoma County Agricultural Preservation and Open Space District, Sonoma Land Trust, Sonoma Ecology Center, Sonoma State University, UC Berkeley Extension, Pepperwood Preserve, City of Santa Rosa, Department of Fish & Game, Resource Conservation Districts (Sotoyome & Goldridge).

1.4 **Regional wildlife corridor survey** to ground truth corridor habitat function suggested by regional vegetation type analysis.
- Using results from analysis of vegetation & other relevant GIS layers to test the use of proposed wildlife corridors by conducting timed surveys using standardized protocols.

Priority: **1**
Opportunity: **C**; Sonoma County Agricultural Preservation and Open Space District, Marisla Foundation, Moore Foundation.
Integration: **R**; Restoration of Laguna wildlife corridor habitats.
Collaboration: Sonoma Ecology Center, USGS, PRBO Conservation Science, Cal Academy of Science, Sonoma State University, Sonoma County Agricultural

Preservation and Open Space District, Sonoma Land Trust, UC Berkeley Extension, Pepperwood Preserve, City of Santa Rosa, Department of Fish & Game

1.5 **Laguna Watershed Megatransect or "Bio-blitz"** project to involve citizen scientists in a biotic assessment of Laguna biodiversity spanning across several habitats.
- Using previously tested standardized sampling methodology survey for plant, invertebrate, vertebrate diversity along a landscape scale transect at set intervals cutting across the watershed from upper to lower elevations.

Priority: **3**
Opportunity: **B**; National Geographic Society, Selectron Corporations Contributions Program
Integration: **R & E**; Restoration of Laguna habitats, Education of public about Laguna biodiversity
Collaboration: Sonoma County Agricultural Preservation and Open Space District, Sonoma Land Trust, Sonoma Ecology Center, Pepperwood Preserve, Sonoma State University, City of Santa Rosa, Department of Fish & Game

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Problems addressed:
- Lack of knowledge regarding the current state of Laguna biodiversity.
- Loss and fragmentation of critical habitat.
- Loss of threatened and endangered species.

Research Component 2:
Historical Ecology Analysis

Priority: **1-3** (Rank 1-5, with 1 being top priority)
Opportunity: **C** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, North Coast Regional Water Quality Control Board, Sonoma Ecology Center, Sonoma State University, Sonoma County Historical Society, Sonoma County Farm Bureau, Resource Conservation Districts (Sotoyome & Goldridge).*

Research Questions: How do our current levels of land use and biodiversity compare to historic levels? How do current impairments reflect historic land use activities?

Research Goal: Evaluation of the historical and current status of Laguna human and natural systems, including trends in land use, resource economics and related perils to Laguna ecosystems:

2.1 **Laguna Oral History** – to create a historic knowledgebase of the ways the Laguna has served locals and has been impacted within the last 50 to 80 years. This will help in better understanding land use history and the mind-set of Laguna long-term residents.
Priority: **1**
Opportunity: **C**; Sonoma County Historical Society, Dean Witter Foundation
Integration: **R & E**; Restoration of Laguna habitats, Education of public about Laguna history
Collaboration: Sonoma Ecology Center, Sonoma State University, Sonoma County, Historical Society, Sonoma County Farm Bureau, Resource Conservation Districts (Sotoyome & Goldridge), Pepperwood Preserve.

2.2 **Historic Laguna hydrology** evaluation in order to better understand impacts of changed conditions and to inform restoration strategy and TMDL development (Laguna specific water quality regulations).
Priority: **1**
Opportunity: **C**; NOAA fisheries, Hind Foundation
Integration: **R**; Restoration of Laguna aquatic habitats,
Collaboration: North Coast Regional Water Quality Control Board, City of Santa Rosa, NOAA Fisheries.

2.3 **Historic vegetation communities and wildlife assessment** to evaluate the dynamics of historic ecosystem function and to inform the restoration of current ecosystem function.
Priority: **2**
Opportunity: **C**; NOAA fisheries, Hind Foundation
Integration: **R**; Restoration of Laguna habitats,
Collaboration: North Coast Regional Water Quality Control Board, City of Santa Rosa, NOAA Fisheries, Pepperwood Preserve.

2.4 **Historical oak ecology** – to elucidate the history of land use and temporal changes in vegetation stages of watershed habitats, and around the use and historical abundance of a Laguna keystone species (Valley oak – *Quercus lobata*).
Priority: **3**
Opportunity: **C**; Hind Foundation, SCAPOSD
Integration: **R**; Restoration of Laguna habitats
Collaboration: Sonoma Ecology Center, City of Santa Rosa, Pepperwood Preserve.

Problems addressed:
- Lack of detailed historical information to consider in design of restoration projects and conservation planning.

Research Component 3:
Conservation Planning

Priority: **1, 3** (Rank 1-5, with 1 being top priority)
Opportunity: **A, C** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, City of Sebastopol, Sonoma Ecology Center, Sonoma State University, Department of Fish & Game, Sonoma County Water Agency, Laguna landowners.*

Research Questions: Where are the areas of highest biotic value in the watershed? How can we best achieve their recognition and protection?

Research Goal: Evaluation of existing habitats and land use to identify important conservation areas and to implement their conservation. Evaluation of Laguna ecological baseline and land use to establish prioritization for conservation land acquisition within the watershed. Establishment of Laguna as recognized wetland complex of national and international significance.

3.1 **Conceptual Area Acquisition Plan (CAAP)** – using historic and expanded knowledgebase to prioritize the acquisition of lands for long-term conservation & management.
Priority: **1**
Opportunity: **A**; San Francisco Bay Joint Venture
Integration: **R**; Restoration of Laguna habitats on priority conservation lands
Collaboration: Department of Fish and Game, Sonoma State University.

3.2 **Ramsar Designation for Laguna** – Using historic and expanded Laguna knowledgebase to achieve the designation of high priority areas as internationally significant wetlands, and continue to add important parcels under this designation over time in order to highlight the importance of Laguna wetlands and to educate the stakeholders and the public.
Priority: **1**
Opportunity: **A**; USFWS National Ramsar Award
Integration: **E**; Public education about the internationally recognized importance of Laguna wetlands
Collaboration: Department of Fish and Game, Sonoma State University, City of Santa Rosa, City of Sebastopol, Sonoma County Water Agency, private Laguna landowners.

3.3 **Laguna Ecosystem Services Evaluation** - Determine the ecological and socio-economic values of the restoration and natural regeneration of Laguna ecosystems (ecosystem services valuation) in face of climate change.
Priority: **3**

Opportunity: **C**; Zaffaroni Foundation, graduate student funding opportunities
Integration: **R**; Prioritization of restoration of Laguna habitats in context of ecosystem services, **E**; Public education on economic value of Laguna habitats
Collaboration: Sonoma State University.

Problems addressed:
- Lack of public appreciation of the ecological and economic value of Laguna ecosystems and their services
- Lack of current prioritization of Laguna parcels with high value for permanent protection.
- Loss and fragmentation of critical habitat.
- Decline and loss of threatened and endangered species.

Research Component 4:
Restoration Efficacy & Conservation Management Appraisal

Priority: **1-2** (Rank 1-5, with 1 being top priority)
Opportunity: **A- C** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, Sonoma Ecology Center, Sonoma State University, Sonoma County Agricultural Preservation and Open Space District, Madrone Audubon Society, PRBO Conservation Science, City of Sebastopol, Sonoma County Regional Parks, Sotoyome Resource Conservation District, Local Dairy Farmers and Sheep Growers.*

Research Questions: How can we measure the long-term success of restoration projects and conservation management techniques? How can we improve restoration and management techniques to minimize negative side-effects and to maximize efficacy?

Research Goal: Creation/expansion of a scientific knowledgebase to inform the implementation of effective restoration and the appropriate long-term management of conservation areas. Development and appraisal of methods to improve the long-term efficacy of restoration and conservation management:

4.1 **Long-term bird surveys** to assess impacts of planned trail system (point counts) & to evaluate riparian restoration success (area searches).
Priority: **1**
Opportunity: **A**; Sonoma County Agricultural Preservation and Open Space District, Madrone Audubon Society
Integration: **R**; Evaluation of restoration success, **E**; Public education via citizen scientists involved in the project(s).
Collaboration: Sonoma County Agricultural Preservation and Open Space District, Madrone Audubon Society, PRBO Conservation Science

4.2 **Pepperweed tarping** to test the efficacy of this technique to control/eradicate this invasive plant.
Priority: **1**
Opportunity: **A**; MRRP
Integration: **R**; Evaluation of restoration success,
Collaboration: City of Sebastopol

4.3 **Endangered Plant Management -** Establishment and testing of conservation management techniques for the endangered Sebastopol meadowfoam (Limnanthes vinculans) in a floodplain seasonal wetland.
Priority: **1**
Opportunity: **A**; US Fish & Wildlife Service
Integration: **R**; Evaluation of restoration success,
Collaboration: Sonoma County Regional Parks.

4.4 **Grazing as effective vernal pool management tool -** Investigation of grazing as effective management tool of endangered vernal pool grasslands on conservation lands and as economically viable opportunity for local ranchers.
Priority: **1**
Opportunity: **A**; USDA – SARE grant program
Integration: **R**; Evaluation of grazing management success, **E**; Public education about the value of grazing on Laguna grasslands for conservation of endangered resources.
Collaboration: Sonoma State University, Sotoyome Resource Conservation District, Local Dairy Farmers and Sheep Growers.

4.5 **Invasive species detection and rapid control -** Establishment of citizen science program for invasive species detection & rapid control at an early stage of infestation
Priority: **2**
Opportunity: **B**; Sonoma-Marin Weed Management Area
Integration: **R**; Early detection and eradication of noxious weeds in watershed, **E**; Public education via citizen scientists involved in the early detection and rapid response programs.
Collaboration: Bay Area Early Detection Network, Sonoma-Marin Weed Management Area, Sonoma County Agricultural Preservation and Open Space District, Sonoma Land Trust, Sotoyome & Goldridge Resource Conservation Districts.

4.6 **Cooper Road Preserve vegetation study** – Evaluation of changes in vernal pool vegetation 12 years after cessation of grazing – evaluation of appropriate long-term management methods to restore to previous diversity levels.
Priority: **2**
Opportunity: **C**; Compton Foundation
Integration: **R**; Restoration of Laguna floodplain vernal pool grasslands

Collaboration: Department of Fish & Game, Sonoma State University

Problems addressed:
- Lack of knowledge regarding the current state of Laguna biodiversity.
- Loss and fragmentation of critical habitat.
- Loss of threatened and endangered species.
- Lack of knowledge about the success of restoration efforts in the Laguna including matrices by which to measure a project as successful or not.

Research Component 5:
Endangered, Threatened or Special Status Species Recovery

Priority: **1-2** (Rank 1-5, with 1 being top priority)
Opportunity: **A- B** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, Sonoma State University, Department of Fish & Game, private landowners.*

Research Questions: What are the ecological needs of the declining species to better understand underlying causes and to implement the appropriate recovery actions?

Research Goal: Assessment of the status and conservation ecology of endangered, threatened and other special status species and related threats to recovery;
 Specific focus: Science-based management of Santa Rosa Plain vernal pool grasslands. Within public conservation lands and as many private lands as possible, we will implement research projects to amend current grazing best management practices on vernal pool properties, expand the scientific knowledgebase on vernal pool plant species, and stimulate protection of additional vernal pool properties

5.1 **Adopt a vernal pool long-term endangered plant survey** to establish a record of the threats, status and natural fluctuations of endangered annual vernal pool plant species and their community and pollinators.
 Priority: **1**
 Opportunity: **A**; Community Foundation of Sonoma County, Mary A. Crocker Trust, Armstrong McDonald Foundation.
 Integration: **R**; Restoration of Laguna and Santa Rosa Plain vernal pools; **E**; Public education via citizen scientists involved in the project.
 Collaboration: Department of Fish & Game, Sonoma State University, private landowners.

5.2 **Endangered vernal pool plant pollination and reproductive ecology** to identify the identity and abundance of vernal pool plant main pollinators and to

compare the seed set of these endangered plants across site quality (degraded or not; pollinators present at high or low levels) and history (natural or created).
Priority: **1**
Opportunity: **A**; US Fish & Wildlife Service, Armstrong McDonald Foundation.
Integration: **R**; Restoration of Laguna and Santa Rosa Plain vernal pools;
Collaboration: Department of Fish & Game, Sonoma State University, private landowners.

5.3 **California Tiger Salamander larval community survey** to determine the main larval food sources and trophic relationships within larval pools.
Priority: **2**
Opportunity: **B**; US Fish & Wildlife Service, Dean Witter Foundation
Integration: **R**; Restoration of Laguna and Santa Rosa Plain vernal pools;
Collaboration: Department of Fish & Game, Sonoma State University, private landowners.

5.4 **Western Pond Turtle Population Status** - Determination of the status, demography & diet of declining Western Pond turtles in the Laguna watershed in order to inform decisions to restore and conserve population numbers and appropriate habitats.
Priority: **2**
Opportunity: **B**; The Walt Disney Company Contributions Program, Dean Witter Foundation
Integration: **R**; Restoration of Laguna populations of the Western pond turtle;
Collaboration: Department of Fish & Game, Sonoma State University, City of Santa Rosa, private landowners.

Problems addressed:
- Lack of knowledge regarding the current state of Laguna biodiversity.
- Loss and fragmentation of critical habitat.
- Loss of threatened and endangered species.

Research Component 6:
Water Quality Improvement
Research Questions: What are the landscape-scale or regional dynamics or factors influencing Laguna water quality? How can these dynamics be influenced to effect substantial water quality improvement?

Priority: **1-2** (Rank 1-5, with 1 being top priority)
Opportunity: **A- B** (Rank A through D, with A being easiest to fund; list of potential funding sources).
Integration with other Laguna de Santa Foundation programs: *Restoration (R), Education (E)*
Prospective collaboration with other organizations: *City of Santa Rosa, Sonoma State University, Department of Fish & Game, private landowners.*

Research Goal: Investigation of landscape level dynamics of Laguna ecosystems affecting water quality: Improved status of Laguna wetland complex with regard to water quality and ecosystem services. Total maximum daily load (TMDL) targets are informed and implemented with the best possible science. Appraisal of the landscape level dynamics, and evaluation of implemented methods for improvement of seasonal and permanent aquatic system water quality and function;

6.1 **Laguna Wildlife Area Restoration** - Scientific inquiry to inform the Laguna Wildlife Area restoration regarding hydrology, sedimentation, control of and role of invasive *Ludwigia* in affecting trophic system dynamics, mosquito abundance, and water quality impairments
Priority: **1**
Opportunity: **B**; NOAA Fisheries, WCB, Mead Foundation
Integration: **R**; Appropriate restoration of Laguna Wildlife Area;
Collaboration: Department of Fish & Game, US Geologic Survey, NOAA Fisheries, USDA-ARS, City of Santa Rosa, private landowners.

6.2 **Landscape scale role of vernal pools in Laguna water quality** - Determination of the role of vernal pools (and their fauna & flora) in landscape scale water storage and nutrient cycling
Priority: **1**
Opportunity: **B**; NSF – Ecosystem Science
Integration: **R**; Restoration of Laguna water quality and floodplain and Santa Rosa Plain vernal pools
Collaboration: NASA-Ames, UC Davis, Department of Fish & Game, City of Santa Rosa, private landowners.

Problems addressed:
- Continued inputs via runoff and sediment from urban centers surrounding the Laguna.
- Mobilization of historic inputs within the Laguna.
- Role of seasonal wetlands in water storage and nutrient cycling on landscape scale.

IV. Research Plan Project Matrix

Project Number		Project Title	Priority	Opportunity	Resotration Integration	Education Integration
1. Long-term Ecological & Biodiversity Assessments in the Face of Climate Change						
	1.1	Aquatic community surveys *	1	C	R	E
	1.2	Mammal surveys **	1	B	R	E
	1.3	Regional (county-wide) GIS vegetation type layer development	1	C	R	
	1.4	Regional wildlife corridor survey	1	C	R	
	1.5	Laguna Watershed Megatransect or "Bio-Blitz"	3	B	R	E
3. Conservation Planning						
	2.1	Laguna oral history	1	C	R	E
	2.2	Historic Laguna hydrology	1	C	R	
	2.3	Historic vegetation communities and wildlife assessment	2	C	R	
	2.4	Historical oak ecology	3	C	R	
4. Restoration Efficacy & Conservation Management Appraisal						
	3.1	Conceptual Area Acquisition Plan (CAAP)*	1	A	R	
	3.2	Ramsar Designation for Laguna*	1	A		E
	3.3	Laguna Ecosystem Services Evaluation	3	C	R	E
5. Endangered, Threatened or Special Status Species Recovery						
	4.1	Long-term bird surveys*	1	A	R	E
	4.2	Pepperweed tarping*	1	A	R	
	4.3	Endangered plant management*	1	A	R	
	4.4	Grazing as effective vernal pool management tool **	1	A	R	E
	4.5	Invasive species detection and rapid control	2	B	R	E
	4.6	Cooper Road Preserve vegetation study **	2	C	R	
5. Endangered, Threatened or Special Status Species Recovery						
	5.1	Adopt a vernal pool long-term endangered plant survey*	1	A	R	E
	5.2	Endangered vernal pool plant pollination and reproductive ecology*	1	A	R	
	5.3	California Tiger Salamander larval community survey	2	B	R	
	5.4	Western Pond Turtle Population Status **	2	B	R	
6. Water Quality Improvement						
	6.1	Laguna Wildlife Area Restoration **	1	B	R	
	6.2	Landscape scale role of vernal pools in Laguna water quality **	1	B	R	

Priority: Rank 1-5, with 1 being top priority; Opportunity: Rank A through D, with A being easiest to fund; * Project already in progress; ** Project proposal submitted or in progress.

V. References and Supporting Documents

Enhancing and Caring for the Laguna – Restoring and Managing the Laguna de Santa Rosa. 2006. Laguna de Santa Rosa Foundation, Santa Rosa, CA, http://lagunafoundation.org/programs_rp_mp_ecl.shtml

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