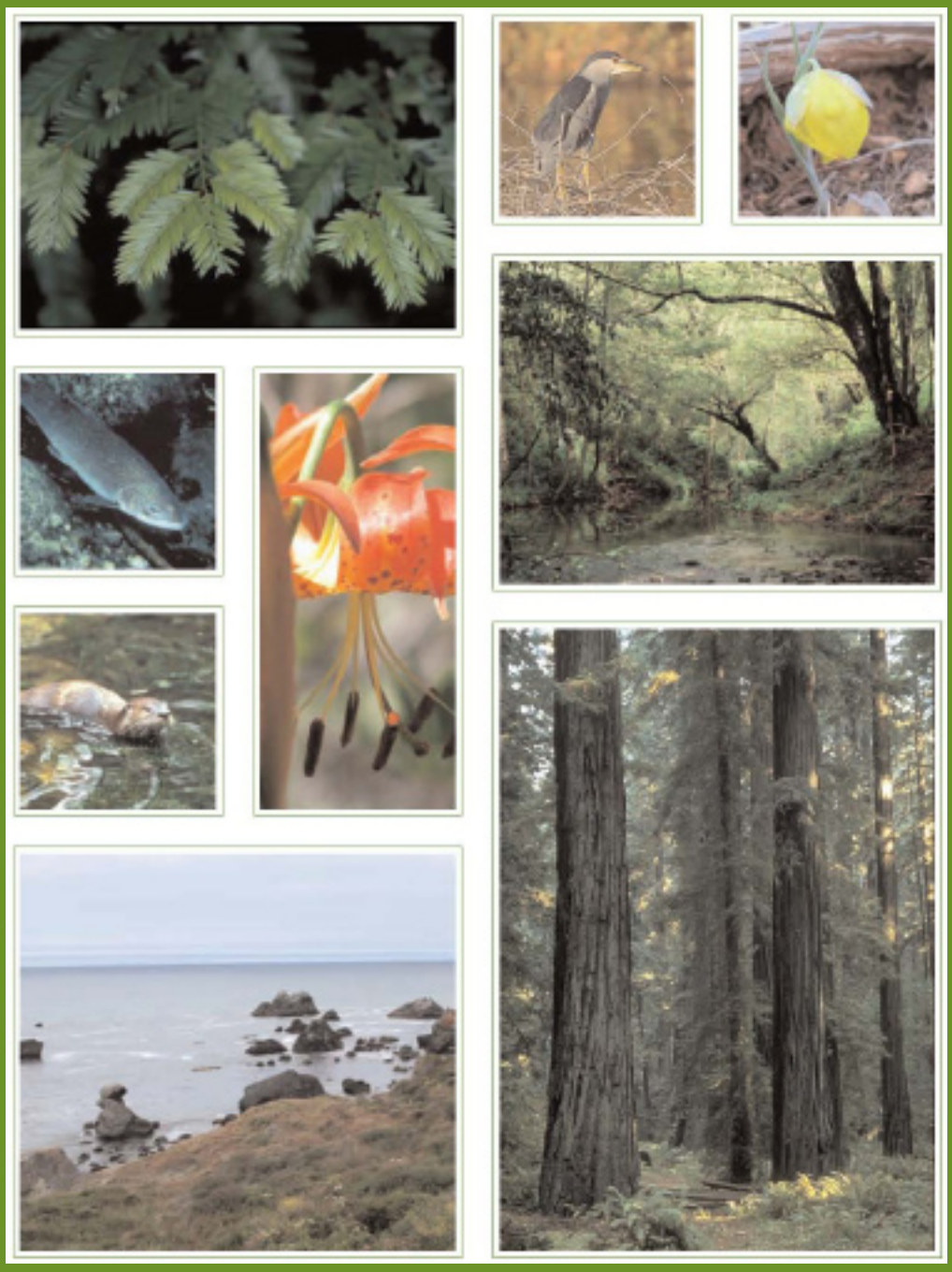
Biodiversity Action Plan

Priority Actions to Preserve Biodiversity in Sonoma County



October 2010

BIODIVERSITY ACTION PLAN

PRIORITY ACTIONS TO PRESERVE BIODIVERSITY IN SONOMA COUNTY

October 2010

Prepared for:
Community Foundation Sonoma County
Sonoma County Water Agency

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Acknowledgements

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Executive Summary
Biodiversity Action Plan of Sonoma County

Need for a Biodiversity Action Plan for Sonoma County

The fragility of Sonoma County's biodiversity and the importance of protecting it are sometimes overlooked by the people who live here. While we enjoy our rural environment and open spaces, we take the wildlife and plant populations they support, and their value to us, for granted. Human activities are rapidly altering the environment and placing Sonoma's unique biodiversity at risk. We have an opportunity, a stewardship responsibility, to conserve and enhance local native habitats to ensure that the biological diversity of Sonoma County is protected and continues to sustain the health and quality of life of future generations.

Experts involved in this planning process agree: Sonoma County is in need of a long-term, steadily-funded, science-driven program to:

- Set measurable goals for species and habitat recovery;
- Track ecosystem viability ("vital signs") and threats in real-time; and
- Prioritize conservation actions that sustain local biodiversity and ecosystem function through an adaptive management framework.

Recognizing this need, Community Foundation Sonoma County (Foundation) engaged in a four-year process to develop this consensus-based Biodiversity Action Plan for Sonoma County. This Action Plan is designed as a living document to evolve via updates that reflect advances in our understanding of biodiversity in Sonoma County. It complements existing regulations and land use plans with recommended voluntary actions that our scientists, conservation organizations, and local community can take to support our regional biodiversity.

Objective

The objective of this plan is to answer the following questions regarding Sonoma County's natural heritage: What do we have? What are the threats? What can we do to reduce risk of losing our biodiversity? This plan is a resource for technical experts, land managers, funders, policy makers and interested citizens regarding the status and natural dynamics of local ecosystems and current threats to biodiversity. It advances a set of non-regulatory actions grounded in a collaborative multi-stakeholder approach to maintain biodiversity in Sonoma County for generations to come.

Vision

Our vision is a Sonoma County with resilient, biologically diverse natural systems that provide lasting ecosystem services into the future. Critical to this vision is an informed populace that celebrates local biodiversity and is inspired to action.

Process

Between 2006 and 2008 twenty participating experts were convened by the Foundation and interviewed to establish a baseline understanding of Sonoma county-wide biodiversity and actions capable of conserving it. Information gathered in these interviews

was consolidated into a draft document in 2008. In 2009-2010 this draft was vetted by a larger panel and revised to reflect recent scientific advances, particularly with respect to how climate change may impact our local biodiversity. The Foundation is committed to supporting this process into the future by collaborating with a collective of local conservation organizations and regional technical experts dedicated to realizing our vision.

What is Biodiversity?

Coined by biologist E.O. Wilson, the term "biodiversity" is defined as the variety and relative abundance of all forms of life, ranging from genes to species, to the broad scale of ecosystems. Measuring biodiversity is more complex than simply counting the number os species in a given area. Biodiversity is composed of: ecosystem diversity, species diversity and genetic diversity. Varying definitions of biodiversity reflect the challenge of reconciling the process-based and elements-based perspectives on biodiversity. As used in this Action Plan, "biodiversity" describes the variety and relative abundance of living things in a given area and their interactions.

Sonoma County Quick Facts

Total area of Sonoma County: 4,152 km^2 (1,603 mi^2; 1,025,982 acres)
Percent area of California: 1.01%
Area of land: 4,082 km^2 (1,576 mi^2; 1,008,684 acres)
Area of water: 498 km^2 (192 mi^2; 123,058 acres)
Ecoregions: California North Coast (58 %), California Central Coast (42 %)
Mountain Ranges: Mayacamas Mountains, Mount Hood Range, Outer Coast Range, and Sonoma Mountains
Highest Elevation: 1,370 meters (4,495 ft) on Cobb Mountain
Length of rivers and stream: 5,354 km (3,327 miles)
Number of native plant species: 2,210
Number of threatened species: 6 (all animals)
Number of endangered species: 27 (22 plants, 5 animals)
Number of species unique to Sonoma County (endemic species): 20
Percent of Sonoma County in protected status: 14.97%
Estimated population size: 464,435 (2007)
Projected population size: 603,000 by 2020
Population growth rate: 14% (1996-2005)
Number of households: 183,518 (2005)
Area of vineyards in cultivation: 243 km^2 (94 mi^2; 60,047 acres)
Number of recipients of drinking water drawn from the Russian River Watershed: 540,000 in tri-county area (Sonoma, Mendocino, and northern Marin)
Amount of water consumed: Unquantified at present
Number of invasive plant species: At least 195 (approximately 8% of County flora)

Sonoma County lies at the core of a global biodiversity "hotspot" (defined as the richest and most threatened reservoirs for plant and animal life on Earth). The California Floristic Province, of which Sonoma County is a part, is one of only 34 recognized hotspots on the globe.[4,5] Mediterranean ecosystems like those found in Sonoma County are in fact second only to tropical rainforests in terms of measured biodiversity.[6]

Due to its coastal geography, varied topography, paleobotany, and microclimate diversity, Sonoma County comprises a near-complete sampling of northern California habitat diversity, from chaparral, grassland, savannah, and forests to beach-dune and near-shore marine environments. Together, these habitats provide critical "ecosystem services" that support our human quality of life, including pollination of our food crops, soil decomposition and nutrient cycling, absorption, retention and filtering of drinking water, flood and wave attenuation, and resilience of our lands and waters to erosion, disease, pests, and warming climate trends. Measures to protect biodiversity recommended here will not only prevent the local extinction of plants and wildlife, but will also support the protection of human health and quality of life via maintenance of key ecosystem services.

What are the Threats to Sonoma County's Biodiversity?

Biodiversity in all regions of the world including Sonoma County is on the decline due to increased rates of ecosystem degradation, resulting in loss of genetic variability and in some cases complete extinction of species, and a decline of the functions and services that ecosystems provide intrinsically and for humanity. Worldwide, habitat loss due to land use changes (such as open space conversion to housing or intensive agriculture) and fragmentation (the conversion of large intact habitats into small, discontinuous parcels) is the single biggest threat to biodiversity. Other threats to biodiversity in Sonoma County include - invasions of non-native species, disruption of natural water cycles, air and water pollution, a lack of knowledge or gaps in the scientific knowledge base, and the uncertainty and stress of global climate change. Destruction of habitat via these threats can ultimately lead to extirpation (local extinction) of our native plant and animal species.

What are the Recommended Actions to Protect Sonoma County's Biodiversity?

This Biodiversity Action Plan advances recommended actions to protect biodiversity in Sonoma County. Recommended actions, detailed in Section 4, are categorized into three main focus areas:

1. Science actions to fill critical gaps in our county-wide knowledge base;
2. Implementation actions to enhance and connect our land network and advance emerging initiatives; and
3. Education and outreach actions to highlight the importance and uniqueness of Sonoma County's biodiversity to its citizenry and decision-makers.

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1 Center for Applied Biodiversity Science. http://www.biodiversityhotspots.org
2 Center for Biological Diversity. http://www.biologicaldiversity.org
3 Parisi 2003

Recommended actions to preserve Sonoma County's biodiversity include:

- Educate our community about the value of Sonoma County's biodiversity and how to protect it
- Implement an over arching "vital signs" monitoring framework that defines what to measure, where, and how often via a county-wide coordinated multi-agency team
- Promote conservation on private lands via landowner outreach and economic incentives
- Protect land via acquisitions and easements in a manner targeted to maximize ecological value and connectivity given limited financial resources
- Conduct a regional climate change vulnerability analyses for species and ecosystems
- Perform cost-benefit analyses of both restoration and development projects to incorporate ecosystem service concepts into project planning

What Next?

The newly formed North Bay Climate Adaptation Initiative (NBCAI) is a consortium of citizens, policy makers, scientists, and land managers dedicated to implementation of priority actions recommended in this Plan. The majority of the Plan's contributors are members of NBCAI and are focused on examining biodiversity conservation through the lens of climate change adaptation, planning for conservation in the face of inevitable climate impacts (climate adaptation is distinguished from climate change mitigation, the practice of reducing greenhouse gasses to minimize the effect of climate change). Just as Sonoma County led the nation in setting local policies for climate mitigation, in partnership with the Foundation, NBCAI will provide a model of fruitful collaboration and local action for implementation of climate adaptation measures focused on ecosystem and watershed conservation.

Document Overview

This Action Plan is composed of four narrative sections that guide the reader through underlying principles of our team approach, the habitats of Sonoma County, threats to biodiversity, and recommended actions to preserve biodiversity.

Appendices are provided that list protected areas, threatened or endangered species, invasive and non-native plants and animals, photographs and quotations from interviewed experts, a glossary of terms, and a list of stakeholder organizations active within the county.

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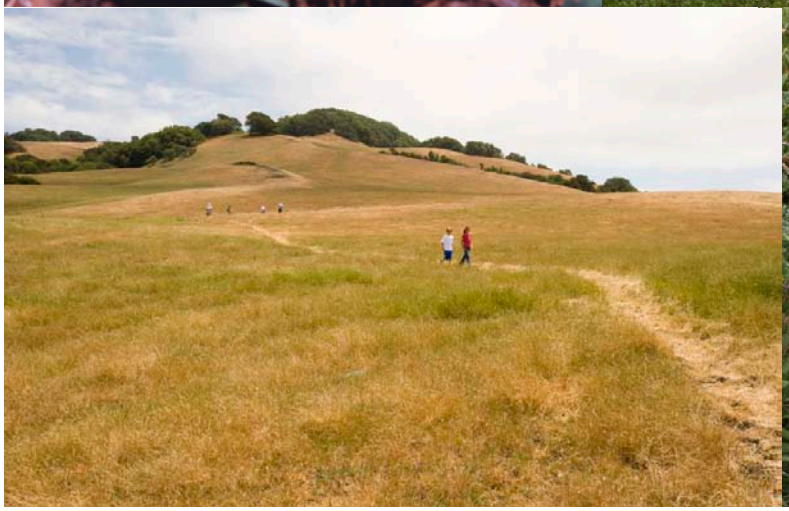
“The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats.

This is the folly our descendants are least likely to forgive us.”

-E.O. Wilson



1. Introduction

1.1 Biodiversity Defined

Biological diversity or "biodiversity" is an expression of the variety and relative abundance of living things in a given area and their interactions.[4,5] Biodiversity is more than just the number of species in a given area (i.e., species richness). It encompasses the relative abundance or the distribution of individuals within a community and their interactions. Biodiversity is composed of: ecosystem diversity, species diversity and genetic diversity and encompasses a complexity that spans a range of scales – from the Earth and landscape to the molecular.

Ecosystem diversity is an indicator of landscape or Earth scale processes. It encompasses the variety of living things or processes and their interactions from a global scale to the habitat level.

Species diversity refers to the variety of different species within an ecosystem. It is used as an indicator of ecosystem function and resilience. For example, with a greater number of bacterial species breaking down organic matter in the soil, there is a greater likelihood that if any one species dies out, others will step in to take their place and the function – organic matter decomposition. An ecosystem with a diverse community of microbes is often more resilient, or able to recover from an environmental disturbance.

Genetic diversity is an indicator of species adaptive capacity. Populations with low genetic diversity are less likely to survive a catastrophic event. Conversely, species with high genetic diversity are resilient and more likely to survive and adapt to environmental stressors (e.g. climate change).

More than simply the sum of its parts, biodiversity is also concerned with the interactions between species or organisms. Understanding biodiversity requires not only measuring the components of a system but also evaluating ecosystem functions. Biodiversity is inextricably linked to the health and viability of human communities. Poorly functioning ecosystems cannot support human populations. Conservation, stewardship and restoration of the natural ecosystems in support of biodiversity are direct actions to safeguard the legacy of an intact, functioning ecosystem for future generations. In recognition of the importance and value of biodiversity, the United Nations declared 2010 the International Year of Biodiversity.[6]

1.2 Significance of Sonoma County Biodiversity

Sonoma County is one of the most biologically diverse places in the United States, home to numerous unspoiled habitats and a treasury of familiar and rare plant and animal species. Matched in species richness in the U.S. only by the southern Appalachians,[7] the region is host to a number of threatened or endangered species. Twenty Sonoma County species are found nowhere else on Earth. Relatively small and highly biodiverse areas including Sonoma County are termed "biodiversity hotspots."

4 California Biodiversity Council. http://biodiversity.ca.gov/index.html
5 Noss 1990
6 2010 International Year of Biodiversity. http://www.cbd.int/2010/welcome
7 Center for Biological Diversity. http://www.biologicaldiversity.org

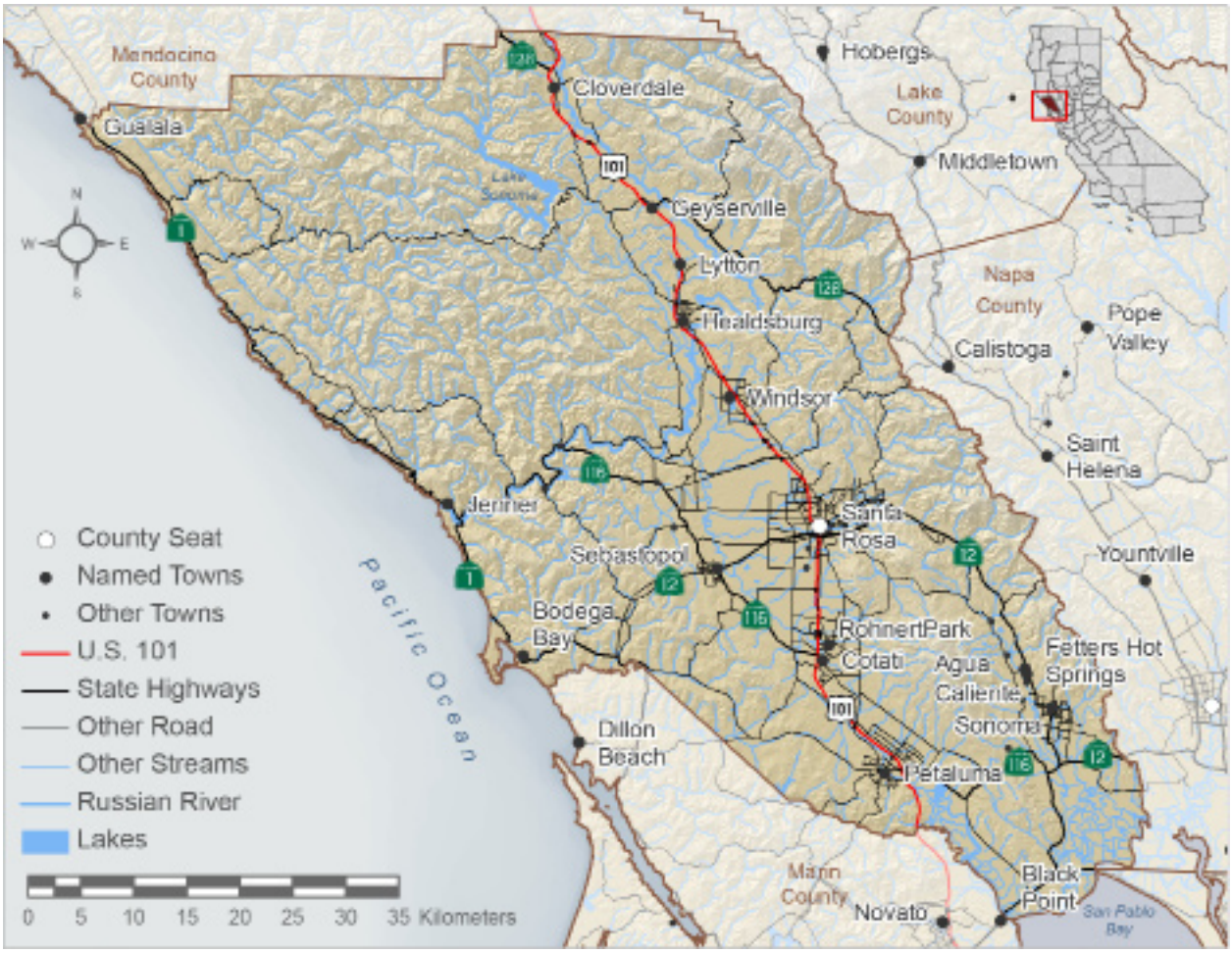


Figure 1. Sonoma County Map (Sources: USGS, US Census Bureau).

These hotspots are a high priority for conservation but are also under great threat of biodiversity loss, largely due to loss of unique habitat.[8]

The people in Sonoma County depend on intact, functioning ecosystems for many things. These functions are termed "ecosystem services." Chief among these services is plentiful, clean drinking water (imagine life without this privilege). Residents also expect protection from seasonal flooding, pollination of our gardens, the annual return of salmon, surrounding scenic beauty, and almost unlimited access to local water sources for irrigation of vineyards and other agriculture. In addition to fundamentally sustaining people and wildlife, natural ecosystems also satisfy our innate need to be immersed in the outdoors. An appealing variety of easily accessible natural areas and the remark-

"Sonoma County's biodiversity is rooted in its large variety of habitats defined by many different soils types, microclimates, and topography. Unique habitats make for a unique flora and fauna, in many cases found nowhere else on Earth!"
–Christina Sloop

8 Myers et al. 2000

able living things these support are inextricably linked to what people value about living in Sonoma County.

1.2.1 Extinction and Extirpation

Extinction, or loss of a species, can be a natural process. The Earth has experienced massive extinctions in the past, however none were the product of anthropogenic, or human-induced impacts. Worldwide, if current rates of habitat destruction continue, half of all species of life on earth will be extinct in 100 years.[9] Extinctions may be global or local. The phenomenon of local extinction is known as extirpation. Extirpated species represent a significant loss to local biodiversity. Tule elk and pronghorn antelope have both been extirpated from Sonoma County. While extirpated species may be reintroduced, the cause of extirpation (e.g. habitat loss) must be addressed for reintroduction to be successful. Local extirpations can be reversed by restoring or enhancing degraded habitats, one of the many ways land protection, restoration and management can positively reverse the extinction trend and foster biological diversity.

1.3 Historic and Current Conditions

Table 1: Summary* of Sonoma County Species of Conservation Interest

	Number of Taxa (species, subspecies, varieties)			
Taxon	**Endangered**	**Threatened**	**Endemic**	**Other****
Invertebrates	3			10
Fishes	2	2		
Amphibians		2		1
Reptiles	1	2		2
Birds	1	2		17
Mammals	1		2	1
Plants	22		18	151

* See Appendix for full listing.

** "Other" species are either US Fish & Wildlife (USFWS) Species of Special Concern; are recognized by the International Union for the Conservation of Nature as Globally Critically Imperiled (G1), Globally Imperiled (G2), or Globally Vulnerable to Extinction (G3); or belong to the California Native Plant Society's CNPS Inventory list 1B (rare, threatened, or endangered in CA or elsewhere).

Sonoma County's biodiversity is decreasing every day, yet natural resource managers are hindered by a lack of comprehensive understanding of historical ecology, including how ecosystem dynamics have been altered within the last century. Certain changes from historic conditions are undeniable, if not always quantifiable.

9 Wilson 2002

Significant impacts on Sonoma County's natural systems include:

- Construction of Warm Springs Dam that created Lake Sonoma and obliterated the town of Skaggs Springs[10] and important indigenous cultural sites,
- Large-scale logging of redwood and other primary forests,
- Radical modification of streams and wetlands,
- Introduction of hundreds of non-native plant and animal species into to natural habitats, and
- Massive reduction of salmonid populations.

1.4 Need for a Biodiversity Action Plan for Sonoma County

The importance of protecting the precious resource of Sonoma County's biodiversity is often overlooked by the people who live here. Many of us take our open spaces, wildlife and plant populations for granted. But recent human activities are rapidly altering the environment, placing its unique biodiversity at great risk. We have an opportunity, and a stewardship responsibility, to conserve and enhance local native habitats to ensure that the biological diversity of Sonoma County is sustained for future generations.

1.4.1 Coordination

Numerous government agencies, academic institutions, community groups, community benefit organizations, and individuals are engaged in preserving the region's endangered habitats and protecting its treasured species. This Action Plan should aid coordination of these disparate efforts as a comprehensive, widely-endorsed plan to guide conservation activities. Countywide prioritization of human and financial resources is critical. The absence of a clear, prioritized conservation effort has contributed to reductions in local biological diversity via missed opportunities for collaboration and consensus-building. This document contains a list of conservation groups and agencies working within the county (Appendix H).

1.4.2 Climate Change

Our emerging understanding of global climate change implications for Sonoma County underscores the need for this Biodiversity Action Plan. Scientists agree that the world is already and will inevitably experience significant impacts due to climate change, including effects on water supplies, agriculture, and fish and wildlife habitats. Climate change will cause dramatic shifts in biodiversity worldwide as species ranges move due to changing climatic conditions. Natural resource managers must act now to plan restoration, conservation and management actions around a future climate that is different than what we experience today. For example, resource managers may shift the species selected for restoration plantings today so that they survive in a future changed climate or work to preserve corridors to aid the animal migration expected decades from now.

Key to including climate change in biodiversity planning is access to ecologically relevant, local scale empirical data for use in concert with downscaled climate models. The 2009 California Climate Adaptation Strategy[11] recommends coordinated and

10 Best et al. 1996

11 2009 California Climate Adaptation Strategy. http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF.

targeted local efforts to protect biodiversity. Local scale implementation of adaptation strategies should enhance ecosystem function and protect Sonoma County's rich biodiversity.

Sonoma County leads the nation's local governments in the development of a coordinated greenhouse gas mitigation strategy (reducing greenhouse gases known to cause climate change). A parallel County coordination effort focused on ecosystem climate adaptation (preventative measures aimed at reducing the eventual cumulative impact of climate change on resources of concern) was launched in 2009 as the North Bay Climate Adaptation Initiative (NBCAI).[12] NBCAI is a collaborative consortium of natural resource managers, scientists, educators, and policy makers working within focus groups via the lens of climate change to protect biodiversity. NBCAI working groups operate in the areas of:

- Habitat Conservation and Restoration Implementation,
- Stakeholder Outreach,
- Science and Technology, and
- Public Policy.

Local scale implementation of adaptation strategies such as those outlined by the 2009 California Climate Adaptation Strategy and NBCAI enhance ecosystem function and protect Sonoma County's rich biodiversity. Adaptation strategies will increase local capacity to deal with uncertainty and ensure that natural resources are maintained for generations to come.

1.5. The Planning Process

Experts involved in this planning process agree: Sonoma County is in need of an ongoing, steadily funded, data-rich, science-driven program that:

- Sets precise, measurable goals for species and habitat recovery,
- Tracks species viability, threat occurrences, and other real-world conditions, and
- Prioritizes the substantial number of conservation actions needed to sustain local biodiversity and ecosystem function.

Recognizing this need, Community Foundation Sonoma County (Foundation) engaged in a long-term process to develop this widely endorsed Biodiversity Action Plan for Sonoma County that will ultimately incorporate regularly updated scientific data and expert input to strategically identify, protect, and enhance the rich biological diversity of local natural communities. This Action Plan is a dynamic or "living" document that is intended to evolve to reflect the ongoing realities relating to biodiversity in Sonoma County.

This report represents the first phase of the multi-year planning and protection process and includes:

- Summary information about Sonoma County's biological diversity,
- Threats to local habitats,
- Results from surveys and interviews conducted with local science and policy experts,

12 North Bay Climate Adaptation Initiative. http://www.nbcai.com.

- A primer on Sonoma County habitats,
- Recommended priority actions,
- A series of species lists including animals and plants of conservation interest, common invasive species, and endangered species,
- A list of participating experts,
- A list of stakeholder organizations operating within the County, and
- A sample questionnaire.

A diverse group of twenty regional science and policy experts were polled to provide information about Sonoma County species and habitats most in need of protection, enhancement or restoration, as well as what conservation actions would best preserve local ecological integrity. Experts' recommendations were compiled via on-line and in-person surveys (Appendix C). Their recommended highest priority conservation actions - those requiring immediate attention, are summarized in this document in Section 4 and their direct quotes inform this document throughout. Survey results informed a draft version of this document reviewed by a panel of experts at a workshop in June, 2010 and further edited and vetted over subsequent months.

Dozens of local and regional experts on Sonoma County's biological diversity and resource use policy collaborated to produce this document. Participating experts are listed in the Acknowledgements. The next phase of the process is a biodiversity assessment of the county. This assessment will embody the experts' recommended larger vision of a biodiverse Sonoma County. As an active, operating consortium of county stakeholders, NBCAI may become the vehicle to implement and/or encourage recommended actions.

2. Landscapes and Habitats

Sonoma County is home to over a hundred plant and animal species, subspecies, and varieties classified as conservation priorities (Table 2, Appendix D). Although limited quantitative data are available, it is well known that conspicuous species that once occurred here are now extirpated (e.g. tule elk, pronghorn antelope) and that other Sonoma County species (tiger salamander, salmon, and the Pitkin Marsh lily, among others) are now being pushed toward the same fate. Table 3 (Appendix D) lists the county's endangered and threatened species and their essential habitat types; each requires special attention and resources if it is to persist into the future. Sonoma County's varied and sometimes isolated habitats foster high levels of endemism (i.e. local uniqueness). Twenty plant or animal species living here evolved in the county and are found nowhere else on Earth (Table 4, Appendix D).

Many species and habitats that are neither threatened, endangered, nor exclusive to Sonoma County nevertheless warrant priority conservation attention (see Table 5, Appendix D). Several experts stressed that even "common" species and habitats, like

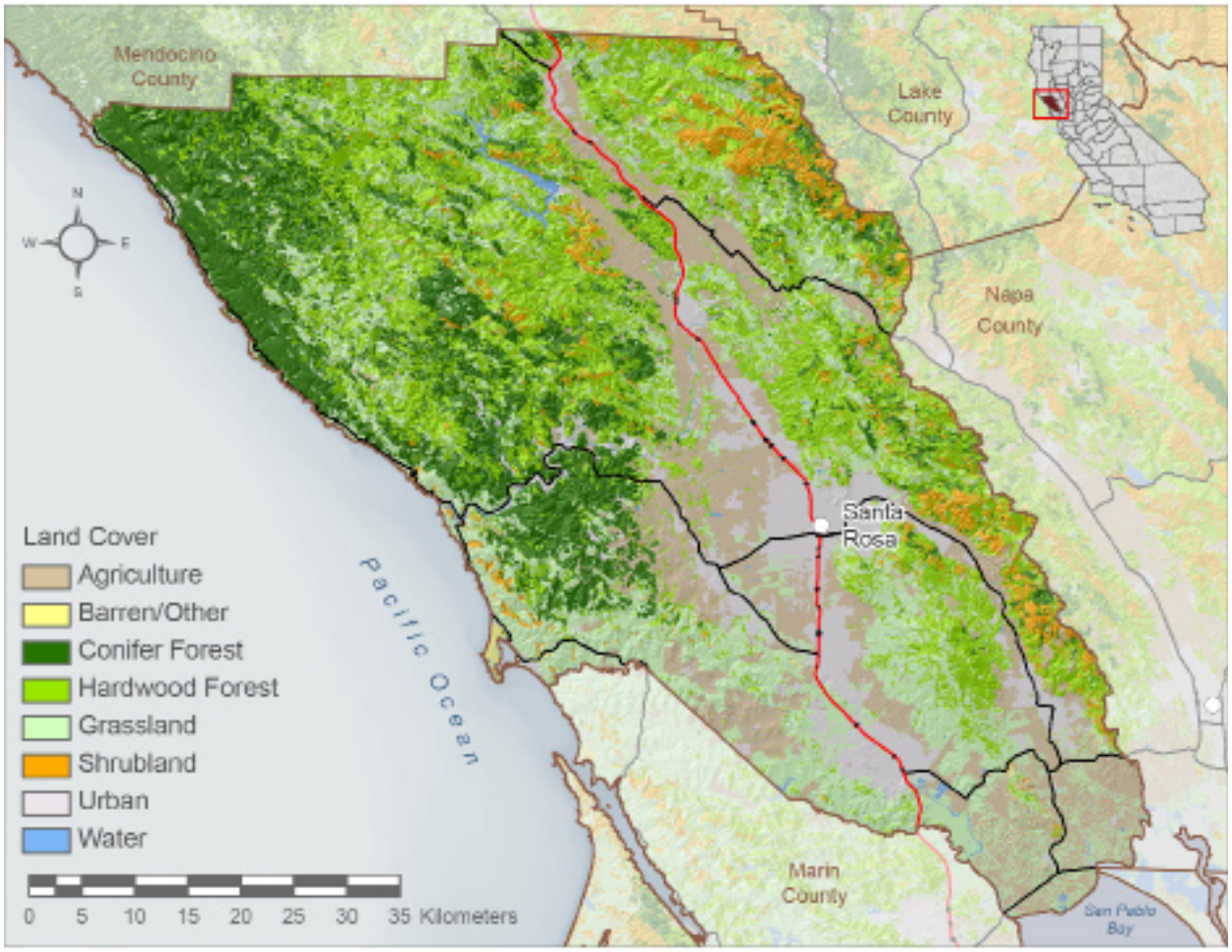


Figure 2. Sonoma County landcover (Source: CalFire). Note, "other" often denotes Sand dunes.

Serpentine Plant Communities

Approximately 42% of Sonoma County's endemic plants are dependent upon soil conditions occurring in serpentine soils. These unique plant communities are adapted to harsh conditions, growing where soils are rich in heavy metals and lacking in calcium and other nutrients. Serpentine plant communities exist as islands surrounded by more common vegetation. The habitat may be widely spaced shrub cover with little to no herbaceous understory or may occur as denser, chaparral-like cover. Several areas in Sonoma County contain serpentine communities including a large portion of the Austin Creek State Recreation Area and the entrance of Pepperwood Preserve on Franz Valley Road.

deer and oak woodland, are integral contributors to local ecological integrity, largely because of their dominance in the landscape. A new slogan has emerged to emphasize this important realization as "Keep our common species common!" Other unofficial candidates for conservation concern are Sonoma County's wide-ranging species like mountain lion, bobcat, Pacific flyway birds and habitat cohorts such as grassland and riparian-specialist birds. Planners should also be aware of the importance of ecosystem 'architects' or 'engineers' and process drivers like beavers, conifers, and willows (C Kjeldsen, pers. comm.), which may also merit special attention.

Special attention must also be paid to species existing at the geographic edges of their natural ranges. So called peripheral populations tend to be smaller, isolated, and more genetically diverse than centralized populations existing in the heart of a species range. Peripheral populations have often adapted to less than ideal conditions and represent an important genetic reservoir for long-term survival of species.[13] Stressors such as those anticipated due to global climate change highlight the need for preserving peripheral populations. These populations may be the most likely to survive in a future, less favorable climate and guard against extirpation or wholesale extinction.

2.1. Plant Communities

Below are descriptions of a sampling of major plant communities or associations that comprise Sonoma County. This is an informal classification borrowed, in part, from Manual of California Vegetation[14] and Wildlife Habitat Relationships Database[15] ; it is based on the form of plant cover (physiognomy), not species composition. Future iterations of this document are expected to include a habitats listing that is more regionalized to, for example, recognize the important compositional changes taking place in plant communities of the county's floristic subregions. For the sake of brevity, some distinct habitats have been lumped (e.g. "salt marsh" compresses the variability inherent in saline and brackish, tidal and backwater systems).[16] A listing of characteristic dominant

13 Lepping and White, 2006
14 Sawyer and Keeler-Wolf 1995
15 California Department of Fish and Game 1999 Version 7
16 See CalFlora (http://www.calflora.org) for excellent, exhaustive information about the county's wild plants. Best et al. 1996 provides a comprehensive overview.

plants of each habitat is provided in Table 6 (Appendix D).

2.1.1. Riparian Habitats

Terrestrial Riparian Habitats

Terrestrial riparian habitat is the assortment of plant life that occurs adjacent to and is influenced by streams, creeks, and rivers. Riparian habitat occurs throughout Sonoma County, especially in rivers and streams that sustain year-round water flow. Native riparian vegetation is well adapted to the dynamic streamside environment and also can be found along freshwater marshes if water is flowing. Most riparian vegetation is deciduous and, unlike in most other California habitat types, summer is the active growing season in the riparian belt. The Sonoma County General Plan[17] provides specific protective measures for riparian corridors along selected streams within the county. The General Plan 2020 update, however, does not extend protection to all 3200 miles of streams shown on county USGS topographic maps.[18]

In-Stream Habitats

In-stream habitats (i.e. the channel portion of freshwater streams) in the county may contain water year-round or may be intermittent if surface water in streams dries during the hot summer months. The in-stream environment is extremely variable: conditions change rapidly with precipitation events and when water is drawn down for a variety of human uses, including irrigation, wells and frost protection. In-stream habitat consists of relatively deep pools interspersed between riffle areas. Overhanging banks and trees along the channel provide shade while root wads, large woody debris, and boulders add vital in-stream complexity.

The Russian River Watershed is the largest drainage in the county, flowing into the Pacific Ocean at Jenner. The Russian River watershed, like all watersheds, comprises in-stream, riparian and upland habitats within the drainage basin. A number of species, including steelhead trout (threatened), chinook salmon (threatened), and coho salmon (endangered) are in severe decline in Sonoma County, primarily from the loss or degradation of the coldwater perennial streams they require for spawning and rearing (D Cook, pers. comm.).[19]

17 Sonoma County 1989
18 Sonoma County 2007a, 2007b
19 National Marine Fisheries Service 2010

Riparian Habitat

"Water is the key: If we do right by fish, we can do right by most other things."
–Rich Walker

"Unfortunately, much loss of biodiversity is due to significant declines in distribution and abundance of species with no special status."
–Peter Baye

In-Stream Habitat

Tolay Lake

Tolay Lake is a seasonal wetland in southern Sonoma County east of Petaluma. In April 2005, the lake and 1,737 acres of the surrounding ranch were purchased by Sonoma County as a regional park. The lake, which had been drained and used agriculturally, is expected to be restored. The park provides habitat for many species of concern, including the California red-legged frog, northwestern pond turtle, golden eagle, burrowing owl, northern harrier, and tricolor blackbird. It has cultural and spiritual significance for the Southern Pomo people and contains important archeological objects and sites. The lake is protected as a County regional park.

Vernal Pool

2.1.2. Wetlands

Wetland habitat has a very complex nutrient cycle which provides the base for a highly productive food web. Additionally, wetlands provide habitat for many resident species of aquatic and terrestrial wildlife and are an important refuge for migratory fish and bird species. For example, anadromous salmonids use saltwater estuarine wetlands as a staging area for the morphological changes necessary to successfully make the transition between salt and fresh water and to gather the energy reserves necessary for the next stage of their life cycle. Fresh and saltwater wetlands improve in-stream water quality by filtering pollutants and improve water quantity by providing groundwater recharge. Wetlands also buffer the effects of storms, reducing flood damage and shoreline erosion.

Wetlands of all types are increasingly scarce throughout California due to agricultural, urban and rural development and extractive land uses and have been identified by CDFG as one of many sensitive natural communities vulnerable to further loss. They are specifically protected in the Sonoma County General Plan 1989[20] and also in the General Plan 2020.[21]

Freshwater Wetlands

Freshwater wetlands include seasonal and perennial lakes, creeks and marshes, vernal pools and swales, seeps springs and riparian corridors comprised of wetland vegetation. Marshes often serve as transitional areas between aquatic and terrestrial riparian habitats. Freshwater wetlands provide important habitat for migrating waterfowl, seasonal migrant birds and amphibians (including the California tiger salamander (*Ambystoma californiense*). Sonoma County contains many freshwater wetlands, as for example: Pitkin, Perry, Cunningham, and Kenwood marshes, the Laguna de Santa Rosa, and the Santa Rosa Plain vernal pool complex. Historically, Tolay Lake was a large and biologically diverse freshwater wetland complex. Sonoma County Regional Parks is in the process of evaluating various opportunities to restore Tolay Lake's historic functions and habitats.

Vernal pools and swales are seasonal freshwater wetlands that occur during the winter rainy season in shallow depressions underlain by hardpan. Most are found

20 Sonoma County 1989
21 Sonoma County 2007a

throughout the Santa Rosa Plain, but some also occur within woodlands in the upper regions of Sonoma County watersheds. Water usually persists for a few months after winter rains cease, providing an aquatic resource for many species of wildlife, some of which are uniquely adapted to this ephemeral ecosystem. Waterfowl, frogs, salamanders, dragonflies and other widespread species use vernal pools for feeding, breeding and juvenile development. Other species (highly specialized plants and macroinvertebrates such as fairy shrimp) have evolved in association with these naturally isolated systems and are completely dependent upon them (vernal pool endemics).

Vernal pool species have developed life cycles that are adapted to months of extremely harsh dry conditions that are relieved for a few months by standing water. Vernal pools were formerly more widespread in Sonoma County, occurring throughout the Santa Rosa Plain, from Cotati to Windsor. Rapid industrial and residential development has eliminated most local vernal pool ecosystems, but some remain within their former range within preserves, mitigation banks, and private parcels. Representing 'islands of biodiversity' that harbor a variety of rare and endemic plant and animal species[22] vernal pool ecosystems deserve a high ranking on the list of local as well as global conservation priorities.

Salt Marsh

Salt marshes are a transitional habitat between the open waters of bays or oceans and freshwater or terrestrial habitats and include saline tidal marsh, intermittently tidal brackish marshes, and back-barrier stream mouth lagoons, all with different plant communities and distinct conservation priorities (P Baye, pers. comm.). Salt marshes are important habitat for endangered species such as salt marsh harvest mouse (*Reithrodontomys raviventris*) and California Clapper Rail (*Rallus longirostris obsoletus*), as well as for juvenile fish, migratory waterfowl. They are among the most productive of all local ecosystems, producing five-to-ten times as much oxygen, and sequestering five-to-ten times as much carbon, per acre as a wheat field.[23] Typically highly productive, these are usually communities of very low species diversity.

In Sonoma County, the Sears Point region in the San

Cunningham Marsh

Cunningham Marsh is a privately owned freshwater wetland surrounded by orchards and grasslands. It drains to Blucher Creek. Cunningham Marsh is home to three rare plants: the state and federally endangered Hickman's cinquefoil, California beaked-rush, and Bolander's reedgrass. This wetland is one of only three known locations of the Sonoma County endemic Pitkin Marsh lily. Portions of the marsh are protected with conservation easements held by CDFG and SCAPOSD.

Salt Marsh

22 Baskin 1994
23 California Coastal Commission 2007

Grassland

Pitkin Marsh

Pitkin Marsh is located along Gravenstein Highway between Graton and Forestville. This freshwater marsh provides habitat for the endangered white sedge, a plant believed extinct until rediscovered there in the early 1980s. Pitkin Marsh is the only known place in the western US where three species of beaked rush occur together. It is considered a botanical treasure. The Marsh is one of three locations in the world (all in Sonoma County) that support the endemic, eponymous Pitkin Marsh lily. In 2007, Sonoma Land Trust negotiated the purchase of the lower Pitkin Marsh. Future efforts will focus on protecting middle and upper Pitkin Marsh.

Pablo Bay area contains large areas of salt marsh. The Petaluma River is tidal to Petaluma and both the Petaluma River and Sonoma Creek discharge into San Pablo Bay. The Petaluma marsh is an ancient marsh and serves as a reference for restoration in the North Bay region. The area between Petaluma and Lakeville has been severely impacted by industrial and agricultural development but is currently undergoing a large restoration to natural tidal habitats. Smaller salt marshes occur in the Bodega Bay area, near Doran Beach.

The Recovery Plan for Tidal Marsh Ecosystems[24] addresses actions to protect listed species such as soft bird's-beak (*Corydylanthus mollis ssp. mollis*) and the salt-marsh harvest mouse (*Reithrodonto mysraviventris*) that occur in Sonoma County salt marshes.

2.1.3. Grasslands

Grasslands occur on the cool, moist coastal bluffs and grassy hilltops and in the hotter, drier inland valleys and foothills where the soils are deep with high clay content. These widespread habitats were historically composed of perennial bunchgrasses, native annual grasses and forbs, but today typically contain mostly non-native annual species interspersed with native perennial grasses and forbs. Climate and soil differences greatly affect grassland species composition.

Many wildlife species utilize grasslands for forage and take shelter in nearby habitats that provide greater cover. Additionally, because of their widespread distribution, grasslands serve as travel corridors for medium and large-bodied mammals. Historically, local Native Americans, including the Pomo and Miwok, managed grasslands to attract game animals such as deer and quail and to cultivate wild grass seed. The grass seed formed the basis for pinole, a regional food staple.

Land cultivation, the conversion to annual pasture grasses, and the lack of historic disturbance regimes, such as grazing from native mammals (e.g., tule elk, pronghorn antelope) have resulted in the loss of most native grasslands in California. Native grasslands have been identified by CDFG as one of many sensitive natural communities that are rare and vulnerable to further loss. These communities have been identified for protection in the Sonoma County General Plan 1989 and in the Sonoma

24 U.S. Fish and Wildlife Service 2009

County General Plan 2020.

Oak Woodland

2.1.4. Oak Woodlands

Oak woodlands occur throughout Sonoma County, mainly on dry warm slopes, but also in more protected, cool and moist sites, often amid mixed evergreen and Douglas-fir forests. Ten of the twenty species of oak in California grow in Sonoma County; eight of these species are trees contributing to our woodlands. These tree species are often individually dominant within certain microclimates and soil types, creating varied oak woodland vegetation patterns. For instance, Oregon white oak (*Quercus garryana*) woodlands occupy cool north-facing aspects; blue oak (*Quercus douglasii*) woodlands occur on drier and shallow soils and coast live oak (*Quercus agrifolia*) woodlands on ridge tops and southern exposures.

These woodlands and their understory vary in density depending on a number of factors (microclimate, soils, disturbance history and others). Throughout California, oak woodlands provide habitat for approximately 2,000 plant, 5,000 insect, 160 bird, and 80 mammal species.[25] The acorns from a variety of oak trees supply food resources for many species of wildlife (e.g., acorn woodpeckers, deer) and traditionally served as a staple food supply for the Native Americans of this area.

"Remember important systems upon which the species and habitat depend. Along with preserving a patch of riparian forest, for example, you must also consider any threats to the stream flows which keep that forest in good shape."
–Rich Walker

An effort is currently underway to develop a voluntary oak woodland management plan for Sonoma County which could provide a foundation for fulfilling several Sonoma County General Plan 2020 policies related to the preservation of important oak woodlands. The Sonoma County Agricultural Preservation and Open Space District has mapped "Core Oak Woodlands" (i.e., woodlands that are the least fragmented) and uses the data to prioritize its conservation efforts (see section 5.2.3).

Oak Savannah

2.1.5. Oak Savannah

Sonoma County is well known for its scenic, open oak savannah habitat, which occurs on valley bottoms and gentle slopes. The overstory canopy layer is open and the understory generally consists of grasses and other herbs with occasional sparsely distributed shrubs. Oak savannah provides habitat for many wildlife species. As in oak woodlands, acorns provide an important source of

25 Meadows 2007

Mixed Evergreen Forest

nutrition for wildlife and were extensively used by Native Americans. Fire was historically an important disturbance event that maintained the open aspect of this habitat type by preventing the establishment and growth of tree and shrub seedlings. Established oaks were protected from the effects of fire by thick bark. Currently, much of this scenic habitat is maintained through ranching operations; cattle, horses, and other ungulates trample or graze seedlings.

Oak savannah, and all other habitats on the Santa Rosa Plain, have been significantly impacted by human activity. Sonoma County General Plan 2020 contains separate Valley Oak zoning to address further losses due to development.

The Laguna de Santa Rosa

The Laguna de Santa Rosa is the largest tributary to the Russian River, draining a 254 square mile watershed. Its main channel extends fourteen miles from Cotati to Forestville. The Laguna consists of a mosaic of creeks, open water, perennial marshes, seasonal wetlands, riparian forests, oak woodlands and grasslands. It serves as important habitat for local wildlife and migratory birds and waterfowl. Additionally, the Laguna absorbs overflow during flood events, reducing the impact on downstream communities. The Laguna is a mix of private and public land. It has no formal protection status.

2.1.6. Mixed Evergreen Forests

Mixed evergreen forest is a multi-layered habitat type that occurs throughout the county. It commonly occurs as transition forest between redwood forest and oak woodlands. Soil ranges from dry to moist, with the moist sites dominated by Douglas-fir and the dry sites dominated by evergreen hardwoods. The understory in mixed evergreen forest is usually densely shaded and poorly developed. This habitat type is widely distributed, with accessible sites occurring at Sugarloaf Ridge State Park, Hood Mountain Regional Park, Annadel State Park and Jack London State Park.

2.1.7. Coniferous forests

Redwood Forests

Coast redwood forests occur along a 450 mile coastal zone strip from Monterey County, California to just north of the Oregon-California border. Coast redwood is usually the dominant tree species but at higher elevations, Douglas-fir or other conifers occur as co-dominants. Redwood trees are adapted to fog, flood, and fire. The trees require the cool, moist air supplied by fog around the crown to prevent dehydration and to provide a year-round water source: fog condenses onto leaves, drips down to the soil, and provides water for the shallow root system. Periodic floods cause formation of silt that would suffocate most tree species; however, redwood trees have adventitious root systems that quickly sprout when buried and spread sideways, restoring oxygen to the root system and intertwining with nearby redwood trees, enhancing their stability.

Redwood trees possess very thick bark that can withstand the heat of most fires and they will readily resprout when the crown is killed by fire. In fact, research suggests that natural disturbances such as fire, wind, and flooding actually facilitate redwood establishment.[26] Others have found natural disturbances (e.g. fire, wind, and flood) prevent establishment of other native trees such as Douglas-fir, California bay, or tan oak that might replace coast redwood where it has historically been the dominant species.[27]

Douglas-Fir and Other Coniferous Forests

Douglas-fir dominates higher elevation moist soils, grading into mixed evergreen forest as the soil becomes drier. It is often found as a mosaic within redwood forests. The understory is usually densely shaded and poorly developed, consisting mainly of woody debris and tree litter. Counter-intuitively, native Douglas-fir acts as an "invasive" in some areas – especially in the absence of natural fire regimes - mimicking many of the negative characteristics (e.g. out-competing local species) usually associated with non-native species.

In Sonoma County, Douglas-fir forest is widespread, with populations occurring in the Russian River drainage, on Rincon Ridge, along Mark West Creek, in Annadel State Park, on Sonoma Mountain. Foothill pine is found in association with blue oak in foothills throughout the county and sugar pine can be found near the inner edge of redwood forest in the Gualala basin. Foothill pine is usually found on serpentine soil in Sonoma County. Other cone bearing species in Sonoma County include knobcone pine, Coulter pine, Monterey pine, western hemlock, and Pacific yew.

2.1.8. Chaparral

Chaparral habitat contains a mix of evergreen, sclerophyllous (tough-leaved) shrubs that form a single layer canopy with little or no understory. This habitat type is common on the dry, rocky, nutrient poor soils of ridge tops and south facing slopes but is much rarer in coastal areas (e.g. maritime chaparral). As distinct from their fog-drenched cousins, plants that inhabit interior chaparral are adapted to harsh, dry conditions: leaves are small, sometimes fuzzy, often and protected by layers of wax and fat that retard dehydration.

Redwood Forest

Coniferous Forest

"People think carbon sequestration happens elsewhere, whereas our forests are excellent at this."
–Tom Robinson

Chaparral

26 Lorimer et al. 2009
27 Cooper 1965

Coastal Scrub

Coastal Strand

The Cedars

The Cedars is a 9mi^2 area named for the presence of Sargent Cypress and characterized by large expanses of serpentine and peridotite rock. Reminiscent of a moonscape, this habitat supports diverse serpentine plant communities. The Cedars forms the separation for the headwaters of the Russian River, the Gualala River, and Austin Creek. It is mix of private and BLM land and has no formal protected status.

Interior chaparral represents a fire-climax community, adapted to a fire periodicity of about 10 to 12 years. Seeds often require fire and/or smoke to germinate and many of the plant species are resprouters, able to regrow following even severe fires. Fires in the chaparral also kill soil pathogens and break down the waxes and oils in leaves that litter the soil surface, thus improving moisture penetration into the soil.

Chaparral occurs in interior portions of Sonoma County, including dry slopes of Hooker, Stuart, Nuns and Adobe Canyons, at Annadel State Park, Hood Mountain Regional Park, Sugarloaf Ridge State Park, and The Geysers.

2.1.9. Coastal Habitats

Coastal Scrub

Coastal scrub habitat occurs on coastal bluffs and mesas of interior hills and canyons. It contains a dense overstory of evergreen shrub vegetation no greater than two meters tall with an understory of smaller shrubs, herbs and grasses. Shrubs are not sclerophyllous, but are adapted to poor nutrients, high wind exposure, and dry soil. This habitat type intergrades with coastal dunes, grasslands, and forests. In Sonoma County, coastal scrub is common north and south of Jenner.

Coastal Strand

Coastal strand habitat consists of the beach and coastal dune and in Sonoma County occurs exclusively along the coast in Sonoma County. This habitat contains an open to closed cover of herbaceous perennials and low growing shrubs above the maximum high tide line. Plants are often prostrate, succulent or possess other adaptations for harsh environments. Species composition varies depending on exposure to wind, salt spray, soil development, and degree of disturbance. Coastal strand often intergrades with coastal prairie and coastal scrub. In Sonoma County, coastal strand habitat occurs at Bodega Dunes State Park, Salmon Creek, Wrights Beach, Goat Rock and Russian Gulch. Coastal strand habitat has been severely impacted by the intentional planting and ongoing invasion of European Beach grass (Ammophila arenaria), with this invader transforming the dynamic physical and nutrient processes of this rare habitat.

Coastal Terrace/ Prairie

Coastal prairie occurs on coastal terraces with deep

well-drained soils. This grassy habitat type extends inland where there is a maritime influence to merge with interior grassland. Much coastal prairie in Sonoma County has been converted to pasture, resulting in a loss of native perennial bunchgrasses. Non-native annual grasses and forbs proliferated during the conversion period and are now naturalized. In Sonoma County, coastal prairie occurs along terraces and hills of the coastline from Estero Americano north to Fort Ross.

2.1.10. Near-shore Marine Habitats

The near shore marine environment in Sonoma County provides habitat and forage for many species of marine mammals, seabirds, and invertebrates. Seals, and sea lions utilize the county's near-shore marine environments for forage, shelter, and reproduction. Tide pools support diverse marine life including mussels, crabs, starfish, sea anemones, and many species of fishes. Many of these organisms are avidly sought by sport fishers and commercial harvesters. For example, the indigenous red abalone (*Haliotis rufescens*), which inhabits nearshore waters along the California coast, is worth approximately $50 per animal in commercial landing value. In Sonoma County, commercial harvest of this species is banned. Locally, this has led to a robust and profitable sport abalone harvest and, unfortunately, to a poaching problem.

Sonoma County is home to four estuaries along the Pacific Coast. The estuaries—at the mouths of Gualala River, Russian River, Salmon Creek, and Estero Americano—are particularly rich in plant and animal species due to the high levels of nutrients from both freshwater and seawater inflow. The estuaries in Sonoma County provide habitat and forage for numerous species of shorebird, seal and sea lion, crab and shrimp, fish, amphibian, and plankton.

2.2. Working Landscapes

Working landscapes are lands used for agriculture, forestry, grazing and dairying. Working landscapes include monocultural plantings where biodiversity is relatively low, as well as grazed pasture grasslands that may contain rich biodiversity including endangered plants and animals. For example, vernal pool ecosystems in Sonoma County containing the endangered California Tiger Salamander as well as numerous endangered annual plants are increasingly grazed by land managers blurring the boundary between historically protected lands

Near-shore Marine

The Geysers

The Geysers is the largest area of geothermal energy development in the world, and in the mid-90s, generated enough electricity to meet the power demands of San Francisco. Spread across northeast Sonoma County, the Geysers area contains significant deposits of serpentine soil and rare associated plants, as well as unique communities associated with the steam vents. The Geysers is on BLM land. The area has no formal protected status.

where cattle grazing was excluded and working landscapes where grazing may be the primary function. Appropriate grazing may be key to mimicking the historic herbivores (e.g. pronghorn) that roamed Sonoma County. Grazed grasslands provide the added ecosystem services of carbon sequestration, and groundwater infiltration and recharge.

Within Sonoma County, working landscapes make up a significant percent of land use. The fate of biodiversity and the long-term success of agriculture are inextricably linked. In addition to providing food, fiber, and timber products we depend upon, working landscapes play a vital role in natural resource protection by serving as urban buffers, providing wildlife corridors for terrestrial species migration, and stopover locations for migratory birds along the Pacific Flyway.

2.3. Urban Landscapes

Urban landscapes are found in cities and small towns where the dominant land use is housing, commercial, or industrial. Urban landscapes can support regional biodiversity. Urban landscapes are rich in biodiversity, but poorly planned cities and towns can be barriers to wildlife movement and migration (e.g. fences and roads). Cities and the roads connecting urban lands provide opportunities for the spread of non-native and invasive plants and animals. "Escapee" garden plants and pets can move from urban landscapes to wild lands.

Cities, their consumption of resources, and their tendency to grow outward into surrounding working landscapes and open spaces are threats to biodiversity. Well-planned urban landscapes with greenways for wildlife movement, sustainable water use, transportation, growth policies and educated citizens can support biodiversity.[28] Compact, non-sprawling urban areas protect the ability of non-urban areas to provide scenic, ecosystem, and biodiversity functions.

2.4. Ecosystem Functions and Services

Protecting and restoring habitat patches and preserving species occurrences are an integral part of local biodiversity conservation. However, the protection, restoration or enhancement of Sonoma County's natural physical and biotic processes is often overlooked. To be most effective, natural resource managers in Sonoma County must seek to enhance not just "habitats" (however defined), but also overall ecosystem functionality, resilience, and sustainability. Viable habitats – and the landscapes they comprise - provide the essential ecosystem functions that all species (including ours) depend on: processing air and water-borne pollutants; supporting bees and other crop pollinators; storing climate-altering carbon; controlling floods and preventing soil erosion; restoring groundwater; and cycling essential nutrients. Without these and other fundamental processes in place, Sonoma County biodiversity will inevitably degrade.

We need to protect and enhance the natural functioning of the County's natural environments, including: the hydrologic integrity and variability of watersheds; connections among disparate habitat fragments to create functional wildlife corridors and allow gene flow; mimicking to the greatest extent possible the effects of a natural fire regime; allowing for groundwater recharge (particularly, reducing human summer and fall demand from sources such as wells near streams and direct, unregulated pumping from

28 Convention on Biodiversity. http://www.cbd.int.

streams); and encouraging more natural meandering and flooding patterns along river systems.

Ecosystem functions are the critical processes of natural environments that support and benefit life. With regard to human life and benefit, these functions are described as "ecosystem services." The concept of ecosystem services arises from an economic valuation of naturally occurring ecosystem functions. What might it cost, for example, to hand pollinate an apple orchard? This natural process or function is provided free of charge by insects and so viewed through an economic lens, the function – pollination, can be described as a service.

Ecosystem services can be categorized as provisioning services (food, water, timber, and fiber), regulating services (the regulation of climate, floods, disease, wastes, and water quality), cultural services (recreation, aesthetic enjoyment, and spiritual fulfillment), and supporting services (soil formation, photosynthesis, and nutrient cycling). While demands for ecosystem services such as food and clean water are growing, climate change and other anthropogenic forces are reducing the capacity of ecosystems to meet these demands. Worldwide, humans have radically altered the natural environment often with detrimental effect to ecosystem services. The loss of species via extinction or extirpation decreases biodiversity and adversely effects ecosystem services. "Changes in biodiversity alter ecosystem processes and change the resilience of ecosystems to environmental change. This has profound consequences for services that humans derive from ecosystems."[29] Simply put, it is in our own best economic and health interest to preserve existing biodiversity, restore lost biodiversity and guard against future losses due to continued anthropogenic effects (e.g. climate change).

Because there is often redundancy within a functioning ecosystem, debate exists about the relative impact of the loss of any one particular species. Numerous species often provide the same or similar service and in theory, if one species is lost, others fill the niche left vacant. However, highly biodiverse areas may not necessarily have increased services due to the overlap of function. Regardless of the possible redundancy of species within an ecosystem, "conserving biodiversity is essential because we rarely know a priori which species are critical to current functioning or provide resilience and resistance to environmental changes."[30]

29 Chapin 2000
30 Chapin 2000

3. Threats and Needs

Changes to the status of Sonoma County's biological diversity are directly related to the ways humans develop and use local land and water resources. The severity of human-caused threats to Sonoma County biodiversity was ranked by botanists, biologists, policy experts, and natural resource managers familiar with Sonoma County. According to these experts, the current top threats requiring action are: habitat loss and fragmentation associated with urban and agricultural development; replacement of native species by invasive non-native species; disruption of natural water cycles; pollution of air and water; the unknown impacts of climate change; and gaps in the scientific knowledgebase.

Threats to biodiversity are varied and individual stressors act both alone and in concert to complicate the reaction of species, habitats, and ecosystems. For example, the combined stressors of water pollution and non-native species invasion can work in concert to dramatically threaten native ecosystems more than one stressor alone.

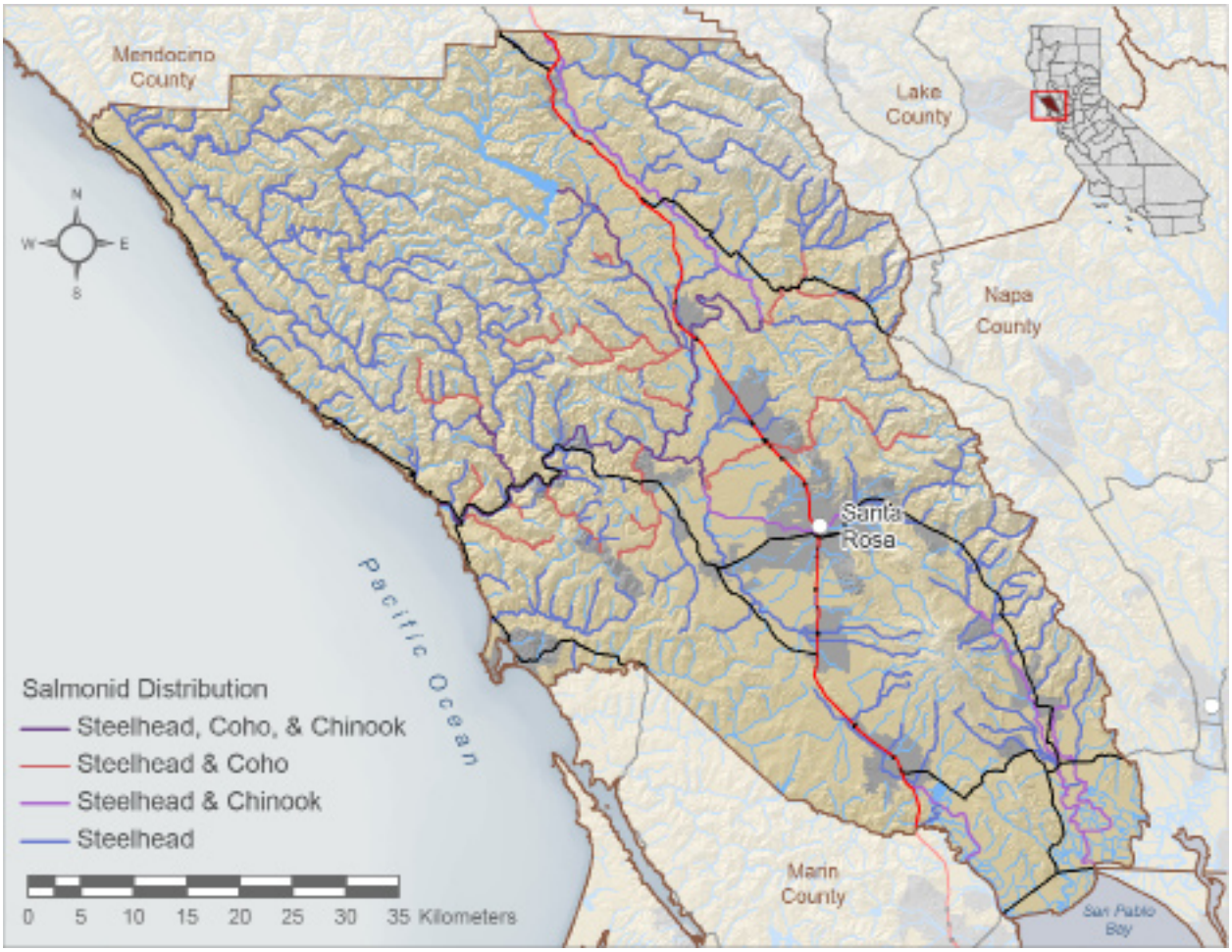


Figure 3. Rivers, Streams, and Salmonids (Source: USGS, CA Dept. Fish & Game, NOAA/NMFS).

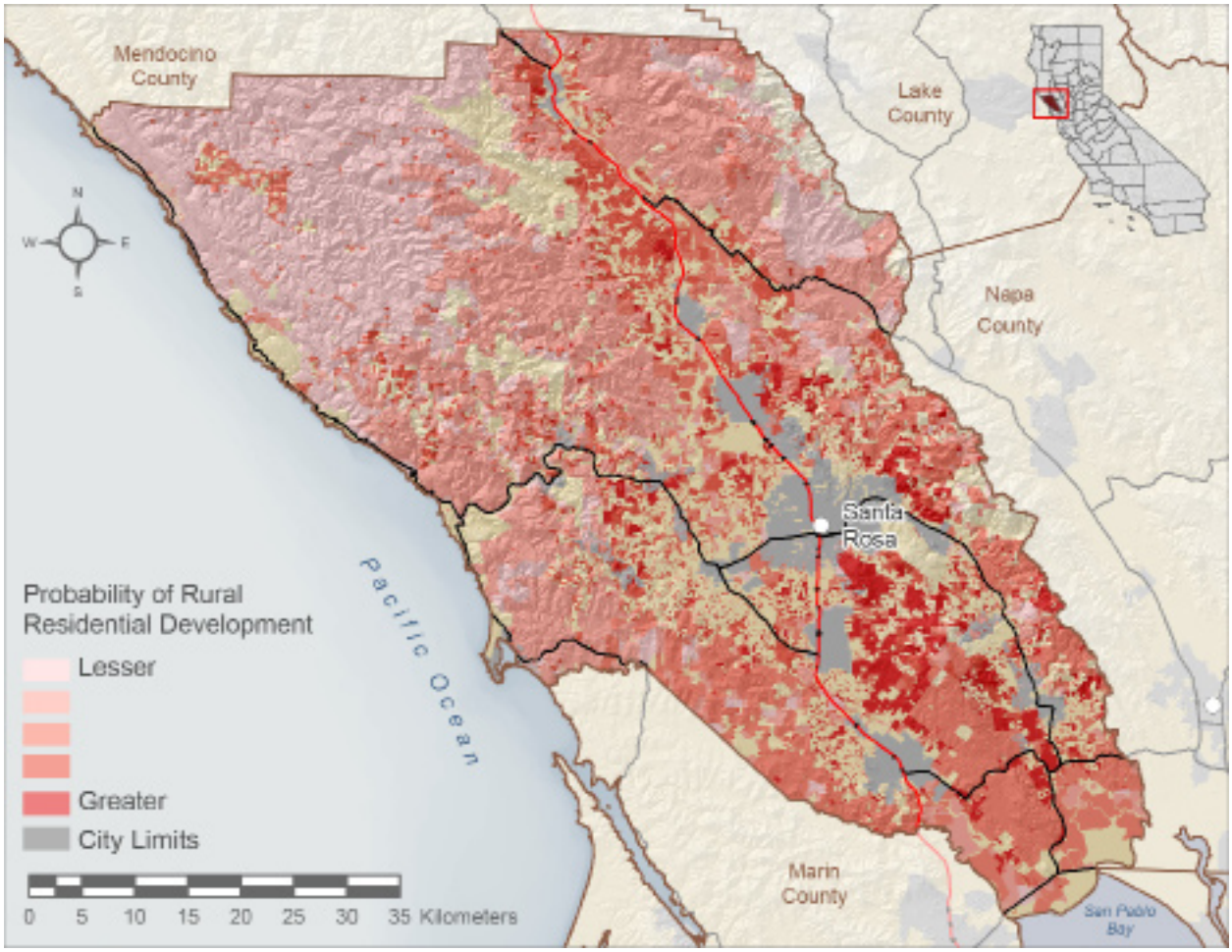


Figure 4. Relative probabilities of future low density rural residential development based on previous development trends (Source: Newburn et al. 2006).

Underlying all of these threats is also a basic need for knowledge. Very large areas of the county, such as the northwestern forests, have scarcely been surveyed at all (P Baye, pers. comm.). The natural resources that exist in unsurveyed areas as well as the associated threats to these resources and actions that might be taken to protect them are completely unknown. There is a lack of information about the frequency of occurrence of processes like flooding, fire and species invasion at different locations. Existing maps that are used to make land use decisions, such as the state's Natural Diversity Database, are incomplete and often inconsistent.

3.1. Habitat Loss and Fragmentation

In Sonoma County, 94.4% of land is in private ownership compared to a national average of 60%.[31] Most experts identified direct land protection (usually via acquisitions or easements) as the single highest priority for conservation of habitats and species in Sonoma County. However, limited funding for acquisition and subsequent management of acquired parcels will limit land that can be purchased and preserved. Too much land is privately held to ignore the impact and potential of preservation of biodiversity on private lands.

31 Fire and Resource Assessment Program 1995

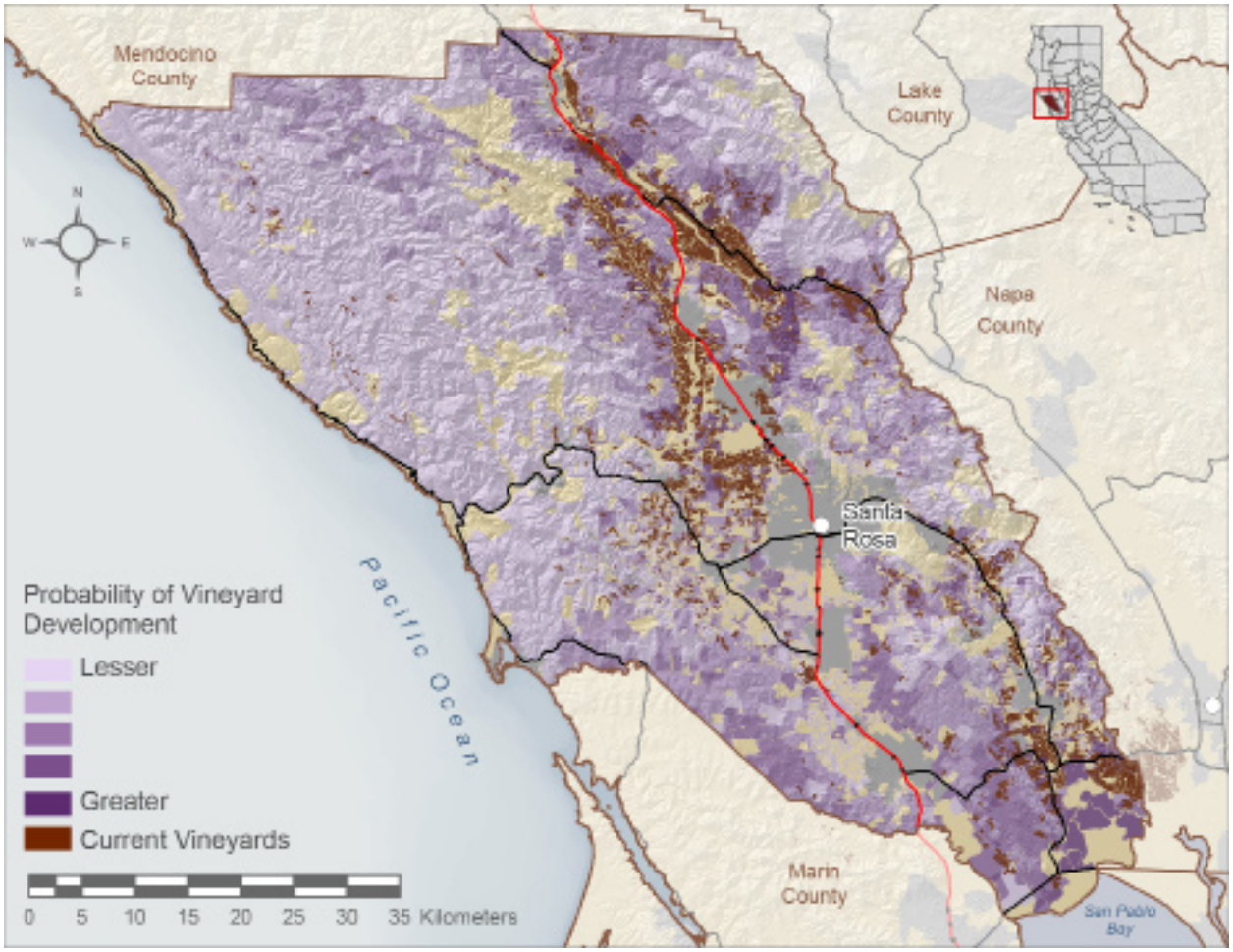


Figure 5. Relative probabilities of future vineyard expansion based on past trends of vineyard development (Source: Newburn et al. 2006).

With an eye toward prioritization given limited funding, land acquisition is generally targeted for locations where payoffs are especially high (e.g. those under highest conversion threat, such as valley floors and foothills, and those of highest biodiversity value). The biodiversity value of the land unit to be protected is not necessarily correlated to its size: Large parcels of undeveloped land, especially those embedded in a matrix of other relatively pristine parcels, have obvious value; however, small patch habitats such as maritime chaparral, vernal pools, freshwater wetlands, closed-cone forests, and serpentine areas are in need of protection because their small size and genetic isolation compound most other threats. In general, parcels are of highest priority for acquisition if they:

- Provide buffers between protected lands and intensive human development
- Contain rare, or unique species
- Are large parcels
- Are adjacent to protected land
- Contain riparian and/or wetland habitat

Maintenance or enhancement of existing protected wildlife corridors around the coun-

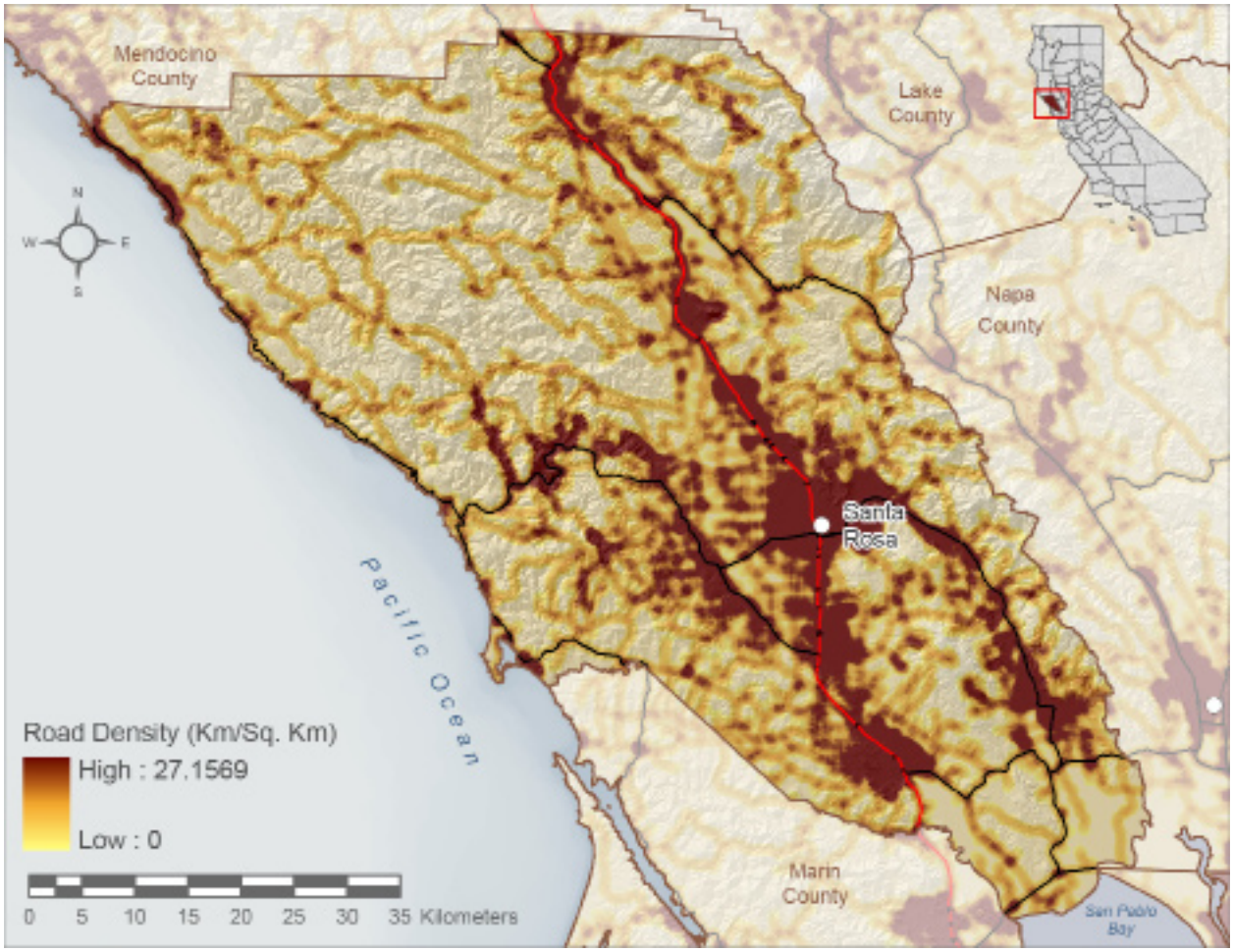


Figure 6. Road density in Sonoma County (Source: Bureau of Transportation and Statistics).

ty (often riparian belts) is also critical. Native species that would particularly benefit from improved habitat connectivity are mountain lions, bobcats, American badgers, spotted skunks, black-tailed deer, raptors, and riparian birds.

The extension of residential, commercial, and agricultural development into previously undeveloped forests, hillsides, and pastures is, experts agree, the single greatest threat to Sonoma County habitats (see Figures 4 and 5). A burgeoning suburban, exurban and rural population on top of a thriving wine grape growing industry (now globally recognized as one of Earth's largest wine-producing districts) challenge local resources. The County's more than 180,000 housing units and approximately 60,000 acres of vineyard take their toll on local water, land, and native wildlife. The conversion of natural areas into housing and agricultural development causes outright habitat loss and insidious fragmentation. California tiger salamander has dwindled to as little as 10 percent of its former range (R Walker and D Cook, pers. comm.) due to urbanization and conversion of rangeland to vineyard. Conversion to housing and vineyard not only leads to habitat destruction but can also contribute to excessive sedimentation of streams, de-watering of landscapes, and changes in runoff patterns that can exacerbate flooding.

Table 2: Summary of Sonoma County Protected Lands

Protected land in Sonoma County	acres
Land held in fee (2010 data)	98,591
Land held under conservation or agricultural easement (2007 data)	58,829
Total land protected in County	157,420
Percent protected	14.97%

* See Appendix for full listing.

Agricultural and residential development occurring amid undeveloped landscapes away from the county's urban centers often results from the division of formerly large parcels (e.g. single family farms) into clusters of smaller, more intensively-developed properties. This process is known as parcelization. Parcelization directly fragments the county's remaining natural areas; isolates species and blocks daily and seasonal animal movement; disrupts migratory corridors; and reduces local species diversity. Divided and developed parcels also require an unsustainable input of water and fossil fuels; provide a vector for the introduction of invasive plants and animals; and pollute the region's watersheds.

Several Sonoma County studies illustrate the impact of habitat loss and fragmentation or parcelization on biodiversity. Merenlender (2009) showed a shift in woodland bird species coincided with exurban (the semi-rural area beyond the suburbs) development. Some bird species reacted as negatively to exurban development as suburban development demonstrating the need for large, uninterrupted land parcels.[32]

Salmonid species also provide an illustrative example: in Sonoma County, the combination of agriculture, urban development, mining, logging, road construction, water diversions, ranching, and recreation have resulted in the loss, degradation, simplification, and fragmentation of habitat for anadromous fishes,[33] or those that live in the ocean mostly and breed in fresh water. The result is well-known declines in salmonid populations.

Other contributors to habitat fragmentation, not to mention direct wildlife casualties, in Sonoma County include roads (see Figure 7) and fences. Notably, Highway 101 bisects the County blocking natural gene flow and providing a significant barrier to wildlife movement and migration (T. Gardali pers. comm.) Wildlife fencing has detrimental effects on native wildlife movement and likely on species reproduction and survival (A Jensen pers. comm.).

Riparian corridors with dense vegetation are critical to large animal movement. Hilty and Merenlender (2004) showed that predatory mammals prefer to move along wide, forested corridors compared to narrow corridors, denuded corridors, or agricultural lands. This study, using cameras placed along the Russian River, Sonoma Creek, and in vineyards, detected movement of large mammals along riparian corridors 11 times more frequent compared to vineyards. More species and more native species were

32 Merenlender et al. 2009
33 NMFS 2005, NMFS 2007a, NMFS 2007b, and NMFS 2007c

found in wide riparian corridors with dense vegetation.[34]

Numerous public agencies and non-profit organizations protect and manage reserve land as refuges for biodiversity. However, of the roughly million acres comprising the county, approximately 1,000 acres or 15 percent, are protected for future generations. In fact, Sonoma County ranks among the lowest of the Bay Area counties in terms of protected lands. In contrast, 59 percent of Marin County and 38 percent of San Mateo County are protected. Table 9 (Appendix D) lists protected land, ownership and acreage in the county. Table 2 provides a summary of this information.

3.2. Invasive Species

When accidentally or intentionally introduced to native habitats, non-native plant and animal species can degrade native habitats in a number of ways: they may directly compete with or prey upon native wildlife and plant species; crowd native plants out of limited growing space; compete with plants directly for sunlight, nutrients, and water; and cause changes in the local environment that indirectly disfavor native species.[35] The occurrence of invasive species in Sonoma County is often associated with human habitation and infrastructure (e.g. roads and agricultural development). Table 7 (Appendix D) lists common invasive plant and animal species documented as established in Sonoma County habitats.

3.3. Degradation of Natural Water Cycles

The human impact in Sonoma County (e.g. housing, agriculture, livestock, industry, and other uses) extracts water from the local streams and wetlands, and demand will only increase in coming years. For example, the Sonoma County Water Agency draws drinking water from the Russian River for sale to over 540,000 residents of Sonoma County, Mendocino County, and northern Marin County. Increased urban development decreases the amount of penetrable land and contributes to increased runoff and decreased recharge of groundwater aquifers.

Such demands on local water supply have complex effects on ecosystems at many levels. Wells, reservoirs, spring boxes, and other methods of sequestering water reduce freshwater flow, affect the quantity and quality of water available to wildlife and plants, and physically degrade riparian and wetland areas. In addition to reducing in-stream flows and depleting groundwater, the construction of water diversion infrastructure often involves intentional or inadvertent creation of in-stream barriers; these, of course, make completion of the life cycle for salmonids and other native fishes difficult or impossible. Warm Springs dam is the largest in the county, but many other small to medium blockages also exist in local streams.

> *"If all impacts had been truly mitigated for, and those mitigation projects were functional, the biodiversity in Sonoma County would likely be in much better shape."*
> –Andrew Jensen

34 Hilty and Merenlender 2004
35 Seabloom et al. 2006

The cumulative effect on stream flow of unregulated groundwater pumping from rural residences and vineyards in foothill areas has not been quantified, but we know human activities are responsible for completely drying many streams during the summer months. We also know that the survival of aquatic wildlife is directly dependent, to varying degrees, on maintenance of particular in-stream physical conditions.

Salmonids are a representative example of the connection between hydrology and species occurrence: both stream substrate and water temperature strongly affect the viability of salmonid populations. Gravel that is 15 cm diameter or smaller is generally preferred by coho and steelhead for redd (nest) production. Land uses which cause erosion of fine sediments into streams (e.g. runoff from agricultural lands and dirt roads) can threaten survival of developing embryos by filling up the spaces between gravel and limiting the movement of water, which supplies oxygen to the eggs. Water temperature is also important, both for egg survival and the survival of juvenile salmonids. When water temperatures become too high, especially in historically cooler refugia like deeper pools, juvenile growth and survival is compromised. Land use factors that may affect water temperature include water withdrawals, clearing of riparian vegetation, manipulation of stream flow, and modification of channel configuration.

The County's finite water resources will almost certainly become more scarce and valuable in the future. There are a number of possible policies that could be put into place to improve water conservation and the functioning of aquatic ecosystems. These include: enforcing regulations on groundwater pumping, minimizing impervious hardscape (e.g. roofs and pavement) in groundwater recharge areas, setting and maintaining minimum levels for summer water in streams; storing winter stream and rain water in tanks for use during summer and fall, developing and promoting feasible gray water standards, and protecting against the degradation of upland hydrology by limiting roads and other human development in upland areas.

No agency tracks how much water is used by Sonoma County residents and permitting and other regulation is unevenly enforced. There is a clear need to regulate groundwater pumping to avoid completely dewatering creeks during periods of peak demand (D Cook, pers. comm.). One potential way to relieve stress on local in-stream and groundwater supplies is to harvest water when it is plentiful (rainy season) and to sequester it in novel ways, such as cisterns for household use during the driest months. Affordable, widely-available household cisterns have not been seriously proposed as an alternative for water conservation in Sonoma County, but a low-budget, cursory feasibility study could be undertaken. Finally, requiring a "balanced water budget" for the county (e.g. in the General Plan) would go a long way toward sustaining local ecosystems (C Kendall, pers. comm.).

3.4. Air and Water Pollution

The runoff into streams of fine sediment, fertilizers, pesticides, household waste, and heavy metals that is associated with large-scale agriculture and rural housing developments threatens to degrade aquatic habitats and directly reduce the survival and reproductive viability of aquatic species. Numerous waterbodies within the Russian River watershed are listed as impaired under the Clean Water Act Section 303(d) and there are some data to suggest that mercury is accumulating in fish of the Russian River

watershed.[36] Lake Sonoma and Lake Mendocino are impaired for mercury in fish tissue. The entire Russian River is listed as impaired for sediment and temperature.[37]

In addition to the familiar effects of water pollution, it is now understood that air and water pollution can also threaten the integrity of native habitats. In areas with serpentine (ultramafic) soils, deposition of atmospheric nitrogen from urban smog and agricultural effluent may be facilitating the invasion of invasive grasses into areas long dominated by native serpentine-associated plant species.[38]

3.5. Global Climate Change

The rapid climate change the world is experiencing today is a dramatic and unprecedented threat to global biodiversity. Climate change, coupled with habitat loss is a challenge for natural resource managers seeking to provide and create habitat for the future. Several studies are presently underway to evaluate potential climate impacts on Sonoma County.[39, 40]

Global climate modeling predicts that some areas around the world will become warmer, while others will cool. Preparing our watersheds for climate change requires decreasing uncertainty to acceptable levels by effectively estimating potential changes to climate, hydrology, and ecosystems based on the best science available at the watershed scale. This information is a starting point for understanding potential impacts to many sectors, including biodiversity, agriculture and transportation infrastructure. Downscaling of state and global climate predictions to the county-level will give natural resource managers an invaluable tool to evaluate expected local impacts due to climate change. Downscaling involves making large-scale information relevant at a smaller scale (L Flint, A Flint, and D Ackerly, pers. comm.).

Natural resource managers are preparing for a "flashier" climate – one with more extreme weather (e.g., longer, hotter droughts as well as increased and more intense rainfall). A warmer, drier climate in Sonoma County could exacerbate some stresses (e.g. water consumption; spread of invasive plants and plant diseases) and lead to apparently irreversible habitat changes as characteristic plant species die out or experience range shifts. For example, less rain during the growing season is forecast to reduce the range of at least some local oak species by up to 59 percent.[41] Some animal species will be resilient enough to cope with expected environmental changes, migrating to new areas to keep up with shifting conditions, but only if remaining natural areas stay connected enough to allow such movements, and if the refugia they are heading for remain viable. Small populations with restricted ranges and/or local endemics adapted to narrow niches could have a harder time adapting to a new climate regime and may face local extinction without intervention, especially if their genetic diversity and associated adaptive potential has been eroded by other stressors (C Sloop, pers. comm.). Reduced adaptive capacity of certain species, and the "synergy between climate

36 Russian River Watershed Association. http://www.rrwatershed.org/mercury.html.
37 North Coast Regional Water Quality Control Board. http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/russian_river.
38 Weiss 2006
39 Loarie et al. 2008
40 Loarie et al. 2009
41 Kueppers et al. 2006

change and habitat change and fragmentation are the most threatening aspect of climate change for biodiversity, and is a central challenge facing conservation."[42]

Species will respond to climate change independently of one another, and as they shift ranges they will form new communities and novel species associations.[43] This spatial and temporal decoupling of species interactions could cause extirpation of multiple species at once (e.g. a plant and its specialized pollinators may both go locally extinct if the pollinators are not present when the plant is in bloom).

All habitats and species in Sonoma County will likely be affected in some way by climate change, but the character and extent of these impacts is little understood at present; regional climate change projections are too vague at present to effectively guide conservation priorities. To identify areas and species most in need of protection from the likely effects, we should consider "modeling our priorities in a GIS-based climate projection that is run at three scales: county, region, and state." (D DiPietro, pers. comm.). Future climate change predictions must be relevant at the land management scale.

3.6. Data Gaps

Despite the efforts of a large community of natural and physical scientists working in and around Sonoma County, there still exist significant gaps in our understanding of not only the basic requirements of specific species, but of the processes and habitats that support them. Holes in our knowledge threaten local ecosystem integrity. Specific scientific assessments to fill these data gaps and scientific research needed to inform and direct conservation efforts are described under recommended actions.

"The primary sources for biodiversity of plants in the county suffer from very incomplete and uneven geographic coverage, opportunistic or haphazard data contributions, outdated records, taxonomically ambiguous or outdated records, and inaccessibility."
–Peter Baye

42 Lovejoy and Hannah 2006
43 Lovejoy and Hannah 2006

4. Recommended Conservation Actions

The challenges posed to the future existence of Sonoma County wild lands are daunting. Fortunately, anthropogenic threats to natural systems and species can be abated by collective and well-directed land preservation and management.

Priority conservation actions needed now to preserve the region's biodiversity are listed here. Recommendations focus on protecting, managing, and enhancing areas of still-intact habitats, rather than concentrating efforts on conserving individual species[44] one at a time. "While it is sometimes necessary to focus on protection and restoration of imperiled species, many of the most vulnerable species in Sonoma County are dependent on a handful of habitats that have been systematically destroyed or degraded throughout California. In order to save a number of species from local extirpation in the near future, it is necessary to protect and restore these habitats (E Heaton, pers. comm.)."

Conservation of natural habitats has often meant acquiring and setting aside key plots of land in formal protected areas. In places like Sonoma County, where most land is privately owned and multiple stakeholder interests are involved, this strategy alone cannot be effective for long-term conservation.[45] Reflecting this reality, this Action Plan recommends a wide array of conservation tools, from performing fundamental research to educating landowners about effective land management practices and the value of healthy ecosystems.

Nearly all of the recommendations that follow can be undertaken using existing information (e.g. outreach materials created by local groups or implementing management guidelines developed by others); in collaboration with existing, ongoing programs (local conservation-minded organizations and programs abound); and with the active participation of the people of Sonoma County.

4.1. Science for Conservation

Science is an integral part of this Plan and conservation of biodiversity. Science for conservation works by: (1) understanding local resources, (2) filling knowledge gaps, (3) implementing specific research projects to advance biodiversity conservation, (4) evaluating the success of conservation science actions. While science underlies all elements of the actions recommended by this Plan, several science-specific actions are outlined in this section. Results from the science actions described below will serve to advance, prioritize, and inform biodiversity conservation.

4.1.1. Map Habitat Types and Species Distributions

A critical step toward conserving Sonoma County biodiversity is to prioritize where on the ground conservation action is most urgently needed. Thus, one of the highly recommended next actions is to initiate a formal biodiversity assessment for Sonoma

44 Although this process will mostly focus on identifying and preserving vital habitats, it is still important to consider monitoring, and where necessary restoring, sensitive indicator species like salmonids; riparian and grassland birds; and invertebrates, to name a few.

45 Wear et al. 1996

County to identify specific locations of highest biodiversity value and/or threat level. Researchers from a wide variety of fields, working in concert, could rapidly, systematically, and thoroughly catalog the county's biodiversity, documenting what is currently known about the distribution of key species and the location and severity of threats to habitats. The results would be spatially-explicit (GIS-based), allowing conservation managers to, for example, identify areas where action is needed and where data for making science-based conservation decisions are lacking.

Although vegetation is a subset of biodiversity, the pressing need for vegetation information merits its own mention. The persistence of animal species, not to mention the viability of ecosystem functions such as erosion prevention, protection of water quality, enhancement of groundwater recharge and reduction of greenhouse gasses, all depend on healthy, resilient plant communities. A comprehensive vegetation mapping effort similar to that done recently in Napa County (and many other areas) is urgently needed. Such an effort must be fine-grained enough to capture the intricate variations in local plant communities, to distinguish, for example, coastal lagoon estuaries from San Pablo bay salt marsh, or maritime chaparral from high-elevation chaparral.

Recommended actions:

- Inventory and apply existing data resources (e.g., Bay Area Uplands Habitat Goals)
- Create a comprehenisive vegetation map
- Consult local experts to further define priority areas based on expert opinion
- Conduct formal analyses (e.g., species and habitat distribution maps including climate change)
- Identify current level of habitat connectivity
- Create conservation GIS to identify areas for conservation action
- Use data that is detailed and frequent surveys to track rates of change in species, communities, and processes

4.1.2. Coordinate Monitoring and Evaluate Success

Coordinated monitoring to evaluate species, habitats, and ecosystems directly addresses identified threats to biodiversity (i.e., habitat loss and fragmentation, invasive species, degradation of natural water cycles, air and water pollution, global climate change, and data gaps).

Recommended actions:

- Inventory and integrate existing monitoring projects in the county
- Expand existing Upland Habitat Goals decision support tool by integrating a Sonoma County focused local-scale conservation GIS
- Develop an over arching monitoring framework to define what to monitor, at what scale, and at what frequency
- Implement monitoring program at recommended intervals and scales

4.1.3. Conduct Priority Conservation Research Projects

In addition to priority mapping and monitoring efforts, experts identified additional research projects to fill data gaps including economic analyses, understanding historic conditions, and climate vulnerability analyses.

Economic Analyses

Incorporating cost-benefit analyses of ecosystem services as a part of development and restoration would elucidate unknowns about the value of building and restoration projects. Elected officials, planners, decision-makers, and natural resource managers would all benefit from cost-benefit analyses of riparian buffers; "smart growth"; water conservation; as well as the success of restoration projects to repair degraded ecosystems and functions. Myriad benefits accrue when species, habitats, ecosystems, and land are protected and preserved. Understanding the true costs and benefits of conservation of biodiversity is invaluable. Placing a dollar value on land use changes with regard to ecosystem services would elucidate the costs of land use changes and prioritize both development and conservation projects.

Riparian habitat restoration via tree planting, for example, provides multiple ecosystem benefits: future nesting sites for birds, shade for streams, cover for large mammals, etc. Trees also sequester carbon, cleaning the air as they grow. Incorporating all the benefits of restoration via economic analysis would allow natural resource managers, land developers, and policy makers to know the cost of conservation action or inaction.

Historic Conditions

We need improved data to determine how intense past land uses were in Sonoma County (G Cooley, pers. comm.). A better understanding of Sonoma County's historical natural conditions is a prerequisite for making informed conservation choices for the future. For example, when restoration is warranted, it's often impossible to answer the basic question "restoration to what?" Historical ecology is a fascinating field that can draw on the wisdom of our long-established ranching and farming families, as well as on the latest science. For example, to learn from a longtime landowner that a particular foothill tributary stream once ended in a wet meadow instead of in confluence with larger streams is to evaluate stream restoration options in a new light.

Recommended actions:

- Improve knowledge of historic ecological conditions
- Cost-benefit analyses of restoration and development projects to incorporate ecosystem services in project planning
- Conduct climate change vulnerability analysis for species and ecosystems

4.1.4. Set Conservation Targets to Define Success

Any action to conserve biodiversity requires clear goals or targets and a way to measure success. Managers need to establish explicit, measurable, scientifically sound biodiversity conservation goals for the county and measure the success of conservation actions against these goals (e.g., "Maintain 100,000 hectares of blue oak woodlands, in order to protect 75 named species and 12 named ecosystem functions").

Recommended actions:

- Define targets and timeframe(s) for achieving them (e.g., acreage by habitat, species, species groups, connectivity, etc.)
- Use existing resources (e.g., San Francisco Bay Joint Venture Implementation Plan, Upland Habitat Goals)
- Develop a short document and/or website that describes the targets
- Develop systematic conservation plan based explicitly on biodiversity
- Develop a local scale "Marxan-like" tool for reserve planning would be an essential tool for improved land management

4.2. Enhance and Connect Our Land Network

Experts envision a county-wide network of biodiverse lands (including public and private lands) from large and intact protected ecosystems to working landscapes, from city-scapes to rural open space. Achieving this vision requires acquisition of priority habitats, preserving connections between protected lands, and appropriate management of both public and private land.

4.2.1. Protect and Connect Priority Habitats

Traditional parcel-by-parcel acquisition and protection of isolated habitat patches (e.g. those eventually identified by the biodiversity assessment), while crucial, will not by itself ensure that native species (and the processes and habitats that support them) persist in Sonoma County. What is really needed is preservation of "large connected pieces everywhere (W Eliot, pers. comm.)." Identifying and protecting the parcels that connect existing or proposed protected areas to create significant swaths of relatively undeveloped habitat is necessary to maintain species local and regional migration patterns and allow them to shift their historic ranges in response to climate change. Reconnecting fragmented habitats is relatively inexpensive and provides a big return on investment (K Gaffney, pers. comm.).

Recommended actions:

- Continue to protect land via acquisitions and easements
- Carefully target acquisitions to maximize ecological value given limited financial resources
- Promote conservation on private lands (see section 5.2.3)
- Maintain and protect corridors

4.2.2 Steward our Protected Lands Network

Appropriate stewardship of existing preserves is critical to maintain biodiversity on protected lands. We must manage the existing in addition to growing the network of preserve lands. Restoration and management of public lands provide a model for appropriate stewardship for private lands and must exemplify the Best Management Practices encouraged among private land owners.

Policies prohibiting grazing on public lands should be reconsidered, as well-managed grazing programs can be an effective tool to control invasive species in grasslands.

4.2.3 Enhance the Ecological Value of Private Land

The vast majority of land (94%) in Sonoma County is privately owned. Successful conservation of biodiversity cannot focus on protected lands alone: it must include maintaining and enhancing the biological value of privately owned parcels.

It is as necessary to actively reward good land and water management practices as it is to penalize destructive practices. For example, it would be helpful to change the current rule whereby deriving any income from land negates its property-tax-exempt status (called the "welfare exemption"). Real estate appraisal methodology should also be reevaluated as, currently, appraisals do not adequately value natural areas; this is preventing many critical acquisitions.

There are many practices which, if adopted by large numbers of private landowners and managers would allow biodiversity to recover. These practices include: invasive species prevention and control; stream-channel maintenance; forest thinning that mimics natural processes; carefully planned livestock grazing; maintaining minimum setbacks from riparian areas (e.g. >100 feet); and prescribed burning where feasible. Landowner participation will be instrumental in the success of invasive species removals and in preventing the establishment and spread of invasive plants and animals. There would also be benefits to resolving the conflict between County policies that advocate vegetation removal for fire prevention, and the desire to protect contiguous areas of valuable native vegetation.

In addition to conservation, conducting research on private lands is also imperative. Avoiding private lands when conducting research projects dramatically limits research sites and can lead to bias and unrepresentative sampling. Research on private lands has the potential to directly inform private land management, including management of biodiversity and endangered species as the vast majority of federally threatened and endangered species exist on private land.[46]

Human-made barriers to wildlife (roads and fences; in-stream barriers) can also be feasibly addressed by promoting good management by private landowners. Poorly constructed and maintained roads and fences contribute to habitat fragmentation, increase sediment input to streams, and directly kill or otherwise reduce viability of wildlife populations. Establishment of a road mortality task force could be a first step to ameliorating these problems. The use of wildlife friendly fencing and fence design should be encouraged; the county could regulate fences as structures, and train and certify fencing contractors to foster this change.

Recommended actions:

- Promote effective economic incentives for land owners
- Protect agriculture and working landscapes as inextricable components of biodiversity
- Encourage voluntary stewardship
- Encourage and conduct research on private lands to complement research on public lands

46 Hilty and Merenlender 2003

- Promote wildlife friendly fencing
- Establish a road mortality task force

4.3. Advance Emerging Initiatives

Traditional methods of natural resource conservation (e.g., protecting land via acquisition) will not be enough to preserve the many species, habitats, and functions provided by the biodiversity of Sonoma County. There is neither enough undeveloped land to purchase nor the money to buy and manage it. New tools, including new funding avenues for traditional conservation must be developed to safeguard biodiversity.

4.3.1. Integrate Water and Watershed Management

Climate change highlights the interdependence between water for humans and water for the environment. This interdependence is most obvious in and around our streams, wetlands, and riparian areas. We should pursue strategies to assure that Sonoma County has enough clean water for all uses.

Recommended actions:

- Protect streams, wetlands, and riparian areas in order to safeguard future water quality and quantity (simultaneously protecting habitat connectivity, enhancing areas with disproportionately high concentrations of sensitive species, and moderating local temperatures).
- Require water supply and treatment projects to provide multiple benefits.
- Integrate groundwater management (drought preparedness) with stormwater management (flood preparedness).
- Increase water efficiency and increase the re-use of water at all scales.

4.3.2 Use Economic Incentives

Properly designed and applied, economic incentive programs can be effective conservation tools. In Sonoma County, economic incentives could be used to encourage, among other things, relatively benign land uses, conservation of natural resources, and beneficial land management practices, and to discourage parcelization, sprawl, and low-density housing.

Ranching is one of the most benign local human land uses and can also be a useful management tool. Sonoma County's ranching industry, however, could die out without some level of subsidy, leaving ranchlands vulnerable to parcelization and conversion to housing or irrigated agriculture. Supporting policies that promote non-irrigated ranching over irrigated agriculture is one commonly suggested idea. The industry also would benefit from basic infrastructure such as local auction houses.

Recommended actions:

- Develop conservation focused economic incentives
- Support Best Management Practices

4.3.3. Develop and Implement Ecosystem Specific Plans

A comprehensive oak woodland management plan exemplifies a targeted plan focused on a habitat-type in Sonoma County rather than individual species or on specific preserve location. The plan will be a resource for landowners that will include Sonoma County-specific information on oak woodland ecology, values (to biodiversity and to humans), factors affecting oak woodlands, and, most importantly, a list of options for landowners who wish to voluntarily improve and/or protect the oak woodland habitat on their property. The adoption of the plan itself will qualify individual landowners, government agencies, and not-for-profit organizations to apply for Wildlife Conservation Board grant funds under the Oak Woodland Conservation Fund, per the California Oak Woodland Conservation Act of 2001.

The plan will raise awareness of the particular biological richness of oak woodlands and their importance to the human experience in the county. It will contain support for policies in General Plan 2020 for revised policies regarding impacts to the county's oak woodlands.

Recommended actions:

- Develop and implement ecosystem-specific management plans.
- Track integration of biodiversity protection with general plan and other land use policies.

4.4. Education and Outreach

In addition to performing basic outreach to the lay public, there is a need for more conversation between researchers, conservationists, landowners, and land managers; scientists would benefit from the practical and historical insights of the land managers, while land managers would benefit from the perspective of scientists to illuminate the far-reaching consequences of their management actions. If Sonoma County's biodiversity is to persist into the next century and beyond, the people who live and work here should be encouraged to recognize that they are the stewards of the land.

Recommended actions:

- Support development of K-12 curricula focused on biodiversity and ecosystem services
- Promote high school service learning opportunities
- Facilitate partnerships between resource agencies and managers and colleges and universities
- Encourage young people to choose careers in conservation and natural resource fields
- Facilitate public access to the reserve network
- Engage stewardship groups

> *"A more aware populace is the number one priority."*
> –Steve Barnhart

- Publicize this Action Plan
- Create and disseminate outreach materials
- Highlight the impact of biodiversity on quality of life, safety, livelihood, and pocketbook for Sonoma County residents

5. Next Steps

5.1. North Bay Climate Adaptation Initiative

The North Bay Climate Adaptation Initiative (NBCAI)[47] is a group of natural resource managers, scientists, policy makers, educators and private stakeholders formed during the 2009 State of the Laguna Conference.[48] Participants include experts and community leaders from a range of natural resource science and management fields critical to understanding the climate adaptation challenge and options for action.
Climate change mitigation aims to reduce greenhouse gas emissions into the atmosphere. However, even if humans stopped emitting greenhouse gasses today, the world will inevitably experience significant impacts due to climate change, including effects on water supply, agriculture, and fish and wildlife habitats. Biodiversity and ecosystem services in Sonoma County will be affected by climate change. Climate change adaptation involves the implementation of preventative measures aimed at reducing the inevitable impacts of climate change on resources of concern. NBCAI seeks to respond to climate change on a local scale and collaborate to implement effective climate adaptation strategies that sustain ecological and human communities of North Bay watersheds.

The goal of NBCAI is to foster an open conversation between technical experts, land managers and policymakers in support of effective climate adaptation strategies that preserve natural resources, biodiversity, and ecosystem services in the North Bay Area. While the focus of NBCAI is climate change adaptation, understanding and conserving biodiversity in Sonoma County is chief among the many actions NBCAI will take in the coming years. NBCAI is poised to coordinate the implementation of the strategies outlined in this Action Plan.

NBCAI operates via working groups focused on habitat conservation and restoration implementation, stakeholder outreach, science and technology, and public policy. The purpose of the working groups is to:

- Develop and implement strategies and outreach for habitat restoration and stewardship that promote biodiversity in a changing climate;
- Create collaborations that enhance understanding of local climate variability and its effects on natural and agricultural systems;
- Provide those making land and resource management decisions in the North Bay region the information, methods, and guidance needed to address the challenges of climate change; and
- Identify and act on opportunities to integrate climate adaptation into Sonoma County planning and policy processes from a regional perspective.

The working groups bring together the human and information resources that are central to effective, integrated land management and conservation planning for Sonoma County's natural resource systems in the face of climate change. Participation in NBCAI is open to all interested parties. For more information, visit www.nbcai.org.

47 North Bay Climate Adaptation Initiative. http://www.nbcai.com.
48 State of the Laguna Conference and Science Symposium. http://www.pyxisweb.net/conference.

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7. APPENDICES

Appendix A: Photo Credits

Front Cover: All images - West Coast Watershed

Page ix: (clockwise from top left) Owl nest - West Coast Watershed; salmonberry - West Coast Watershed; Burke's goldfields - Laguna de Santa Rosa Foundation; wetland - West Coast Watershed; child - West Coast Watershed; grassland - Sonoma County Agricultural Preservation and Open Spaces District; trillium - West Coast Watershed; big leaf maple - West Coast Watershed; (center) coastal scrub - West Coast Watershed

Page 9: Riparian habitat - West Coast Watershed

Page 9: In-stream habitat - Sonoma County Agricultural Preservation and Open Spaces District

Page 10: Vernal pool habitat - Laguna de Santa Rosa Foundation

Page 11: Salt marsh habitat - West Coast Watershed

Page 12: Grassland habitat - Sonoma County Agricultural Preservation and Open Spaces District

Page 13: Oak woodland - Denise Woods

Page 13: Oak savannah - Denise Woods

Page 14: Mixed evergreen forest habitat - West Coast Watershed

Page 15: Redwood forest habitat - West Coast Watershed

Page 15: Coniferous forest habitat- West Coast Watershed

Page 15: Chaparral - Denise Woods

Page 16: Coastal scrub habitat - West Coast Watershed

Page 16: Coastal strand habitat - West Coast Watershed

Page 17: Near shore marine habitat - West Coast Watershed

Appendix B: Glossary

Adaptive Management: The process of adjusting actions based on new and better information obtained from ongoing monitoring efforts.

Anadromous: living mostly in the ocean, and breeding in fresh water. Chinook, coho, and steelhead are all anadromous fishes.

Anthropogenic: Resulting from the influence or effect of humans.

Aquifer: An underground reservoir of water.

Bioaccumulation: The uptake and concentration of chemicals by plants and animals.

Biodiversity: An expression of the variety of living things in a given area and their interactions.

Climate Change Adaptation: The practice of implementing preventative measures aimed at reducing the eventual cumulative impact of climate change on resources of concern.

Climate Change Mitigation: The practice reducing greenhouse gases known to cause climate change.

Ecosystem: A functional unit of living things in a given area, linked together through nutrient and energy cycling.

Ecosystem Diversity: The variety and relative abundance of living things or processes and their interactions from a global scale to the habitat level.

Ecosystem Function: The critical processes of natural environments that support and benefit life.

Ecosystem Service: The beneficial outcomes from ecosystem functions with regard to human life; the economic valuation of ecosystem functions.

Edaphic: Referring to characteristics of soil. Edaphic characteristics include pH, chemistry, texture, and many others.

Endemic: Found only in a specific geographic region.

Extinct: A species that is no longer found on Earth.

Extirpation: No longer found in a given area; local extinction.

Fluvial: Of or relating to rivers.

Fragmentation: The process by which continuous lands, habitats, and/or ecosystems are divided into smaller pieces; parcelization.

Genetic Diversity: The variety and relative abundance of genetic characteristics of a species.

Invasive: An introduced or non-native species which, once established, has the potential to spread widely and cause environmental degradation.

Keystone Species: A species whose continued presence and well-being is vital for the healthy function of an ecosystem.

Pacific Flyway: A migratory path for birds from Alaska to Patagonia, passing through California.

Parcelization: The division of formerly large parcels into clusters of smaller, more intensively-developed properties; fragmentation.

Resilience: The ability of an ecosystem to tolerate disturbance from stressors without collapse or loss of function.

Riparian: Of or relating to rivers or streams.

Refugia: Places where species can take refuge from stressors; places that contain high biodiversity because species have used them for refuge from stressors.

Relative Abundance: The number of organisms of a particular kind as a percentage of the total number of organisms of a given area or community.

Sclerophyllous Vegetation: Vegetation with hard leaves and short internodes (the distance between leaves along the stem). Sclerophyllous plants occur in all parts of the world and are typical in chaparral habitats.

Species Diversity: The variety and relative abundance of different species within an ecosystem.

Species Richness: The variety of different species within an ecosystem; the count.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a particular pollutant that a waterbody can receive and still meet water quality objectives.

Ultramafic: Containing iron and manganese. Ultramafic rock and soil are home to distinct plant communities. Serpentine plant communities of California are one example.

Watershed: An area of land within which all water will flow to the same location; a drainage basin.

Appendix D: Biodiversity Lists

Table 3: Threatened and Endangered Species in Sonoma County

Taxon	Common Name	Scientific Name	Status[1]	Habitat
Crustaceans & Insects	California Freshwater Shrimp	*Syncaris pacifica*	LE	In-stream riparian
	Behren's Fritillary	*Speyeria zerene behrensii*	LE	Coastal terrace prairie
	Myrtle's Silverspot	*Speyeria zerene myrtleae sensu lato*	LE	Coastal strand, coastal prairie
Fishes	Coho Salmon - Central California Coast ESU	*Oncorhynchus kisutch*	LE	In-stream riparian, estuary, nearshore marine
	Chinook Salmon - California Coast ESU	*Oncorhynchus tshawytscha*	LT	In-stream riparian, estuary, nearshore marine
	Steelhead - Central California and Northern California DPS's	*Oncorhynchus mykiss*	LT	In-stream riparian, estuary, nearshore marine
	Tidewater Goby	*Eucyclogobius newberryi*	LE	In-stream riparian
Amphibians	California Red-legged Frog	*Rana draytonii*	LT	Riparian, freshwater wetland
	California Tiger Salamander	*Ambystoma californiense*	LT	Grassland, oak savannah, riparian, freshwater marsh, vernal pools
Birds	California Clapper Rail	*Rallus longirostris obsoletus*	LE	Salt marsh
	Snowy Plover	*Charadrius alexandrinus*	LT	Riparian, coastal habitats
	Western Snowy Plover	*Charadrius alexandrinus nivosus*	LT	Riparian, coastal habitats
	Western Yellow-billed Cuckoo,	*Coccyzus americanus occidentalis*	C	Riparian
Mammals	Salt-marsh Harvest Mouse	*Reithrodontomys raviventris*	LE	Salt marsh

Plants	Sonoma Alopecurus	*Alopecurus aequalis var. sonomensis*	LE	Freshwater marsh
	Napa Milkvetch	*Astragalus clarianus*	LE	Oak woodland, serpentine
	Sonoma Sunshine	*Blennosperma bakeri*	LE	Grassland vernal pools
	White Sedge	*Carex albida*	LE	Freshwater marsh
	Sonoma Spineflower	*Chorizanthe valida*	LE	Coastal prairie
	Vine Hill Clarkia	*Clarkia imbricata*	LE	Freshwater marsh in grassland, chaparral
	Soft Bird's-beak	*Cordylanthus mollis ssp. mollis*	LE	Salt marsh
	Pennell's Bird's-beak	*Cordylanthus tenuis ssp. capillaris*	LE	Serpentine chaparral
	Baker's Larkspur	*Delphinium bakeri*	LE	Coastal Scrub, Grassland
	Yellow Larkspur	*Delphinium luteum*	LE	Coastal scrub, coastal prairie
	Loch Lomond Button-celery	*Eryngium constancei*	LE	Seasonal wetland of Loch Lomond
	Burke's Goldfields	*Lasthenia burkei*	LE	Vernal pools
	Contra Costa Goldfields	*Lasthenia conjugens*	LE	Vernal pools
	Pitkin Marsh Lily	*Lilium pardalinum ssp. pitkinense*	LE	Freshwater marsh
	Sebastopol Meadowfoam	*Limnanthes vinculans*	LE	Freshwater marsh, vernal pools
	Tidestrom Lupine	*Lupinus tidestromii*	LE	Coastal strand
	Point Reyes Lupine	*Lupinus tidestromii var. layneae*	LE	Coastal strand
	Many-flowered Navarretia	*Navarretia leucocephala ssp. plieantha*	LE	Vernal pools, wet forest floors
	Calistoga Popcorn-flower	*Plagiobothrys strictus*	LE	Geysers Geothermal Area

Plants	Hickman's Cinquefoil	*Potentilla hickmanii*	LE	Coastal scrub, freshwater marsh, conifer forest
	Kenwood Marsh Checker-mallow	*Sidalcea oregana ssp. valida*	LE	Freshwater marsh
	Showy Indian Clover	*Trifolium amoenum*	LE	Grassland, coastal scrub, serpentine soils

Table 4: Endemic Species in Sonoma County

Common Name	Scientific Name	Habitat
California Red Tree Vole	*Arborimus pomo*	Coniferous Forest
Salt-marsh Harvest Mouse	*Reithrodontomys raviventris*	Salt Marsh
Baker's manzanita	*Arctostaphylos bakeri ssp. bakeri*	Serpentine
The Cedars manzanita	*Arctostaphylos bakeri ssp. sublaevis*	Serpentine
Vine Hill manzanita	*Arctostaphylos densiflora*	Chaparral
Rincon manzanita	*Arctostaphylos stanfordiana ssp. decumbens*	Chapparal Oak Woodland
Sonoma sunshine	*Blennosperma bakeri*	Vernal Pools
Cedars fairy lantern	*Calocortus raichei*	Serpentine
White sedge	*Carex albida*	Freshwater Marsh
Pitkin Marsh Indian paintbrush	*Castilleja uliginosa (presumed extinct)*	Freshwater Marsh
Vinehill clarkia	*Clarkia imbricata*	Grassland
Pennell's bird's beak	*Cordylanthus tenuis ssp. Capillaris*	Serpentine, Chaparral
Geysers panicgrass	*Dichanthelium acuminatum*	Geysers Geothermal Area
Serpentine daisy	*Erigeron serpentinus*	Serpentine Freshwater Marsh
Pitkin Marsh lily	*Lilium pardalinum ssp. Pitkinense*	Freshwater Marsh
Petaluma popcorn flower	*Plagiobothrys mollis var. vestitus (presumed extinct)*	Salt Marsh
Kenwood Marsh checkerbloom	*Sidalcea oregana ssp. Valida*	Freshwater Marsh
Hoffmann's jewelflower	*Streptanthus glandulosus var. hoffmanii*	Serpentine
Dorr's Cabin jewelflower	*Streptanthus morrisonii ssp. hirtiflorus*	Serpentine
Morrison's jewelflower	*Streptanthus morrisonii ssp. Morrisonii*	Serpentine

Table 5: Other Species of Conservation Interest in Sonoma County

The following species are classified as either Species of Special Concern[4] (SSC); are recognized by the International Union for the Conservation of Nature (IUCN) as Globally Critically Imperiled (G1), Globally Imperiled (G2), or Globally Vulnerable to Extinction (G3); or belong to the California Native Plant Society's Inventory lists 1A (presumed extinct in CA) and 1B (rare, threatened, or endangered in CA) [CNPS key: 1B.1=>80% occurrences threatened; 1B.2=20-80% occurrences threatened].

Taxon	Common Name	Scientific Name	Status*
Invertebrates	California Fairy Shrimp	*Linderiella occidentalis*	G3
	Tomales Isopod	*Caecidotea tomalensis*	G2
	Vernal Pool Andrenid Bee	*Andrena blennospermatis*	G2
	Ricksecker's Water Scavenger Beetle	*Hydrochara ricksecker*i	G1
	Leech's Skyline Diving Beetle	*Hydroporus leechi*	G1
	Pacific Sand Bear Scarab Beetle	*Lichnanthe ursina*	G2
	Buprestid Beetle	*Trachykele hartmani*	G1
	Opler's Longhorn Moth	*Adela oplerella*	G2
	Mimic Tryonia	*Tryonia imitator*	G2
	Splittail	*Pogonichthys macrolepidotus*	G2
Amphibians	Foothill Yellow-legged Frog	*Rana boylii*	G3
Reptiles	Pacific Pond Turtle	*Actinemys marmorata*	G3
	Northern Pacific Pond Turtle	*Actinemys marmorata marmorata*	G3
Birds	Double-crested Cormorant	*Phalacrocorax auritus*	SSC
	White-tailed Kite	*Elanus leucurus*	SSC
	Osprey	*Pandion haliaetus*	SSC
	Burrowing Owl	*Athene cunicularia*	SSC
	Northern Harrier	*Circus cyaneus*	SSC
	Cooper's Hawk	*Accipter cooperii*	SSC

4 A species is considered a Species of Special Concern if, although the species is not Endangered or Threatened, it is extremely uncommon, or has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations.

Birds	Sharp-shinned Hawk	*Accipiter striatus*	SSC
	Golden Eagle	*Aquila chrysaetos*	SSC
	Tricolored Blackbird	*Agelaius tricolor*	G2, SSC
	Purple Martin	*Progne subis*	SSC
	Vaux Swift	*Chaetura vauxi*	SSC
	California Horned Lark	*Eremophila alpestris actia*	SSC
	San Pablo Song Sparrow	*Melospiza melodia samuelis*	SSC
	Bell's Sage Sparrow	*Amphispiza belli belli*	SSC
	Yellow Warbler	*Dendroica petechia*	SSC
	Saltmarsh Common Yellowthroat	*Geothlypis trichas simosa*	SSC
	Yellow-breasted Chat	*Icteria virens*	SSC
Mammals	Sonoma Tree Vole	*Arborimus pomo*	G3
Plants	Pink Sand-verbena	*Abronia umbellata ssp. breviflora*	CNPS 1B.1
	Blasdale's Bent Grass	*Agrostis blasdalei*	G2, CNPS 1B.2
	Point Reyes Bentgrass	*Agrostis clivicola var. punta-reyesensis*	G3
	Franciscan Onion	*Allium peninsulare var. franciscanum*	CNPS 1B.2
	Sonoma Alopecurus	*Alopecurus aequalis var. sonomensis*	CNPS 1B.1
	Napa False Indigo	*Amorpha californica var. napensis*	CNPS 1B.2
	Bentflower Fiddleneck	*Amsinckia lunaris*	G2
	Coast Rock Cress	*Arabis blepharophylla*	G3
	Baker's Manzanita	*Arctostaphylos bakeri ssp. bakeri*	G2, CNPS 1B.1
	The Cedars Manzanita	__	G2, CNPS 1B.2

Sonoma Canescent Manzanita	*Arctostaphylos canescens ssp. sonomensis*	G3, CNPS 1B.2
Vine Hill Manzanita	*Arctostaphylos densiflora*	G1, CNPS 1B.1
Hairy Manzanita	*Arctostaphylos hispidula*	G3
Rincon Ridge Manzanita	*Arctostaphylos stanfordiana ssp. decumbens*	G3, CNPS 1B.1
Serpentine Milkweed	*Asclepias solanoana*	G3
Brewer's Milkvetch	*Astragalus breweri*	G3
Clara Hunt's Milk-vetch	*Astragalus claranus*	CNPS 1B.1
Alkali Milk-vetch	*Astragalus tener var. tener*	G1, CNPS 1B.2
Big-scale Balsamroot	*Balsamorhiza macrolepis var. macrolepis*	G3, CNPS 1B.2
Sonoma Sunshine	*Blennosperma bakeri*	CNPS 1B.1
Narrow-anthered California Brodiaea	*Brodiaea californica var. leptandra*	CNPS 1B.2
Bolander's Reedgrass	*Calamagrostis bolanderi*	G3
Serpentine Reedgrass	*Calamagrostis ophitidis*	G3
Round-leaved Filaree	*California macrophylla*	CNPS 1B.1
Pygmy Cypress	*Callitropsis pygmaea*	CNPS 1B.2
The Cedars Fairy-lantern	*Calochortus raichei*	G1, CNPS 1B.2
Coastal Bluff Morning-glory	*Calystegia purpurata ssp. saxicola*	CNPS 1B.2
Swamp Harebell	*Campanula californica*	CNPS 1B.2
Sonoma White Sedge	*Carex albida*	CNPS 1B.1
Deceiving Sedge	*Carex saliniformis*	CNPS 1B.2

Pitkin Marsh Indian Paintbrush	*Castilleja uliginosa*	CNPS 1A
Rincon Ridge Ceanothus	*Ceanothus confusus*	CNPS 1B.1
Calistoga Ceanothus	*Ceanothus divergens*	CNPS 1B.2
Vine Hill Ceanothus	*Ceanothus foliosus var. vineatus*	CNPS 1B.1
Holly-leaved Ceanothus	*Ceanothus purpureus*	CNPS 1B.2
Sonoma Ceanothus	*Ceanothus sonomensis*	CNPS 1B.2
Pappose Tarplant	*Centromadia parryi ssp. parryi*	CNPS 1B.2
Dwarf Soaproot	*Chlorogalum pomeridianum var. minus*	CNPS 1B.2
San Francisco Bay Spineflower	*Chorizanthe cuspidata var. cuspidata*	CNPS 1B.2
Woolly-headed Spineflower	*Chorizanthe cuspidata var. villosa*	CNPS 1B.2
Sonoma Spineflower	*Chorizanthe valida*	CNPS 1B.1
Franciscan Thistle	*Cirsium andrewsii*	CNPS 1B.2
Vine Hill Clarkia	*Clarkia imbricata*	CNPS 1B.1
Round-headed Chinese-houses	*Collinsia corymbosa*	CNPS 1B.2
Point Reyes Bird's-beak	*Cordylanthus maritimus ssp. palustris*	CNPS 1B.2
Soft Bird's-beak	*Cordylanthus mollis ssp. mollis*	CNPS 1B.2
Pennell's Bird's-beak	*Cordylanthus tenuis ssp. capillaris*	CNPS 1B.2
Serpentine Cryptantha	*Cryptantha clevelandii var. dissita*	CNPS 1B.1
Pygmy Cypress	*Cupressus goveniana ssp. pygmaea*	G2
California Lady's-slipper	*Cypripedium californicum*	G3
Baker's Larkspur	*Delphinium bakeri*	CNPS 1B.1

Golden Larkspur	*Delphinium luteum*	CNPS 1B.1
Geysers Dichanthelium	*Dichanthelium lanuginosum var. thermale*	CNPS 1B.1
Western Leatherwood	*Dirca occidentalis*	G2, CNPS 1B.2
Dwarf Downingia	*Downingia pusilla*	G3
California Bottlebrush Grass	*Elymus californicus*	G3
Narrowleaf Fleabane	*Erigeron angustatus*	G1
Biolett's Fleabane	*Erigeron biolettii*	G3
Greene's Narrow-leaved Daisy	*Erigeron greenei*	CNPS 1B.2
Serpentine Daisy	*Erigeron serpentinus*	G1, CNPS 1B.3
Supple Daisy	*Erigeron supplex*	G1, CNPS 1B.2
Tiburon Buckwheat	*Eriogonum luteolum var. caninum*	CNPS 1B.2
Snow Mountain Buckwheat	*Eriogonum nervulosum*	G2, CNPS 1B.2
Largeleaf Filaree	*Erodium macrophyllum*	G3
Loch Lomond Button-celery	*Eryngium constancei*	CNPS 1B.1
Tuolumne Button-celery	*Eryngium pinnatisectum*	CNPS 1B.2
San Francisco Wallflower	*Erysimum franciscanum*	G3
Pacific Fawnlily	*Erythronium helenae*	G3
Gray's Fritillary	*Fritillaria grayana*	G1
Fragrant Fritillary	*Fritillaria liliacea*	G2, CNPS 1B.2
Ojai Fritillary	*Fritillaria ojaiensis*	CNPS 1B.2
Roderick's Fritillary	*Fritillaria roderickii*	CNPS 1B.1
Blue Coast Gilia	*Gilia capitata ssp. chamissonis*	CNPS 1B.1

Woolly-headed Gilia	*Gilia capitata ssp. tomentosa*	CNPS 1B.1
Dark-eyed Gilia	*Gilia millefoliata*	G2, CNPS 1B.2
Pale Yellow Hayfield Tarplant	*Hemizonia congesta ssp. congesta*	CNPS 1B.2
Short-leaved Evax	*Hesperevax sparsiflora var. brevifolia*	CNPS 1B.2
Two-carpellate Western Flax	*Hesperolinon bicarpellatum*	G2, CNPS 1B.2
Point Reyes Horkelia	*Horkelia marinensis*	G2, CNPS 1B.2
Thin-lobed Horkelia	*Horkelia tenuiloba*	G2, CNPS 1B.2
California Satintail	*Imperata brevifolia*	G2
California Walnut	*Juglans californica*	G3
Northern California Black Walnut	*Juglans hindsii*	G1
Burke's Goldfields	*Lasthenia burkei*	CNPS 1B.1
Baker's Goldfields	*Lasthenia californica ssp. bakeri*	CNPS 1B.2
Perennial Goldfields	*Lasthenia californica ssp. macrantha*	CNPS 1B.2
Contra Costa Goldfields	*Lasthenia conjugens*	CNPS 1B.1
Perennial Goldfields	*Lasthenia macrantha ssp. macrantha*	G3
Delta Tule Pea	*Lathyrus jepsonii var. jepsonii*	CNPS 1B.2
Colusa Layia	*Layia septentrionalis*	G2, CNPS 1B.2
Legenere	*Legenere limosa*	G2, CNPS 1B.1

Jepson's Leptosiphon	*Leptosiphon jepsonii*	CNPS 1B.2
Rose Leptosiphon	*Leptosiphon rosaceus*	CNPS 1B.1
Crystal Springs Lessingia	*Lessingia arachnoidea*	G1, CNPS 1B.2
Woolly-head Lessingia	*Lessingia hololeuca*	G3
Coast Lily	*Lilium maritimum*	G2, CNPS 1B.1
Pitkin Marsh Lily	*Lilium pardalinum ssp. pitkinense*	CNPS 1B.1
Lilac Lily	*Lilium rubescens*	G3
Sebastopol Meadowfoam	*Limnanthes vinculans*	CNPS 1B.1
Bristly Desert-gold	*Linanthus acicularis*	G3
Large-flower Desert-gold	*Linanthus grandiflorus*	G3
Jepson's Desert-trumpets	*Linanthus jepsonii*	G2
Coast Range Desert-trumpets	*Linanthus latisectus*	G3
Napa Lomatium	*Lomatium repostum*	G3
San Mateo Bush Lupine	*Lupinus eximius*	G2
Cobb Mountain Lupine	*Lupinus sericatus*	G2, CNPS 1B.2
Tidestrom's Lupine	*Lupinus tidestromii*	CNPS 1B.1
Nodding Tarweed	*Madia nutans*	G3
Mt. Diablo Cottonweed	*Micropus amphibolus*	G3
Marsh Microseris	*Microseris paludosa*	G2, CNPS 1B.2
Bare Monkeyflower	*Mimulus nudatus*	G3
Curly-leaved Wild-mint	*Monardella undulata*	G3
Robust Monardella	*Monardella villosa ssp. globosa*	CNPS 1B.2
Cotula Navarretia	*Navarretia cotulifolia*	G3
Baker's Navarretia	*Navarretia leucocephala ssp. bakeri*	CNPS 1B.1

Many-flowered Navarretia	*Navarretia leucocephala ssp. plieantha*	CNPS 1B.2
Monterey Pine	*Pinus radiata*	G1
White-flowered Rein Orchid	*Piperia candida*	G3, CNPS 1B.2
Narrow-petal Rein Orchid	*Piperia leptopetala*	G3
Petaluma Popcorn-flower	*Plagiobothrys mollis var. vestitus*	CNPS 1A
North Coast Semaphore Grass	*Pleuropogon hooverianus*	G1, CNPS 1B.1
Marin Knotweed	*Polygonum marinense*	G1
Hickman's Cinquefoil	*Potentilla hickmanii*	CNPS 1B.1
California Scrub Oak	*Quercus dumosa*	G1
California Beaked-rush	*Rhynchospora californica*	G1, CNPS 1B.1
Victor's Gooseberry	*Ribes victoris*	G3
Tall Snapdragon	*Sairocarpus virga*	G3
Point Reyes Checkerbloom	*Sidalcea calycosa ssp. rhizomata*	CNPS 1B.2
Marin Checkerbloom	*Sidalcea hickmanii ssp. viridis*	G3
Mapleleaf Checkerbloom	*Sidalcea malachroides*	G3
Purple-stemmed Checkerbloom	*Sidalcea malviflora ssp. purpurea*	CNPS 1B.2
Kenwood Marsh Checkerbloom	*Sidalcea oregana ssp. valida*	CNPS 1B.1
Beach Starwort	*Stellaria littoralis*	G3
Bearded Jewelflower	*Streptanthus barbiger*	G3
Socrates Mine Jewel-flower	*Streptanthus brachiatus ssp. brachiatus*	G2, CNPS 1B.2
Freed's Jewel-flower	*Streptanthus brachiatus ssp. hoffmanii*	G2, CNPS 1B.2
Green Jewel-flower	*Streptanthus breweri var. hesperidis*	CNPS 1B.2
Howell's Jewelflower	*Streptanthus howellii*	G2

Plants

Three Peaks Jewel-flower	*Streptanthus morrisonii ssp. elatus*	CNPS 1B.2
Dorr's Cabin Jewel-flower	*Streptanthus morrisonii ssp. hirtiflorus*	CNPS 1B.2
Kruckeberg's Jewel-flower	*Streptanthus morrisonii ssp. kruckebergii*	CNPS 1B.2
Morrison's Jewel-flower	*Streptanthus morrisonii ssp. morrisonii*	CNPS 1B.2, G2
Suisun Marsh Aster	*Symphyotrichum lentum*	G2
Beaked Tracyina	*Tracyina rostrata*	G1, CNPS 1B.2
Two-fork Clover	*Trifolium amoenum*	CNPS 1B.1
Santa Cruz Clover	*Trifolium buckwestiorum*	G1, CNPS 1B.1
Saline Clover	*Trifolium depauperatum var. hydrophilum*	CNPS 1B.2
Coastal Triquetrella	*Triquetrella californica*	CNPS 1B.2
Coast Range Triplet-lily	*Triteleia lugens*	G3
Fringed False Helleborne	*Veratrum fimbriatum*	G3
Small-flower Deathcamas	*Zigadenus fontanus*	G3

Table 6: Characteristic Plants of Sonoma County Habitats

Habitat	Common Name	Scientific Name
Terrestrial Riparian	**Trees**	
	Big Leaf Maple	*Acer macrophyllum*
	Black Cottonwood	*Populus balsamifera ssp. trichocarpa*
	Box Elder	*Acer negundo*
	Fremont Cottonwood	*Populus fremontii ssp. fremontii*
	Northern California Black Walnut	*Juglans californica var. hindsii*
	Oregon Ash	*Fraxinus latifolia*
	Red Alder	*Alnus rubra*
	White Alder	*Alnus rhombifolia*
	Willow	*Salix spp.*
	Shrubs	
	Blue Elderberry	*Sambucus mexicana*
	California Blackberry	*Rubus ursinus*
	California Wild Rose	*Rosa californica*
	Coltsfoot	*Petasites frigidus*
	Mulefat	*Baccharis salicifolia*
	Snowberry	*Symphoricarpos albus var. laevigatus*
Freshwater Wetlands	**Herbaceous Plants**	
	Cattail	*Typha sp.*
	Bur-reed	*Sparganium erectum ssp. stoloniferum*
	Broad-leaved Arrowhead	*Sagittaria latifolia*
	Common Sedge	*Carex densa*
	Common Water Plantain	*Alisma plantago-aquatica*
	Ditch-carrot	*Oenanthe sarmentosa*
	Pondweed	*Potamogeton sp.*
	Soft-stem Tule	*Scirpus tabernaemontani*
	Water hemlock	*Cicuta douglasii*
Salt Marsh	**Herbaceous Plants**	
	Alkali Heath	*Frankenia salina*
	Priairie Bulrush	*Scirpus maritimus*
	Marsh Grindelia	*Grindelia hirsutula*
	Fleshy Jaumea	*Jaumea carnosa*
	Pickleweed	*Salicornia virginica*

Vernal Pools	**Herbaceous Plants**	
	Burke's Goldfields	*Lasthenia burkei*
	Downingia	*Downingia sp.*
	Sebastopol Meadowfoam	*Limnanthes vinculans*
	Semaphore Grass	*Pleuropogon californicus*
	Sonoma Sunshine	*Blennosperma bakeri*
Native Grassland	**Grasses**	
	Beardless Wild Rye	*Leymus triticoides*
	Big Squirreltail	*Elymus multisetus*
	Blue Bunchgrass	*Festuca idahoensis*
	Needlegrass	*Nassella sp.*
	Pacific Blue Grass	*Poa secunda*
	Perennial Ryegrass	*Lolium perenne*
Oak Woodland	**Trees**	
	Black Oak	*Quercus kelloggii*
	Buckeye	*Aesculus californica*
	Oregon Oak	*Quercus garryana*
	Valley Oak	*Quercus lobata*
	Shrubs	
	Cream Bush	*Holodiscus discolor*
	Elderberry	*Sambucus mexicana*
	Hillside Gooseberry	*Ribes californicum*
	Poison Oak	*Toxicodendron diversilobum*
	Snowberry	*Symphoricarpos albus var. laevigatus*
Oak Savannah	**Trees**	
	Buckeye	*Aesculus californica*
	Coast Live Oak	*Quercus agrifolia*
	Valley Oak	*Quercus lobata*
	Understory	
	Blue Bunchgrass	*Festuca idahoensis*
	California Fescue	*Festuca californica*
	Needlegrass	*Nassella sp.*
Mixed Evergreen Forest	**Trees**	
	California Bay	*Umbellularia californica*
	California Black Oak	*Quercus kelloggii*
	Canyon Live Oak	*Quercus chrysolepis*

Mixed Evergreen Forest	Coast Live Oak	*Quercus agrifolia*
	Douglas-fir	*Pseudotsuga menziesii*
	Madrone	*Arbutus menziesii*
	Oregon Oak	*Quercus garryana*
	Tanoak	*Lithocarpus densiflorus*
	Understory	
	Creeping Snowberry	*Symphorocarpus mollis*
	Hazelnut	*Corylus cornuta*
	Mountain Dogwood	*Cornus nuttallii*
	Sword Fern	*Polystichum munitum*
Coniferous Forest: Redwood	**Trees**	
	Bigleaf Maple	*Acer macrophyllum*
	Coast Redwood	*Sequoia sempervirens*
	California Bay	*Umbellularia californica*
	Douglas-fir	*Pseudotsuga menziesii*
	Grand Fir	*Abies grandis*
	Tanoak	*Lithocarpus densiflorus*
	Understory	
	Blue Huckleberry	*Vaccinium ovatum*
	California Polypody	*Polypodium californicum*
	Deer Fern	*Blechnum spicant*
	Hazelnut	*Corylus cornuta*
	Salal	*Gaultheria shallon*
	Sword Fern	*Polystichum munitum*
	Thimble Berry	*Rubus parvifolius*
Coniferous Forest: Douglas Fir & Mixed	**Trees**	
	Bigleaf Maple	*Acer macrophyllum*
	Blue Oak	*Quercus douglasii*
	California Bay	*Umbellularia californica*
	Douglas-fir	*Pseudotsuga menziesii*
	Foothill Pine	*Pinus sabiniana*
	Grand Fir	*Abies grandis*
	Ponderosa Pine	*Pinus ponderosa*
	Tanoak	*Lithocarpus densiflorus*
	Sugar Pine	*Pinus lambertiana*
	Shrubs	
	Coffeeberry	*Rhamnus californica*

Coniferous Forest: Douglas Fir & Mixed	Hazelnut	*Corylus cornuta*
	Mountain Dogwood	*Cornus nuttallii*
	Snowberry	*Symphorocarpus mollis*
Chaparral	Chamise	*Adenostema fasciculatum*
	Chaparral Pea	*Pickeringia montana*
	California Coffeeberry	*Rhamnus californica*
	Ceanothus	*Ceanothus spp.*
	Knobcone Pine	*Pinus attenuate*
	Manzanita	*Arctostaphylos spp.*
	Mountain Mahogany	*Cercocarpus betuloides*
	Scrub Oak	*Quercus berberidifolia*
	Toyon	*Heteromeles arbutifolia*
Coastal Scrub	California Coffeeberry	*Rhamnus californica*
	California Figwort	*Scrophularia californica*
	Coast Buckwheat	*Eriogonum latifolium*
	Cow Parsnip	*Heracleum lanatum*
	Coyote Brush	*Baccharis pilularis*
	Live Forever	*Dudleya farinose*
	Wax Myrtle	*Myrica californica*
	Yellow Bush Lupine	*Lupinus arboreus*
Coastal Terracee/ Prairie	**Native**	
	California Fescue	*Festuca californica*
	California Oatgrass	*Danthonia californica*
	Pacific Hair Grass	*Deschampsia cespitosa ssp. holciformis*
	Pacific Reed Grass	*Calamagrostis nutkaensis*
	Red Fescue	*Festuca rubra*
	Non-Native	
	Foxtail Fescue	*Vulpia myuros*
	Little Quaking Grass	*Briza minor*
	Six-weeks Fescue	*Vulpia bromoides*
	Soft Chess	*Bromus hordeaceus*

Serpentine	Baker's Manzanita	*Arctostaphylos bakeri*
	Chamise	*Adenostema fasciculatum*
	Foothill Pine	*Pinus sabiniana*
	Knobcone Pine	*Pinus attenuate*
	Leather oak	*Quercus durata*
	Musk Bush	*Ceanothus jepsonii*
	Sargent Cypress	*Cupressus sargentii*
	Toyon	*Heteromeles arbutifolia*
	Yerba Santa	*Eriodictyon californicum*

Table 7: Common Invasive Plant and Animal Species

Latin Name	Common Name or Description	Habitat Notes
Ludwigia sp	Prolific marsh plant	Riparian and wetland
Arundo donax	Arundo	Riparian and wetland
Lepidium latifolium	Mustard-like pepperweed	Occurs across aquatic and terrestrial habitats
Vinca major	Periwinkle	Occurs across aquatic and terrestrial habitats
Centaurea solstitialis	Yellow starthistle	Occurs widely, especially disturbed areas and grassland
Taeniatherum caput	Medusa head grass	Grassland and savannah
Lolium perenne spp.	Italian rye grass	Grassland and savannah
Festuca spp.	Fescue	Grassland and savannah
Cytisus scoparius	Scotch broom	Grassland and savannah
Genista monspessulana	French broom	Grassland and savannah
Felis cattus	Domestic cat	Occurs across terrestrial habitats
Canis familiaris	Domestic dog	Occurs across terrestrial habitats
Sus scrofa	Feral pig	Occurs across terrestrial habitats
Didelphis virginiana	Opossum	Occurs across terrestrial habitats
Meleagris gallopavo	Turkey	Occurs across terrestrial habitats
Rana catesbeiana	Bullfrog	Aquatic habitats
Procambarus spp.	Crawfish	Aquatic habitats
Gambusia affinis	Mosquitofish	Aquatic habitats
Micropterus dolomieu	Smallmouth bass	Aquatic habitats
Micropterus salmoides	Largemouth bass	Aquatic habitats
Lepomis macrochirus	Bluegill	Aquatic habitats
Lepomis cyanellus	Green-eared sunfish	Aquatic habitats
Ameiurus catus and A. nebulosis	Catfishes	Aquatic habitats

Appendix E: Aligned Goals of Biodiversity Action Plan and the Sonoma County General Plan 2020

Table 8: Aligned Goals of Biodiveristy Action Plan and the Sonoma County General Plan 2020

Biodiversity Action Plan	Sonoma County General Plan 2020
Inventory and use existing resources (e.g., Bay Area Uplands Habitat Goals)	OSRC-7e, 7j
Consult local experts to further define priority areas based on expert opinion	OSRC-7e
Conduct formal analysis (e.g., species and habitat distribution maps including climate change)	OSRC-7e
Identify current level of habitat connectivity	OSRC-7h, 7l
Create conservation GIS to identify areas for conservation action	OSRC-7i, 7j
Use data that is detailed and frequent surveys to track rates of change in species, communities, and processes	
Create a comprehensive vegetation map	
Inventory existing monitoring projects in the county	
Develop an overarching monitoring framework to define what to monitor, at what scale, and at what frequency	OSRC-7e
Support data sharing and decrease duplication by coordination and utilizing existing resources (e.g. San Francisco Bay Area Conservation Commons, California Avian Data Center)	
Implement monitoring program at recommended intervals and scales	
Improve knowledge of historic ecological conditions	
Cost-benefit analyses of restoration and development projects to incorporate ecosystem services in project planning	
Conduct climate change vulnerability analysis for species and ecosystems	OSRC-7h, 8l
Define targets and timeframe(s) for achieving them (e.g., acreage by habitat, species, species groups, connectivity, etc.).	OSRC-7e
Use existing resources (e.g., San Francisco Bay Joint Venture Implementation Plan, Upland Habitat Goals)	OSRC-7e, 7j
Develop a short document and/or website that describes the targets	
Develop systematic conservation plan based explicitly on biodiversity	

Develop a local scale "Marxan-like" tool for reserve planning would be an essential tool for improved land management	
Continue to protect land via acquisitions and easements	OSRC-7f, 7r, 7u
Carefully target acquisitions to maximize ecological value given limited financial resources	
Promote conservation on private lands	OSRC-7c
Maintain and protect corridors	OSRC-8f, 8h
Promote effective economic incentives for land owners	OSRC-8g
Protect agriculture and working landscapes as an inextricable components of biodiversity	
Encourage voluntary stewardship	OSRC-7l, 7p
Encourage and conduct research on private lands to complement research on public lands	OSRC-7e, 8k
Promote wildlife friendly fencing	OSRC-7d
Establish a road mortality task force	
Protect streams, wetlands, and riparian areas in order to safeguard future water quality and quantity	
Require water supply and treatment projects to provide mulitple benefits	
Integrate ground water management with stormwater management	
Increase water use efficiency and increase the re-use of water at all scales	
Support agricultural Best Mangement Practices	
Develop conservation focused economic incentives	
Develop and implement ecosystem-specific management plans	OSRC-7l, 7q, 7r, 7s, 7t, 7u,8f, 8k
Track integration of biodiversity with the Sonoma County General Plan 2020	
Support development of K-12 curricula related to biodiversity	
Promote high school service learning opportunities	
Facilitate partnerships between resource agencies and managers and colleges and universities	
Encourage young people to choose careers in conservation-related fields.	

Facilitate public access to the reserve network
Contact stewardship groups
Publicize this action plan
Create and disseminate of outreach materials
Highlight the effect of biodiversity on quality of life, safety, livelihood, and pocketbook for Sonoma County residents

Appendix F: interviewed Experts

Table 9: Interviewed Experts

Name	Affiliation	Area of Expertise	Email
Steve Barnhardt	Pepperwood Preserve	Ecology, education	sbarnhart@santarosa.edu
Peter Baye		Coastal plant ecology, geomorphology	baye@earthlink.net
Alistair Bleifuss	Public Works Department, City of Santa Rosa	Environmental Specialist	ableifuss@srcity.org
Caroline Christian	Sonoma State University	Ecology and conservation research	christian@sonoma.edu
Dave Cook	Sonoma County Water Agency	Endangered species, habitat restoration	dcook@scwa.ca.gov
Gene Cooley	California Dept. Fish & Game	Botany, invasives	gcooley@dfg.ca.gov
Caitlin Cornwall	Sonoma Ecology Center	Conservation planning	caitlin@sonomaecologycenter.org
Deanne DiPietro	Sonoma Ecology Center	Invasive species, mapping	deanne@sonomaecologycenter.org
Wendy Eliot	Sonoma Land Trust	Conservation planning	wendy@sonomalandtrust.org
Sheri Emerson	City of Santa Rosa, Sonoma County Agriculture and Open Space District	Habitat management and restoration	semerso2@sonoma-county.org
Karen Gaffney	Sonoma County Agriculture and Open Space District, West Coast Watershed	Watershed ecology	kgaffney@westcoastwatershed.org
Emily Heaton	University of California at Berkeley	Vineyards and birds	eheaton@nature.berkeley.edu
Andrew Jensen	State Water Quality Control Board	Environmental science	ajensen@waterboards.ca.gov
Curtis Kendall	Audubon California Mayacamas Mountains Sanctuary	Habitat management and restoration	ckendall@audubon.org

Chris Kjeldsen	Sonoma State University Emeritus		Kjeldsen@sonoma.edu
Adina Merenlender	University of California at Berkeley	Ecology, corridors, vineyards	adina@nature.berkeley.edu
Nathan Rank	Sonoma State University	Ecology, population genetics	nathan.rank@sonoma.edu
Christina Sloop	Laguna de Santa Rosa Foundation, San Francisco Bay Area Joint Venture	Ecology	christina@lagunafoundation.org
David Stokes	University of Washington	Conservation biology	dstokes@u.washington.edu
Kasey Wade	Santa Rosa Junior College	Environmental conservation	kwade@santarosa.edu
Richard Walker	CAL FIRE	Vegetation ecology, corridors	rich.walker@fire.ca.gov

Appendix G: Protected Land in Sonoma County

Table10: Protected Land in Sonoma County

Agency Name	# of Areas	Unit Area in the County (Acres)
City of Cloverdale	1	33
City of Cotati	5	18
City of Healdsburg	5	14
City of Petaluma	32	1446
City of Rohnert Park	13	100
City of Santa Rosa	72	1907
City of Sebastopol	4	37
City of Sonoma	10	32
Town of Windsor	15	102
City Subtotal	**157**	**3689**
County of Sonoma County Regional Parks Dept.	45	7048
County Subtotal	**45**	**7048**
United States Army Corps of Engineers	1	5955
United States Bureau of Land Management	4	7676
United States Fish and Wildlife Service	1	791
Federal Subtotal	**6**	**14422**
Audubon Canyon Ranch	1	527
California Academy of Sciences	1	2848
California Native Plant Society	1	1.57
Land Trust of Napa County	2	1298
Marin Audubon Society	1	10
Sonoma Land Trust	15	5667
The Nature Conservancy	1	641
Non-Profit Subtotal	**22**	**10993**
Sonoma County Agricultural Preservation and Open Space District	31	6051
Sonoma County Water Agency	3	2792
Special District Subtotal	**34**	**8843**
California Department of Fish and Game	14	13654
California Department of Parks and Recreation	19	35413
California State Coastal Conservancy	2	330
California State Lands Commission	1	1056
California State University Sonoma	1	213
University of California	1	247
State Subtotal	**38**	**50913**
Total	**301**	**95906**

Appendix H: Sonoma County Stakeholder Organizations

Table 11: Sonma County Stakeholder Organizations

Sonoma County Stakeholders	website
Atascadero Green Valley Watershed Council	www.atascaderogreenvalleywatershed.net
Audubon Canyon Ranch	www.egret.org
Audubon Society - Madrone Chapter	www.audubon.sonoma.net
Bay Area Early Detection Network	www.baedn.org
Bay Area Open Space Council	www.openspacecouncil.org
Bay Institute	www.bay.org
Blutcher Creek Watershed Council	www.bluchercreek.org
Calflora Database	www.calflora.org
California Association of Winegrape Growers	www.cawg.org
California Department of Fish and Game	www.dfg.gov
California Department of Food and Agriculture	www.cdfa.ca.gov
California Invasive Plant Council	www.cal-ipc.org
California Native Plant Society	www.cnps.org
California Native Plant Society - Milo Baker Chapter	www.cnpsmb.org
California State Coastal Conservancy	www.scc.ca.gov
California State Parks	www.parks.ca.gov
City of Cotati	www.ci.cotati.ca.us
City of Petaluma	www.cityofpetaluma.net
City of Rohnert Park	www.ci.rohnert-park.ca.us
City of Santa Rosa	www.ci.santa-rosa.ca.us
City of Sebastopol	www.ci.sebastopol.ca.us
City of Sonoma	www.sonomacity.org
Climate Protection Campaign	www.climateprotectioncampaign.org
Colgan Creek Watershed Group	www.ci.santa-rosa.ca.us
Community Clean Water Institute	www.ccwi.org
Community Foundation of Sonoma County	www.sonomacf.org
Cotati Creek Critters	www.cotaticreekcritters.info
County of Sonoma	www.sonoma-county.org
Federated Indians of the Graton Rancheria	www.gratonrancheria.com

Friends of Copeland Creek	www.students.sonoma.edu/clubs/focc/FOCC1.htm
Friends of Mark West Creek	www.markwestwatershed.org
Friends of the Petaluma River	www.friendsofthepetalumariver.org
Goldridge Resource Conservation District	www.goldridgrcd.org
Laguna de Santa Rosa Foundation	www.lagunafoundation.org
LandPaths	www.landpaths.org
Marin/Sonoma Weed Management Area	www.marinsonomaweedmanagement.org
Marin-Sonoma Mosquito and Vector Control District	www.msmosquito.com
National Marine Fisharies Service	www.nmfs.noaa.gov
National Oceanic and Atmospheric Administration	www.noaa.gov
National Resource Conservation District	www.nrcs.usda.gov
North Bay Climate Adaptation Initiative	www.nbcai.com
North Coast Regional Water Quality Control Board	www.swrcb.ca.gov/northcoast
Occidental Arts and Ecology Center	www.oaec.org
Pepperwood Preserve	www.pepperwoodpreserve.org
PRBO Conservation Science	www.prbo.org
Rohnert Park and Cotati Creeks Council	
Roseland Creek Watershed Group	www.ci.santa-rosa.ca.us
Russian River Watershed Council	www.rrwc.net
San Francisco Bay Joint Venture	www.sfbayjv.org
San Francisco Estuary Institute	www.sfei.org
Sebastopol Water Information Group	www.owlfoundation.net/swig
Sonoma County Agricultural Preservation and Open Space District	www.sonomaopenspace.org
Sonoma County Farm Bureau	www.sonomacountyfarmbureau.com
Sonoma County Water Agency	www.scwa.ca.gov
Sonoma County Water Coalition	www.scwatercoalition.org
Sonoma Ecology Center	www.sonomaecologycenter.org
Sonoma Land Trust	www.sonomalandtrust.org

Sotoyome Resource Conservation District	www.sotoyomercd.org
Southern Sonoma County Resource Conservation District	www.sscrcd.org
Santa Rosa Junior College	www.santarosa.edu
Sonoma State University	www.sonoma.edu
The Center for Social and Environmental Stewardship	www.cfses.org
The Nature Conservancy	www.nature.org
Town of Windsor	www.ci.windsor.ca.us
United States Department of Agriculture - Agriculture Resource Service	www.nal.usda.gov
Upland Habitat Goals	www.uplandhabitatgoals.org
West Coast Watershed	www.westcoastwatershed.com
West County Watershed Network	www.emeraldfoundation.ca
Western United Dairymen	www.westernuniteddairymen.com
Wildlife Conservation Board	www.wcb.ca.gov
West Coast Watershed	www.westcoastwatershed.com
West County Watershed Network	www.emeraldfoundation.ca
Western United Dairymen	www.westernuniteddairymen.com
Wildlife Conservation Board	www.wcb.ca.gov