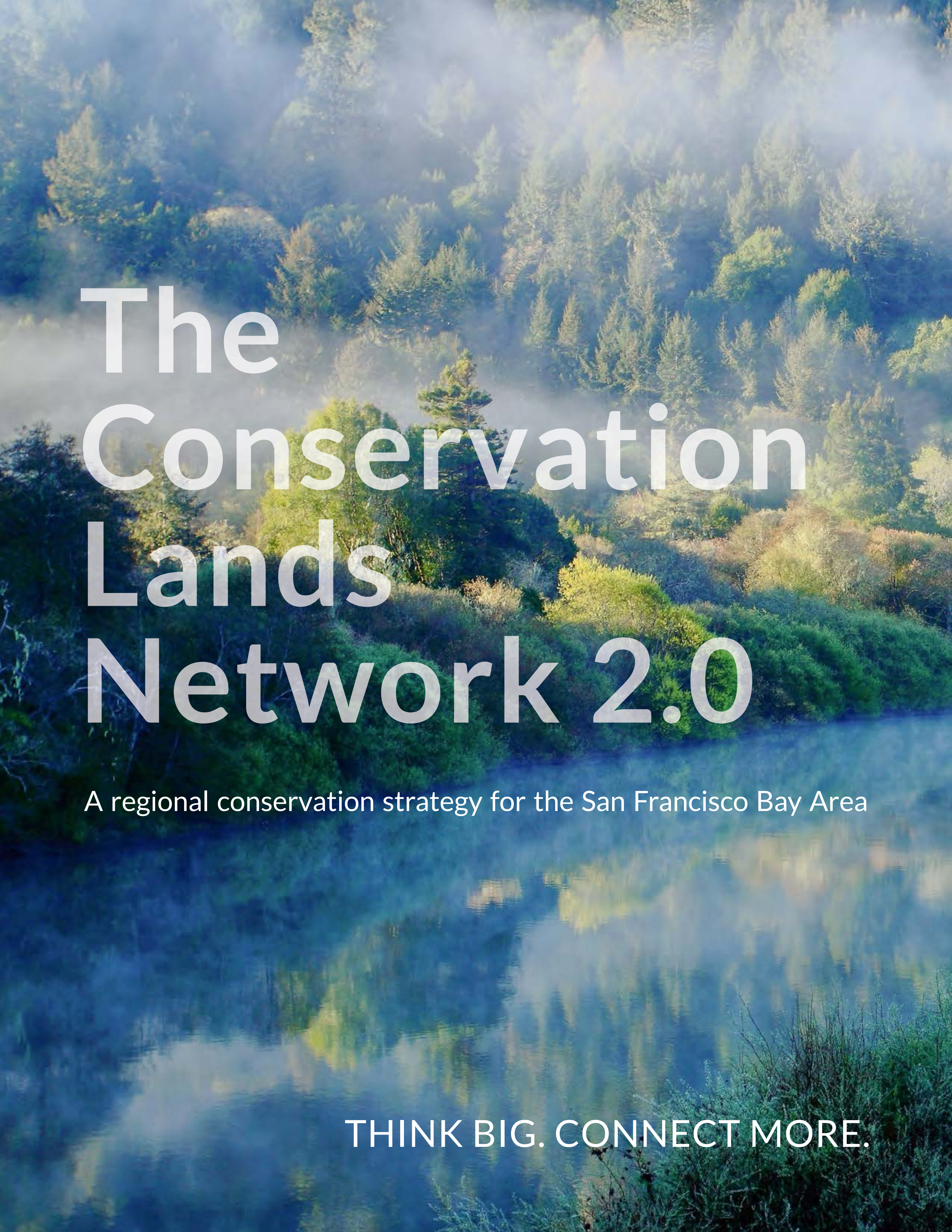

The Conservation Lands Network 2.0

A regional conservation strategy for the San Francisco Bay Area

THINK BIG. CONNECT MORE.

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Additional Copies and More Information

This report, the original Conservation Lands Network 1.0 Project Report, the Conservation Lands Network Explorer, and other conservation tools and information are available at www.bayarealands.org.

BAY AREA
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COUNCIL

The Bay Area Open Space Council is a collaborative of member organizations actively involved in permanently protecting and stewarding important parks, trails and working lands in the ten-county San Francisco Bay Area.

openspacecouncil.org

Front: Lower Russian River.
Photo by Corby Hines.

Back: California quail.
Photo by Steve Rottenborn.

Preface

This report is the result of a multi-year interdisciplinary team effort of the Upland Habitat Goals project to develop the second iteration of the Conservation Lands Network, initially launched in 2011. The report itself describes the goals and overall approach, as well as key updates to the underlying data and the resulting network.

As the project itself is based upon the original Conservation Lands Network (CLN), this report builds on the report from the CLN 1.0 (Bay Area Open Space Council 2011). Readers new to this project will want to refer to that report for a detailed description of the approach and methodology, interpreting the network, additional resources, and more.

The report not only documents the scientific approach used to develop the Conservation Lands Network, it describes the assumptions, decisions, and recommendations of the CLN team. It will help users of the network data, the interactive Explorer tool, the Conservation Portfolio Report, and other resources at BayAreaLands.org understand the basis of these tools and recommendations, and find both guidance and inspiration.

Funders

The Conservation Lands Network would not have been possible without the generous support and guidance of the Gordon and Betty Moore Foundation and the California State Coastal Conservancy, and significant time and expertise contributions from over 100 practitioners and experts from around the Bay Area. We wish to express our deepest gratitude to all of our partners.

Funding for the Conservation Lands Network 2.0 Science Expansion project was provided by:

- **California State Coastal Conservancy**
- **Gordon and Betty Moore Foundation**
- **The members and supporters of the Bay Area Open Space Council**

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Tidy Tips at Coyote Ridge, Santa Clara County. Photo by Cait Hutnik.

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Stewardship teams planting at Mt. Umunhum. Photo by Lech Naumovich.

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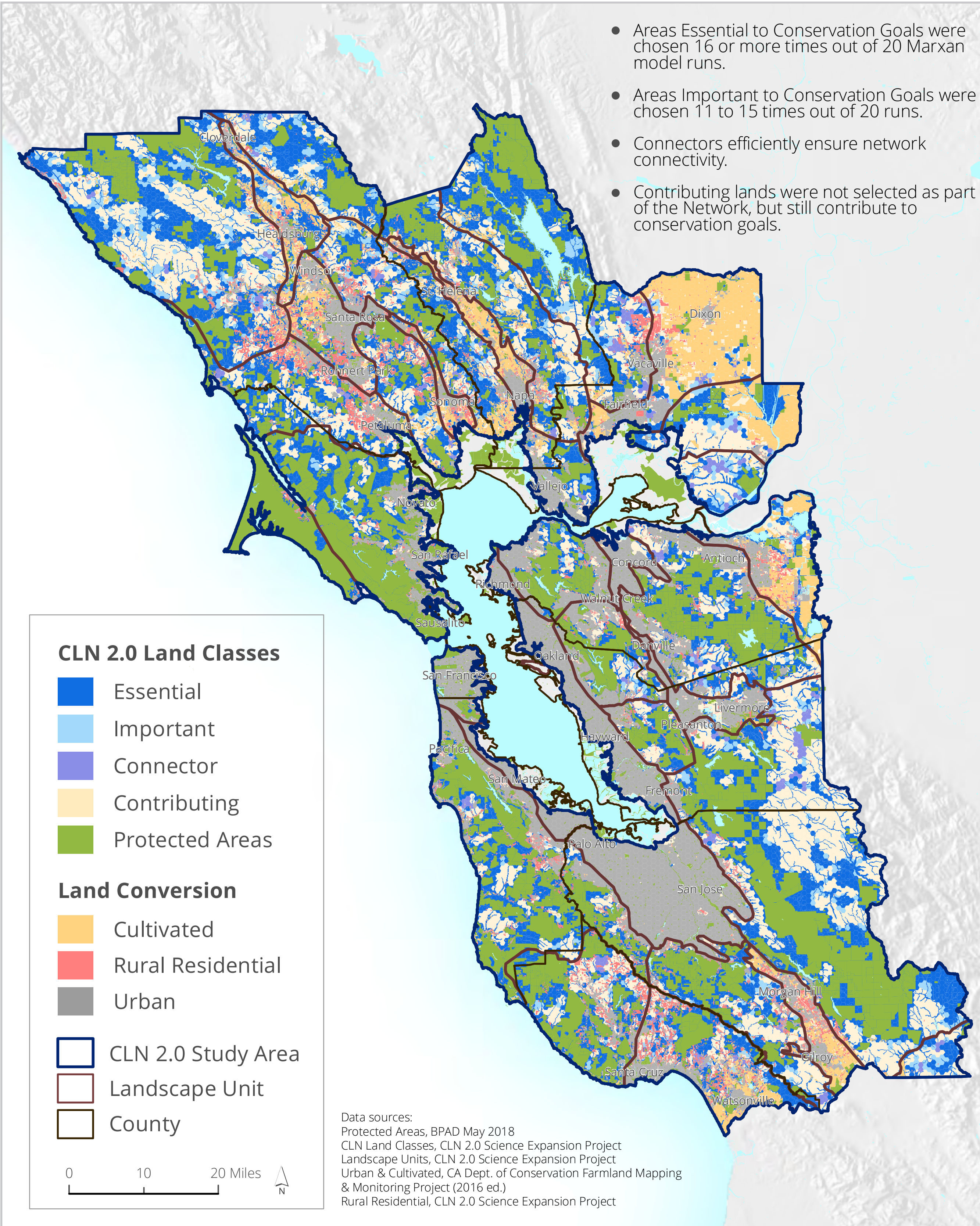
A special thank you to **GreenInfo Network** for their support building the website, developing the CLN Explorer, and providing invaluable guidance.

The project team would also like to thank Katherine Dudney, Annie Burke, Suzanne Beahrs, Matt Gerhart, Matt Freeman, and Anne Crealock for their invaluable input and assistance, and the many photographers who generously shared their images, helping to tell the story of Bay Area conservation.

Purisima Creek, San Mateo County. Photo by Teddy Miller.

Figure A ■ **Map of the Conservation Lands Network 2.0, a regional vision for land and habitat conservation in the Bay Area.**
A high-resolution, zoomable version of this map is available at BayAreaLands.org.



Executive Summary

The stunning and unique landscapes of the Bay Area support an internationally recognized diversity of habitats, flora, and fauna. Magnificent redwood forests, oak grasslands dotted with native wildflowers, vast hillside and valley rangelands, riparian stream valleys, and more provide habitat for myriad native and endemic plants and animals. These lands also provide critical ecosystem services that support the entire region with clean air and water, reduced flood risk, and unparalleled recreational opportunities.

The Conservation Lands Network, launched in 2011, is the science-based guide for achieving the Bay Area Open Space Council's Upland Habitat Goals. It guides future conservation efforts throughout the region by identifying strategic investments in land acquisition and stewardship and focusing conservation actions toward priority areas that contain a comprehensive representation of the region's biodiversity, including habitats that are particularly rare or that support ecological resilience.

The Conservation Lands Network 2.0 is our regional conservation strategy. It shows a path toward preservation of a full complement of Bay Area habitat types. This diversity — including wildlife corridors, habitat connectivity, rangelands, riparian areas, and interconnections with the baylands — will give human and natural communities the best chance of persisting — even thriving — in the face of climate change.

The Conservation Lands Network is the upland habitat companion to the Subtidal and the Baylands Habitat Goals projects. With leadership and support from the Bay Program of the California State Coastal Conservancy, these three frameworks together plot a course for conserving the Bay Area's ecosystems. With the completion of Conservation Lands Network 2.0, all three frameworks include recommendations for adapting to and mitigating climate change. Elements in the Conservation Lands Network 2.0, including new watershed and riparian habitat data, strengthen the planning connections between upland, bayland, and subtidal habitats.

Fortunately, the region's history of successful conservation efforts has already protected from destruction some 1.4 million acres across the Bay Area — the nine counties that touch the San Francisco Bay plus Santa Cruz County. This includes more than 140,000 acres protected since the launch of the Conservation Lands Network. These 1.4 million acres represent iconic landscapes such as the coast's prairies and redwood forests and inland oak woodlands and serpentine grasslands. All of these successes accomplish habitat conservation goals set by the Conservation Lands Network in some way.

The Conservation Lands Network 2.0 is the result of a team of experts measuring conservation successes, assessing new information, and setting new goals for the future. It sets forth a bold vision for strategically protecting a total of 2.5 million acres, or approximately half of the Bay Area, in order to maintain the ecological functions necessary for life in the region.

Tule Elk at Tomales Point, Marin County. Photo by Bob Gunderson.

The goals are big, and they are achievable. The updated Conservation Lands Network was created around five regional conservation goals for the 10-county Bay Area, an area of nearly 5 million acres. An updated set of 2,035 unique habitat and species conservation targets provided specific goals representative of the region's biodiversity.

Based on updated land use data and a new protected areas gap analysis, the Conservation Lands Network 2.0 lays out a blueprint for conserving a 2.5 million-acre connected network of priority creeks, forests, woodlands, grasslands, and chaparral. The project's original goal of 2 million acres has been increased to 2.5 million acres, reflecting the addition of Santa Cruz County to the study area and calls for conserving half the Bay Area's land resources. The target date has been moved from 2030 to 2050, the year by which some effects of climate change are expected to be irreversible and significant. The Bay Area's innovative park and trail agencies and land and water conservation organizations have created a system of conserved parks, preserves, watersheds, and working farms and ranches totaling 1.4 million acres. By continuing to work strategically toward the same goals, including engaging local and regional land use planning agencies, the region can achieve 2.5 million conserved acres by 2050.

Goals of the Conservation Lands Network 2.0

1. **Conserve 2.5 million acres of priority lands by the year 2050.**
2. **Conserve rare, diverse, and irreplaceable landscapes, and manage them for health and resilience.**
3. **Conserve core habitats and the lands that connect them, and manage them for permeability, health, and resilience.**
4. **Conserve a regional network of streams, wetlands, ponds, seeps, and associated riparian and upland areas, and manage for health and resilience.**
5. **Steward all lands to maintain ecological and hydrological processes that support ecosystem function and resilience.**

The CLN 2.0 includes new, updated, and relevant information that will help us meet those goals strategically. This update has incorporated the importance of habitat connectivity and corridors, both for wildlife movement and to provide resilience in the face of climate change. In addition to assessing the inextricable relationships between upland habitats and intertidal and aquatic ecosystems, the network also incorporates an understanding of the conservation values of private rangelands and forestland.

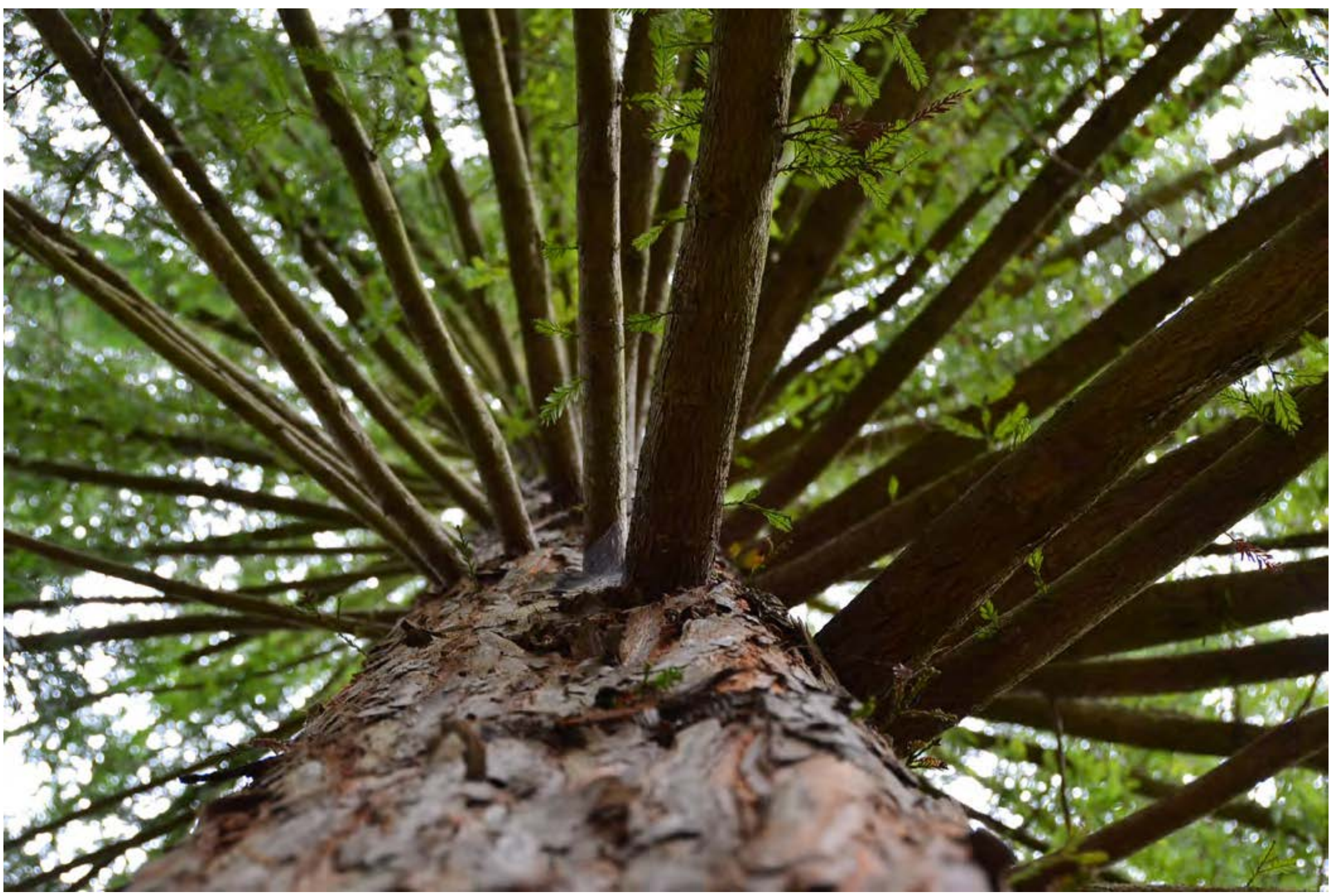
Stewardship is crucial. Reaching these goals will require more than the conservation of an additional 1.1 million acres through fee title or conservation easement acquisition. The Conservation Lands Network also recognizes the enormous and increasing role land stewardship will play in our conservation future. The modified landscapes of the Bay Area require management in order to function for biodiversity. Equally important is continuing the work of park agencies, reserves, not-for-profit organizations, and many others to foster the land stewardship ethic that exists in the Bay Area. A healthy ecosystem depends on a connection to the land by all people who live here.

As the Bay Area's human population expands and development pressure grows, there is an opportunity to advocate for the inclusion of natural and working lands in the balance of planning for future housing and other development, and work together to take care of the surrounding lands that sustain the Bay Area for all of us.

This is a collective effort. The Conservation Lands Network 2.0 team includes some 100 scientists and other experts and conservation professionals. This team has aggregated and analyzed new scientific data on species occurrences and distributions, threats posed by climate change and the ability of plants, animals, and habitats to adapt, and calls for action. It will take an even broader collective effort to implement these strategies and reach our goals, and public and private landowners all have roles to play.

The Conservation Lands Network offers a suite of tools for decisionmaking. It is an actionable guide for future conservation investments, urban planning strategies, and much more. These tools and more are all available at BayAreaLands.org:

- An interactive map (the Conservation Lands Network Explorer) and custom reporting tool (Conservation Portfolio Report)
- Downloadable maps and datasets
- Progress Dashboard of regional conservation goals



Coast redwood in Redwood Regional Park, Contra Costa County. Photo by Annie Burke.

Key terms

For definitions of other terms used here and elsewhere in the Conservation Lands Network, see the glossary in the CLN 1.0 report (BAOSC 2011).

Bay Area
For the purposes of the Upland Habitat Goals Conservation Lands Network, the Bay Area includes ten counties: the nine that touch the San Francisco Bay, along with Santa Cruz County.

Conservation Lands Network (CLN)
The configuration of Bay Area habitats and linkages needed to meet the goals for biodiversity conservation. This includes lands already protected as well as those proposed for conservation; it is a guide and not a list of priority properties. The Conservation Lands Network is best explored through the maps and CLN Explorer tool available at BayAreaLands.org.

Conserved or Protected Areas
Natural and working lands permanently protected by fee title ownership or conservation easement preventing conversion to uses incompatible with biodiversity conservation. These lands are tracked in the Bay Area Protected Areas Database, BPAD. Also called existing protected lands.

Irreplaceability
The relative importance of certain areas being included in the CLN in order to meet all the habitat and species conservation target goals.

Landscape Resilience
The ability of a landscape to sustain desired ecological functions, robust native biodiversity, and critical landscape processes over time, under changing conditions, and despite multiple stressors and uncertainties (from Beller *et al.* 2018).

The 'Landscape Resilience' dataset provided by The Nature Conservancy and available in the CLN 2.0 Explorer is an index that indicates the presence and accessibility of microhabitat options by quantifying both the permeability of the landscape and the diversity in potential "wetness" and "heat" based on topography.

Marxan
Conservation planning software designed to assist in developing a near-optimal spatial reserve design that achieves specified biodiversity representation goals. Marxan was developed at the University of Queensland and can be downloaded at no cost at www.uq.edu.au/marxan.

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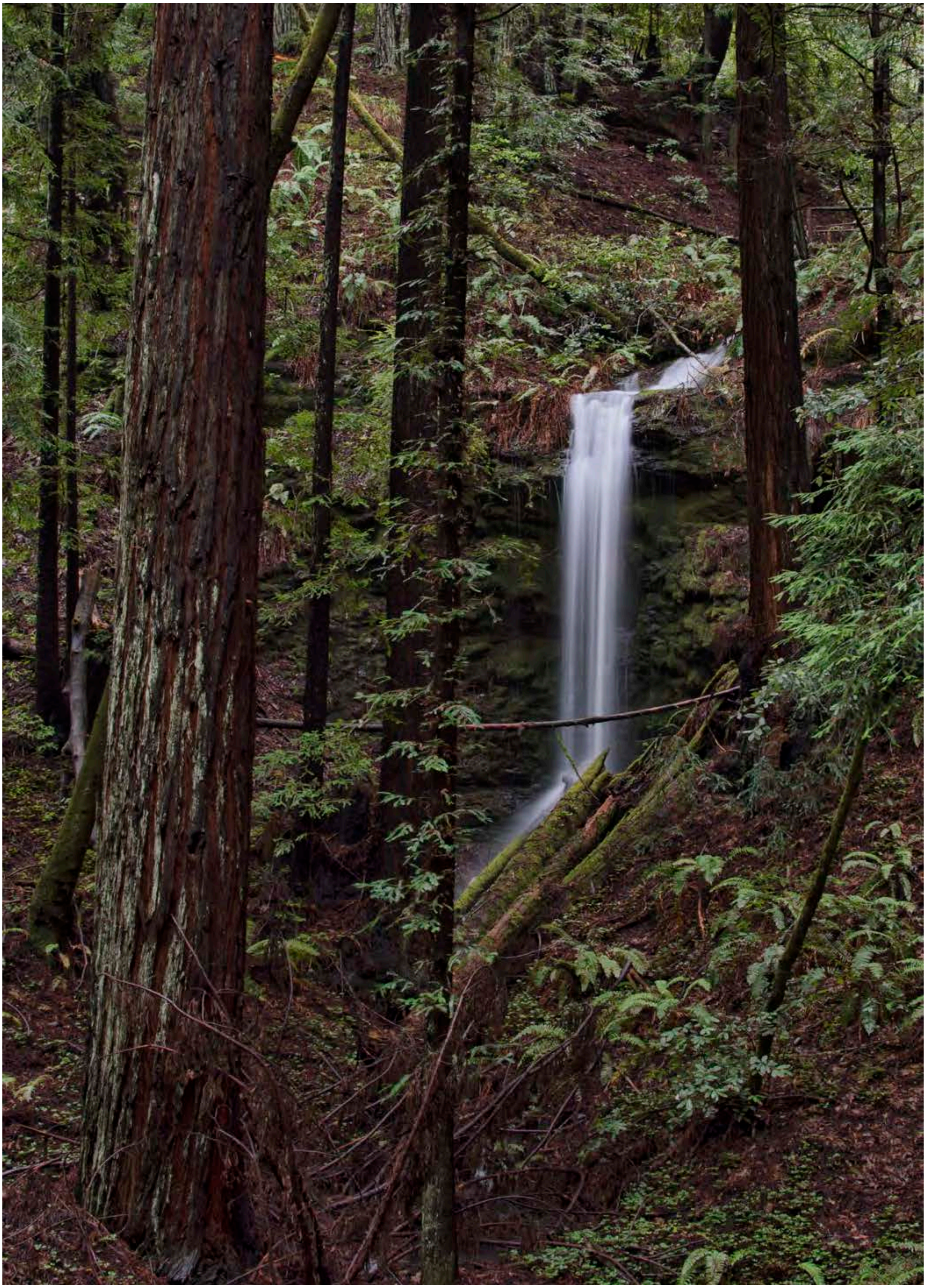
Figures



Waterfall into Gazos Creek in the Santa Cruz Mountains. Photo by Teddy Miller.

CHAPTER

1 Introduction

Fog over Pepperwood Preserve, Sonoma County. Photo by Stuart Weiss.

The San Francisco Bay Area is fortunate to still have iconic species like mountain lion, bobcat, Golden Eagle, and steelhead trout. Indeed, most species that represent the region's former biological richness still survive. This is due in large part to the amount of habitat remaining — only some of which has been permanently conserved. One has only to look at the long list of Bay Area threatened and endangered species to know that, for those species, the remaining open space is just barely enough. All species will face even greater pressures in the future.

Bold action is needed to conserve the unique natural landscapes and the rich biodiversity that surround and exist within communities in the San Francisco Bay Area. These areas form the region's life support system by purifying, storing, and conveying water, producing food, sequestering carbon, and so much more. The healthier and more connected these natural areas remain, the better able they

Sierran Chorus Frog at Anderson Lake County Park. Photo by Steve Rottenborn.

will be to provide life-giving benefits to people and wildlife while withstanding the effects of population increases and climate change in the coming decades (Chan *et al.* 2006).

Earth is in the midst of a biodiversity crisis, referred to as the "sixth extinction" (Kolbert 2014), as species and ecosystems suffer from accelerating human alterations of the environment. Habitat destruction, climate change, pollution, invasive species, and complex interactions among these and other factors threaten the extinction of one million or more species in coming decades, recently documented by the International Panel on Biodiversity and Ecosystem Services (IBPES 2019, Hoekstra *et al.* 2005). While the drivers must be addressed at a global scale, most actual conservation actions are inherently local. The Bay Area can lead the charge in stemming the global extinction crisis, and the Conservation Lands Network is our collective strategy to respond to this crisis.

Conservation requires work at a regional scale. Because species, habitats, water, and natural processes do not adhere to county or other administrative boundaries, conservation efforts must consider the entire Bay Area landscape. This regional view is also a tool to strategically link the work of the 65+ land conservation and management organizations working in the Bay Area, and to demonstrate the potential of working together to achieve a bold mission. Through the Conservation Lands Network vision, the Bay Area Open Space Council draws together these organizations in a collaborative effort.

Pressures of the human population are immense. The Bay Area population is expected to increase by two million people between 2010 and 2040 (MTC 2017). With current housing needs at crisis level, land will need to be developed to accommodate a growing population and create affordable housing and ancillary infrastructure such as roads and commercial services. Every investment includes tradeoffs between development benefits and nature's benefits. A livable Bay Area has affordable housing for people as well as natural and working lands that provide habitats for wildlife, supply water, produce food, and provide outdoor recreation.

"…given that climate change is likely to cause long-range movements by species, it will become increasingly important to consider the strategic value of individual habitat units or enduring features as part of a larger network within entire ecological regions."

— Schmitz *et al.* 2015

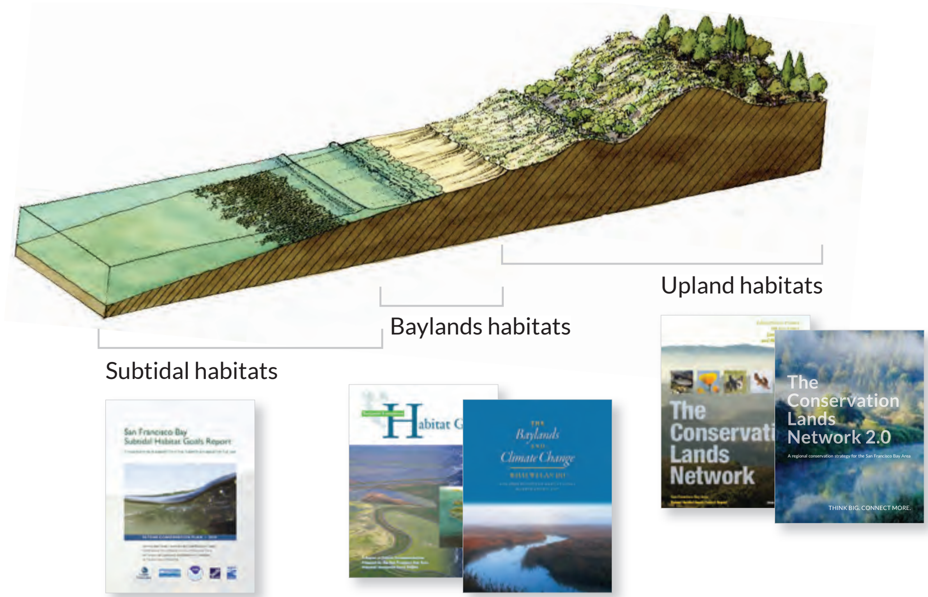
The effects of climate change threaten humans and the natural world alike. Drought, severe storms, extended fire seasons, and sea level rise are already here. A network of intact natural lands surrounding our cities and towns will buffer the effects of climate change and ensure that people, animals, and plants have access to clean water, clean air, and open space.

The Conservation Lands Network 2.0 is our regional land conservation strategy. It is a science-based tool that identifies a network of natural areas and working lands representing a full complement of Bay Area habitat types that protect biodiversity. Permanent protection of these lands will also require thoughtful stewardship that supports natural processes. This diversity, including wildlife corridors, habitat connectivity, rangelands, drinking water source watersheds, riparian areas, and interconnections with our Baylands, will give our human and natural communities the best chance of persisting — even thriving — in the face of climate change.

Subtidal, Baylands, and Uplands Habitats

The Conservation Lands Network is one of a trio of regional studies, each of which focuses on a major biome of the Bay Area (Figure 1.1). These three frameworks support and are supported by the Bay Program of the California State Coastal Conservancy and plot a course for conserving all of the Bay Area's ecosystems.

Figure 1.1 ■ The Three Regional Conservation Goals Projects for the San Francisco Bay Area.



The San Francisco Bay Subtidal Habitat Goals Project, launched in 2010, covers all habitats submerged beneath the water of the Bay. It sets a vision for improving the subtidal ecosystem over the next 50 years through science-based protection and restoration of habitats. See www.sfbaysubtidal.org.

The San Francisco Baylands Ecosystem Habitat Goals Project, launched in 1999, covers the historic tidelands of San Francisco, San Pablo, and Suisun Bays, and aims to restore 100,000 acres of wetlands and related habitats around San Francisco Bay. The Baylands Ecosystem Habitat Goals Science Update 2015 incorporated considerations of climate change and sea level rise. See www.baylandsgoals.org.

The San Francisco Bay Area Upland Habitat Goals Project, launched in 2006, covers the terrestrial habitats of the Bay Area. In 2011, the project produced the Conservation Lands Network 1.0, a data-driven vision and guide for the strategic preservation of priority upland habitats, and in 2014 published a report showing progress made toward specific habitat acreage goals (Progress Report 2014). Released in 2019, the Science Update, Conservation Lands Network 2.0, incorporates new and updated data and sets revised goals. See BayAreaLands.org.

"The CLN provides a clear and compelling vision of a connected and resilient network of protected parks, open spaces, and well-managed working lands. We at the Santa Clara Valley Open Space Authority use the CLN as an essential reference to ensure that we're making smart conservation investments in the areas that matter the most to sustain ecological integrity over the long-term. We and our conservation partners throughout the Bay Area are so fortunate to have the CLN and its related planning tools at our fingertips."

— Matt Freeman,
Santa Clara Valley Open Space Authority

The Conservation Lands Network

Preservation of land at the regional level is necessary to ensure the long-term resilience of the region's diverse species and ecological communities, especially in the face of challenges such as climate change, drought, and population growth. The Conservation Lands Network (CLN) provides the scientific foundation, planning framework, databases, and mapping tools to enable the region's land conservation organizations and planning agencies to identify regional priority areas for conservation.

On a practical level, the CLN is a map of priority areas (Figure A) selected based on a gap analysis that compares existing conserved lands against an inventory of the Bay Area's natural habitats ranked for rarity and ecosystem importance by local ecologists and biologists. The network incorporates a diversity of spatially explicit environmental information, including priority stream corridors, habitat connectivity, and groundwater recharge areas.

The network is a map representing the priority lands that, if protected and well-managed, will support a full representation of the Bay Area's habitats in robust amounts. It is a vision for conserving enough of the types, amounts, and distribution of habitats needed to sustain diverse and healthy ecosystems, including biodiversity, recreation, local water supplies, food production, and climate change mitigation.

The purpose of the CLN is to equip decisionmakers with the data and regional context to make smart conservation investments. It helps answer the question, "what could regional land conservation success look like in the Bay Area?"

"In 2011, the Land Trust of Napa County began the process to update its strategic priorities for land conservation within Napa County. We worked with key advisors from the CLN 1.0 to modify the Bay Area-wide CLN framework with Napa-specific data layers that fine-tuned our biodiversity priorities.

The CLN provided us with transparent conservation values that we could articulate, for the first time, with landowners, with our Board of Trustees and with our conservation partners.

Since our priority update in 2012, we've completed lasting conservation work on over 23,000 acres of high-priority biodiversity lands in the County."

— Lena Pollastro,
Land Trust of Napa County

The Impact of CLN 1.0

With the inception of the Upland Habitat Goals Project in 2006, the process of developing the Conservation Lands Network provided a focus and a forum for the regional conservation community. The CLN provided a framework for documenting and measuring the collective impact of open space agencies and advocacy organizations. The regional approach has encouraged practitioners to look beyond their jurisdictions and areas of direct interest.

The launch of the CLN in 2011 provided a decision support framework for considering the landscape context as well as the ecological resources of conservation opportunities. Two major funders, the Coastal Conservancy and the Gordon and Betty Moore Foundation, require the use of CLN Conservation Portfolio Reports in grant applications. Having a unified platform for assessment of potential conservation projects — particularly those with multiple stakeholders — facilitates collaboration.

Since the launch of BayAreaLands.org in 2011, some 650 individuals have registered on the site to generate custom reports and/or download GIS datasets. The CLN data and geographic framework have contributed to several major scientific papers (*e.g.*, Heller *et al.* 2015) and many conference presentations. College and university teachers have used the CLN to train the next generation of conservationists.

The CLN has also provided a platform for some ambitious science-based conservation planning projects. One notable example is the Terrestrial Biodiversity and Climate Change Consortium, which used the CLN framework to investigate climate change implications for biodiversity. The results provided input data for climate change adaptation studies such as North Bay Climate Ready and California's Fourth Climate Assessment.

CLN 1.0 also inspired local downscaling of the approach and data. County-scaled versions of the CLN have been implemented by the Land Trust of Napa County and the Land Trust of Santa Cruz County. The *Conservation Blueprint for Santa Cruz County* (Mackenzie *et al.* 2011) in turn inspired the incorporation of Santa Cruz County into CLN 2.0.

Finally, the CLN 1.0 Progress Report in 2014 documented the contribution of recent acquisitions and easements to overall habitat and conservation acreage goals. Such explicit assessments are rare in the conservation world.

Bay Checkerspot Butterfly on Coyote Ridge, Santa Clara County. Photo by Stuart Weiss.

Progress Toward Original Goals

The CLN measures progress toward habitat goals by assessing the current protected acreage of coarse-filter conservation targets against specific per-target acreage goals (discussed in greater detail in Chapter 3). Although there are 1,282 individual coarse-filter conservation targets, the targets and their acreage goals can be summed across the study area, providing a useful snapshot for the region. It is important to remember that these regional totals tell only part of the story; they do not reflect the distribution of conserved coarse-filter conservation targets among landscape units, which is the most important scale for measuring habitat goals.

Since the completion of CLN 1.0, 144,000 acres have been permanently conserved (per the 2010 and 2018 editions of the Bay Area Protected Area Database). Progress in protected acreage is shown by county in Figure 1.2, and by vegetation type in Figure 1.3. For comparison purposes, CLN 1.0 vegetation types and goals are used (note that the vegetation map used as the foundation of the CLN was updated between CLN 1.0 and 2.0, resulting in several additional vegetation types, described in Chapter 3). Subsequent progress reports will employ CLN 2.0 vegetation types and acreage goals. Most vegetation types saw conservation increases, some with significant gains toward acreage goals.

Figure 1.2 ■ Conservation Progress by County, 2010 and 2018. Source: Bay Area Protected Areas Database 2010 and 2018 editions.

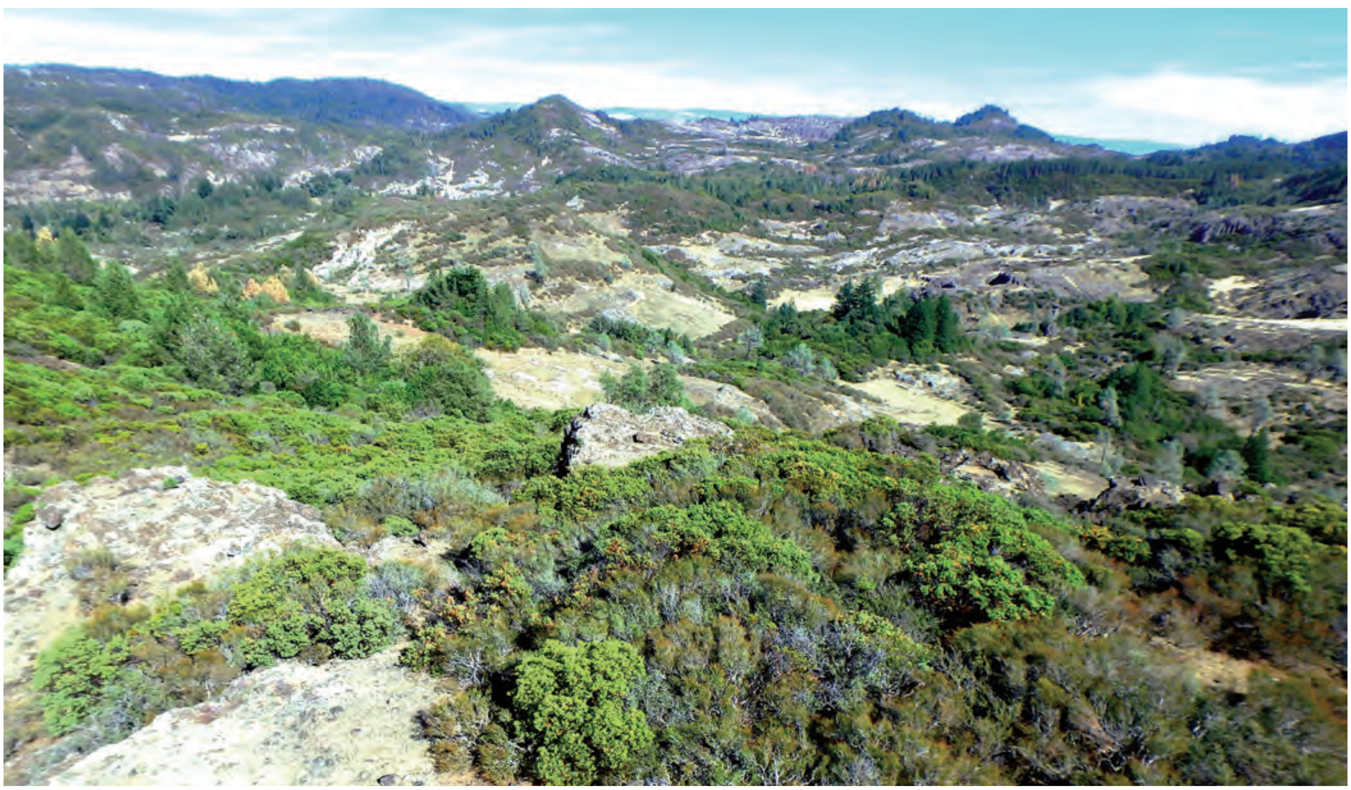
County	Protected acres, 2010	Protected acres, 2018	Acres added between 2010 and 2018
Alameda	117,465	123,530	6,065
Contra Costa	128,303	147,967	19,664
Marin	197,143	201,086	3,943
Napa	141,253	157,021	15,768
San Francisco *	5,717	5,458	0
San Mateo	113,229	121,278	8,049
Santa Clara	239,734	257,596	17,862
Santa Cruz	77,093	90,921	13,829
Solano	62,400	76,470	14,069
Sonoma	172,391	217,387	44,996
Total	**1,254,728**	**1,398,974**	**144,246**

* *The decrease in protected acreage shown for San Francisco County is the result of some small errors in the 2010 BPAD and subsequent data refinements.*

One of the greatest success stories in habitat preservation from 2010 to 2018 has been in the **Ponderosa Pine Forest** vegetation type, with a 22% jump toward its regional conservation goal of approximately 8,600 acres. This was largely the result of the sizeable acquisition of the Montesol Ranch Conservation Easement by the Land Trust of Napa County and Trust for Public Land. Ponderosa pine forests are rare and support multiple target species such as Pileated Woodpecker, western gray squirrel, rubber boa, and others.

Other big gains toward individual vegetation type conservation goals include:

- **Redwood forest** (classified as both Redwood and Redwood - Douglas-Fir) conservation increased by 24,000 acres, reaching 77% of its goal of approximately 154,000 acres protected. Significant contributions came from San Vicente Redwoods (Santa Cruz County) and Buckeye Forest (Sonoma County) acquisitions.
- **Coastal Scrub** conservation increased by 3,600 acres, moving it to 97% of its goal of approximately 71,000 protected acres. Significant contributions came from Pomponio Ranch Conservation Easement and Butano Farms acquisitions (both in San Mateo County).
- **Serpentine Grassland** conservation increased by 1,800 acres, reaching 52% of its goal of approximately 15,000 protected acres. The Coyote Ridge Open Space Preserve acquisition (Santa Clara County) was a significant contribution.



Montesol Ranch, Napa County. Photo courtesy Land Trust of Napa County.

Cool Grasslands in the Sonoma Coast Range. Photo by Stuart Weiss.

Figure 1.3 ■ Conservation Progress by Vegetation Type Between 2010 and 2018. Vegetation types are sorted in descending order by the amount of progress (in acres) toward their respective goals since CLN 1.0, for the ten-county study area. For definitions of vegetation types, see Figure 4.5 in the CLN 1.0 report. Source: Bay Area Protected Areas Database 2010 and 2018 editions.

Vegetation type (CLN 1.0)	Total acres in the CLN 2.0 study area	CLN 1.0 acreage goal	Acres protected as of 2010	Acres protected as of 2018	Change in protected acres, 2010-2018	
					Acres	%
Redwood Forest	295,841	148,130	92,363	113,776	21,413	23
Warm Grasslands	520,890	263,663	131,830	151,223	19,392	15
Moderate Grasslands	149,767	77,273	64,165	78,067	13,901	22
Montane Hardwoods	327,514	169,601	90,190	99,157	8,967	10
Hot Grasslands	269,259	134,629	54,433	63,312	8,879	16
Douglas-Fir Forest	170,510	88,710	68,120	76,848	8,728	13
Coast Live Oak Forest / Woodland	238,890	128,613	96,380	103,986	7,606	8
Tanoak Forest	28,065	25,259	2,044	6,274	4,230	207
Barren / Rock	6,654	5,038	1,378	5,496	4,118	299
Cool Grasslands	76,682	60,632	43,543	47,367	3,824	9
Coastal Scrub	103,320	70,947	64,841	68,477	3,636	6
Blue Oak Forest / Woodland	191,358	98,587	70,637	73,403	2,766	4
Redwood - Douglas-Fir	12,066	6,033	3,176	5,922	2,746	86
Mixed Montane Chaparral	153,444	90,322	46,579	49,317	2,738	6
California Bay Forest	48,913	29,016	27,266	29,207	1,940	7
Ponderosa Pine Forest (Non-Maritime)	11,521	8,646	2,626	4,510	1,883	72
Serpentine Grassland	16,632	14,919	5,992	7,814	1,821	30
Serpentine Leather Oak Chaparral	39,386	31,508	18,195	19,646	1,451	8

Vegetation type (CLN 1.0)	Total acres in the CLN 2.0 study area	CLN 1.0 acreage goal	Acres protected as of 2010	Acres protected as of 2018	Change in protected acres, 2010-2018	
					Acres	%
Knobcone Pine Forest	12,897	9,750	5,478	6,386	908	17
Serpentine Hardwoods	16,863	15,177	5,572	6,234	662	12
Canyon Live Oak Forest	7,154	5,393	1,459	2,035	576	39
Central Coast Riparian Forest	15,301	13,770	5,833	6,381	547	9
Oregon Oak Woodland	37,876	28,649	4,812	5,356	544	11
Black Oak Forest / Woodland	4,193	3,541	333	757	423	127
McNab Cypress	9,677	8,710	5,101	5,486	385	8
Sandhills	5,666	5,099	1,678	2,062	384	23
Permanent Freshwater Marsh	2,568	2,311	593	958	365	62
Serpentine Conifer	8,095	7,285	3,273	3,575	302	9
Bishop Pine Forest	7,224	5,162	3,968	4,244	276	7
Interior Live Oak Forest / Woodland	8,923	6,694	4,639	4,900	261	6
Semi-Desert Scrub / Desert Scrub	45,901	34,440	26,222	26,466	244	1
Mixed Conifer / Pine Forest	430	323	135	329	194	144
Mixed Chaparral	15,139	11,354	3,995	4,183	188	5
Coastal Terrace Prairie	870	783	12	161	149	1,216
Serpentine Barren	1,149	1,034	707	852	145	21
Chamise Chaparral	93,824	58,371	44,672	44,812	140	0
Native Grassland	1,165	1,049	877	1,007	130	15
Valley Oak Forest / Woodland	6,795	6,115	2,729	2,847	118	4
Coastal Salt Marsh / Coastal Brackish Marsh	1,880	1,692	899	953	53	6
Serpentine Scrub	1,026	924	551	591	40	7
Dune	1,087	979	651	690	38	6
Sandhill Parkland	226	204	68	103	35	52
Monterey Pine Forest	2,664	1,615	1,859	1,873	14	1
Sargent Cypress Forest / Woodland	2,955	2,660	2,318	2,329	11	0
Santa Cruz Cypress	209	189	99	106	6	7
Serpentine Knobcone Pine	457	411	238	238	0	0
Serpentine Riparian	135	121	57	57	0	1
Juniper Woodland and Scrub	197	178	197	197	0	0
Coulter Pine Forest	266	239	68	68	0	0
Pygmy Cypress Forest	106	96	106	106	0	0
Monterey Cypress Forest	91	45	53	53	0	0
Grand Fir	216	194	53	53	0	0
Wet Meadows	205	185	46	46	0	0
Sycamore Alluvial Woodland	97	87	68	68	0	0
Blue Oak / Foothill Pine Woodland *	32,516	24,449	12,184	12,052	(132)	(1)
Total	**3,006,757**	**1,710,804**	**1,025,364**	**1,152,412**	**127,048**	**12%**

* *The 2010 version of BPAD mistakenly included a 10,000ac conservation easement reflected here in the 2010 numbers. Subsequent correction of that error caused changes in protected acreage in several vegetation types, including Blue Oak/ Foothill Pine Woodland. Between 2010 and 2018, 1,118 acres of this vegetation type were protected.*

CHAPTER 2

Regional Conservation Goals & Strategic Updates

La Honda Creek Open Space Preserve. Photo by Frances Freyberg.

Overview

In order to take advantage of the latest technology and new developments in land conservation, the Bay Area Open Space Council conducts comprehensive updates of the underlying data and the Conservation Lands Network itself every five to ten years.

The updates with Conservation Lands Network 2.0 will provide guidance for regional conservation and stewardship efforts into the next decade. The Science Expansion was based on five regional conservation goals, several conservation themes, and a focus on stewardship as a necessary component of long-term conservation.

Regional Conservation Goals of the Conservation Lands Network

Conserve 2.5M acres of priority lands:
57% achieved

Goal 1. Conserve 2.5 million acres of priority lands by the year 2050.

The Conservation Lands Network (CLN) 2.0 sets an ambitious goal of conservation of approximately 50% of the Bay Area's terrestrial habitat (approximately 2.5 million acres) by 2050 — the date by which most climate models agree that weather extremes caused by global climate change will sharply increase. Importantly, the network identifies which lands will most effectively protect biodiversity and ecological processes while allowing for climate resilience.

The CLN is a guide to achieve that goal. It offers a regional framework to ensure the ecological function of the nearly 5 million acres that comprise the nine counties touching the San Francisco Bay plus Santa Cruz County — the ten counties that, for the purposes of this report, comprise the Bay Area.

Why 50%?

The idea of conserving half of the landscape for nature has developed over several decades, and now has become mainstream conservation thinking. In the 1980s, conservation goals were on the order of 10-15% of each ecosystem type on a global level. In the 1990s, the Wildlands Project first proposed that half of North America be conserved in a connected network for the sake of megafauna like grizzly bears. The proposal shocked people at the time, but the logic made scientific sense at a biogeographic scale — if one were serious about conserving biodiversity and functioning ecosystems. Large landscape initiatives such as Yellowstone to Yukon grew out of the Wildlands vision.

In 2010, CLN 1.0 proposed basically the same 50% goal — the original 2.0 million acre goal comprised approximately half of the CLN 1.0 study area, which did not include Santa Cruz County. This was based on conservation success to date, a biogeographic analysis, and the realities of designing a coherent representative and connected network of protected lands in a heavily populated region.

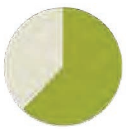
Leading conservation biologist E.O. Wilson proposes that 50% is a good minimum conservation goal, and the E.O. Wilson Foundation's Half-Earth Project calls for this on a global scale. Foundation President and CEO Paula Ehrlich explains, "Half-Earth is E.O. Wilson's call to conserve half our planet's lands and seas in order to safeguard the bulk of biodiversity. Half-Earth was conceived as a moonshot; an inspiring goal that would drive conservation efforts to a new level."

Other groups, including major conservation organizations, have followed this lead; Nature Needs Half is calling for conservation of 50% of the planet by 2030, and the Center for American Progress is calling for 30% by 2030 and 50% by 2050.

Conserve and steward rare and irreplaceable landscapes:
39% achieved

Conserve 90% of Rank 1 habitats:
51% achieved

Conserve 75% of Rank 2 habitats:
62% achieved



Conserve 50% of Rank 3 habitats:
74% achieved

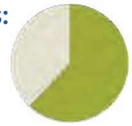
Goal 2. Conserve rare, diverse, and irreplaceable landscapes, and manage them for health and resilience.

Rare habitats are important at many ecological scales. In addition to harboring unique or endemic plant and animal species, rare habitats often play critical roles in the landscape. Ponds, for instance, as sources of water, are disproportionately critical to the functioning of the surrounding habitats. Rare habitats contribute to the diversity of entire ecosystems, and because of their inherent scarcity, are likely to be lost to human land uses. The process of inventorying and prioritizing rare habitats is especially relevant in a biodiversity hotspot such as the Bay Area.

In order to ensure that the most valuable lands of the region are included in the network, the Vegetation Focus Team ranked the rarity of each of the Bay Area habitats at local scales of mountain ranges and valleys. Rare habitats such as the Sandhills in Santa Cruz County, serpentine chaparral in eastern Alameda County, and Sargent cypress of The Cedars in Sonoma County were given high ranks, while more common vegetation types were ranked lower. This helped the project team design a network around the priority conservation of the rarest lands. The network represents an optimized configuration of lands required to meet the 2.5 million acre goal. While all natural land is irreplaceable, an “irreplaceable landscape” has a specific meaning in the CLN context. Irreplaceability refers to the relative importance of certain areas being included in the network in order to meet all the habitat and species conservation target goals.

Sandhills habitat, south ridge of Quail Hollow, Santa Cruz County. This rare habitat is a rank 1 habitat in the Conservation Lands Network 2.0, with a 90% conservation goal. Photo by Jodi McGraw.

Conserve large, contiguous habitat blocks:
62% achieved



Conserve connecting lands (linkages):
31% achieved

Goal 3. Conserve core habitats and the lands that connect them, and manage them for permeability, health, and resilience.

In the Bay Area, where development and infrastructure are intermixed with natural lands, safeguarding a network of connected, permeable core habitats is the best strategy to bolster the ecosystem's ability to adjust to and recover from significant change.

Core habitats are areas that have experienced the least amount of impact from human development within the partially urbanized landscape of the Bay Area. The undeveloped parks, preserves, watershed lands, and working rangelands throughout the Bay Area are core habitat areas. These are contiguous lands where biodiversity-sustaining natural processes — such as primary production, nutrient cycling, and vegetation community succession — are presumed to still be intact and functioning.

The network is composed primarily of core areas. The process to create the network involves selecting high ranking habitat types from core areas first.

Connections (often called "linkages") between core areas are essential; these lands facilitate dispersal of individuals (essential to healthy populations) and access to other suitable habitat. The latter is increasingly critical given shifts in species ranges as a result of climate change. Coyote Valley in Santa Clara County, for instance, connects the core habitat areas of the Santa Cruz Mountains and the Diablo Range to the east. Although the network captures many of these connections, a companion strategy to identify and conserve the largest contiguous habitat blocks and key regional linkages that connect them has been developed (Bay Area Critical Linkages).

The permeability of a landscape reflects the quality of its structure with respect to species movement — habitat connectedness, matrix of land uses, and natural and human-made barriers to movement (Hilty *et al.* 2019). For example, rural residential development, which is most prominent in Sonoma and Santa Cruz counties, is less permeable for species movement than natural landscapes. Figure 3.7 shows landscape connectivity (permeability) in the Bay Area.

Coyote Valley is a key connector between the Santa Cruz Mountains and the Diablo Range, both core habitat areas. Photo by Derek Neumann, Santa Clara Valley Open Space Authority.

Goal 4. Conserve a regional network of streams, wetlands, ponds, seeps, and associated riparian and upland areas, and manage for health and resilience.

Conserve priority 1 and 2 streams:
49% achieved

Conserve natural landcover within stream valleys:
61% achieved

Conserve ponds:
25% achieved

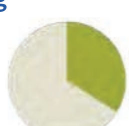
The places in the landscape that harbor water and moisture are engines of biodiversity that tie habitats together through the flows of water. The moisture in these areas also buffers the effects of aridification. In this way, wet areas (including ponds, wetlands, seeps, and riparian zones) can be considered climate change refugia — places that are relatively buffered from climate change over time and that enable persistence of biodiversity (Morelli *et al.* 2017).

Additionally, several climate-stabilizing processes are associated with streams. Stream valleys act as cold air drainages, distributing cool and moist air to cold air pools that support stable refugia (McLaughlin *et al.* 2017). Saturated soil along waterways promotes the growth of forest canopies along streams, which shield stream temperatures from direct sunlight (Lloret *et al.* 2012). Riparian forests and wetlands attenuate storm energy and store flood water (Millennium Assessment 2005).

Giacomini Marsh, Nicasio, Marin County. Photo by Stuart Weiss.

Goal 5. Steward all lands to maintain ecological and hydrological processes that support ecosystem function and resilience.

Conserve groundwater recharge zones within planning watersheds of fish-bearing streams:
34% achieved



Preserve remaining intact headwater source areas:
38% achieved

Conservation involves the preservation of habitat as well as the stewardship required to facilitate natural processes that sustain populations. Ecological and hydrological processes operate at all scales. The CLN identifies the lands most important for maintaining these landscape-level natural processes. The network includes large, diverse blocks of natural land and the stream networks and wildlife corridors that connect them, thus supporting population (and gene) dispersal as well as hydrological processes such as rainwater capture, groundwater recharge and discharge, and flooding.

Stewardship activities that maintain, enhance, restore, or mimic ecological and hydrological processes are crucial. For example, prescribed burns can mimic natural fire, an ecological process that controls certain plant species and stimulates others. Although many processes (such as fire) are not reflected in the mapping for the CLN, all ecological and hydrological processes that contribute to healthy ecosystems in the Bay Area are recognized as key to achieving habitat and biodiversity goals.

Key Conservation Themes of the CLN 2.0

Mitigating and Adapting to Climate Change

"The IPCC report demonstrates that it is still possible to keep the climate relatively safe, provided we muster an unprecedented level of cooperation, extraordinary speed and heroic scale of action. But even with its description of the increasing impacts that lie ahead, the IPCC understates a key risk: that self-reinforcing feedback loops could push the climate system into chaos before we have time to tame our energy system, and the other sources of climate pollution."

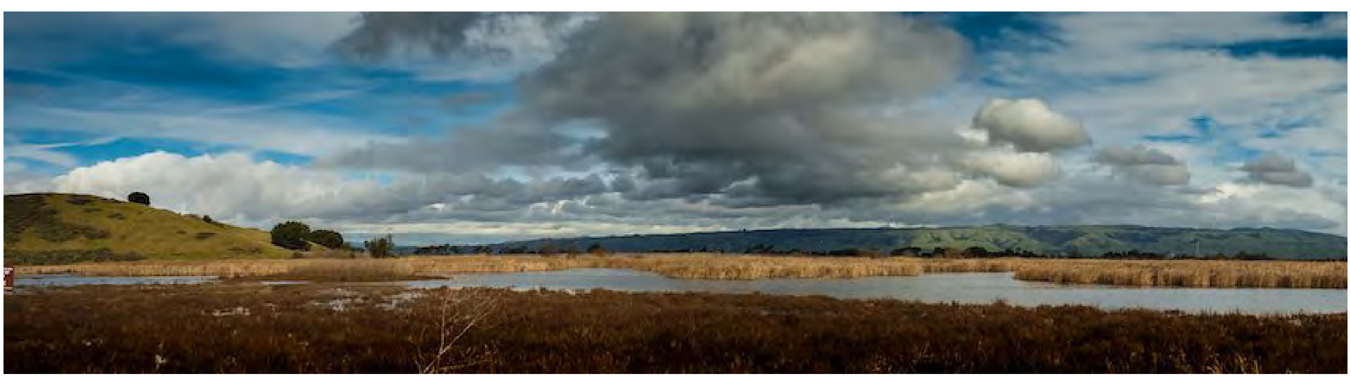
—Mario Molina, 1995 Nobel Prize winner in Chemistry; author of the IPCC Fourth Assessment Report

Climate change is affecting the entire planet. Here in the Bay Area, the mean temperature has risen 1.7° F since the early 1900s. Scientists expect greater variability of temperature and precipitation (booms and busts) within a general warming trend, aridification of the landscape as evaporative demand (drought stress) increases, and rearrangements of species distributions to track climate (Ackerly *et al.* 2018).

Human land uses can contribute to and exacerbate climate change effects, while intact natural landscapes can buffer the effects of climate change through natural processes such as the absorption of floodwaters, the discharge of groundwater into streams, and the growth of forests and woodlands that provide shade and reduce evaporation (Fahrig 2003, Opdam and Wascher 2004). Climate change effects, however, exacerbate the problems caused by human disruption of natural processes, all of which adds urgency to efforts to conserve land and restore natural processes.

Climate adaptation actions are needed across all scales, from parcels to landscapes. Examples at the parcel scale include reducing fire fuels through prescribed burning and other measures, improving stream function by repairing or removing artificial obstructions, and increasing local species abundance by restoring native plant communities that provide food and cover. At the landscape scale of the Conservation Lands Network, climate change adaptation approaches for land and biodiversity conservation are particularly focused on conserving physical diversity to provide future climate space for species expected to be displaced by climate change (Schmitz *et al.* 2015)— an approach called "conserving nature's stage" (Beier *et al.* 2015).

The Conservation Lands Network offers strategic data that can be used to support local and regional climate adaptation decisionmaking. CLN data align with several so-called "no regrets" climate adaptation approaches — actions whose benefits are known and will remain important even if the effects of climate change are not as predicted. Figure 2.1 describes how the CLN supports six such approaches.



Coyote Hills Regional Park, Alameda County. Photo cc Charlie Day.

The approaches above also bring many societal benefits. The same areas identified as important for biodiversity climate adaptation provide ecosystem services and act as buffers to natural hazards for people. For example, conservation of stream valleys and headwaters is essential to maintaining water supplies for both ecosystems and people. Intact landscapes and watersheds absorb and release stormwater slowly, minimizing damage to property.

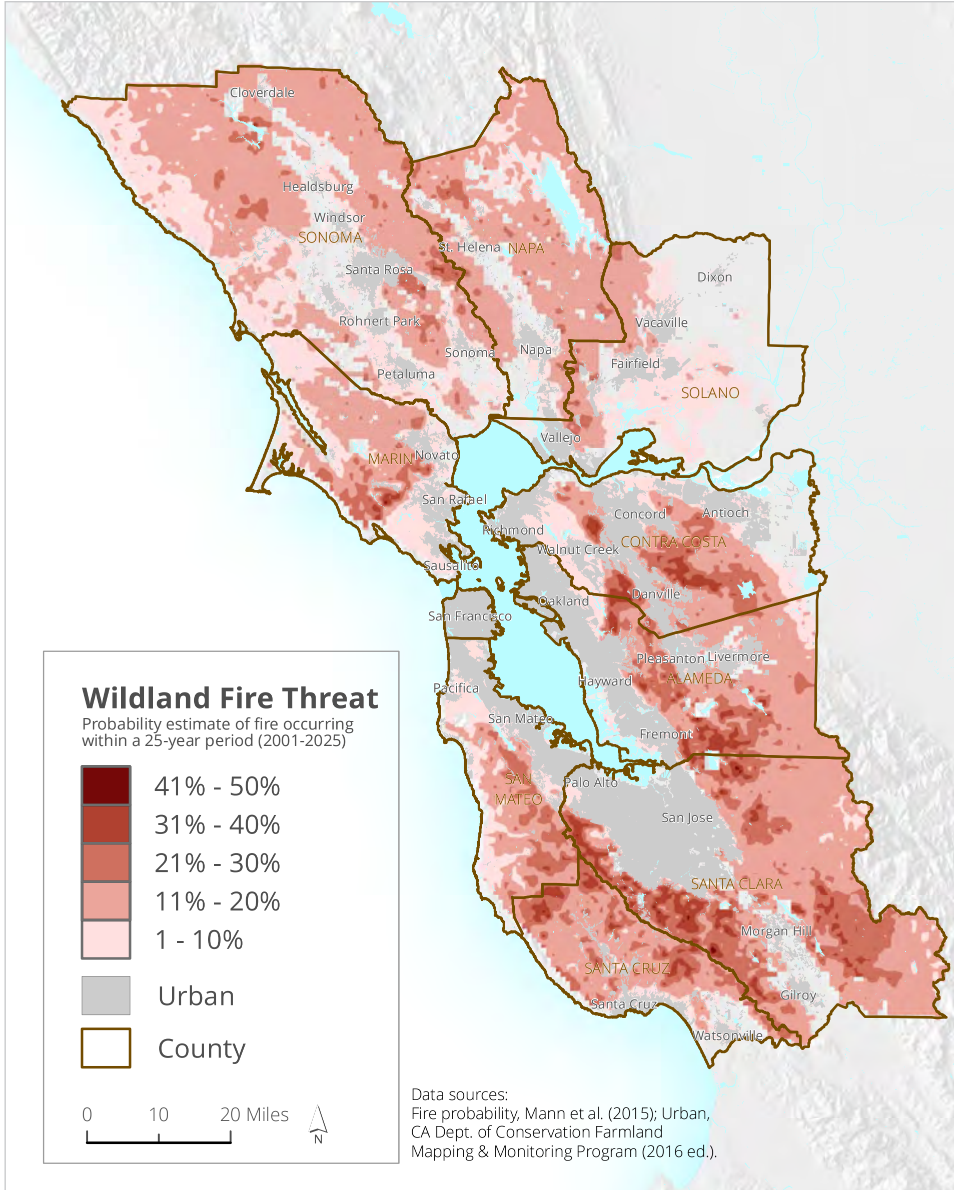
Grasshopper sparrow at Calero Reservoir, Santa Clara County. Photo by Steve Rottenborn.

Figure 2.1 ■ Climate Change Adaptation Approaches to Land and Biodiversity Conservation. Datasets packaged with the CLN database and available for download at BayAreaLands.org are marked with an asterisk (*). Adapted from Schmitz *et al.* 2015.

Climate change adaptation approach	How this is incorporated by the CLN 2.0
Conserve current patterns of biodiversity	The CLN itself is designed to capture the full range of habitats and species with high goals based on rarity.
Conserve large, intact, natural landscapes	Through the Conservation Suitability layer, the CLN captures large contiguous landscapes with each landscape unit, while steering conservation into areas with the least human impact.
Conserve topographic and climatic diversity	The network targets locally rare vegetation types, thus capturing a full range of mesoclimatic diversity (Heller *et al.* 2015).
Ensure animal and plant species have clear pathways to suitable climate and habitat in the face of increasing temperatures and rising sea levels	The network includes local connectivity (on the scale of several km) in addition to topographic complexity. Landscape Resilience data* (TNC 2018) combines local topoclimatic diversity (heat index and topographic moisture) with local connectivity. Areas with high topoclimatic diversity that are well connected locally allow species to track climate on a local scale. Omniscape (TNC)* guides conservation of connectivity at broader scales (tens of km) Critical Linkages* identifies species-specific corridors among large landscape blocks within and beyond the CLN study area. Potential future upland transition zones at the baylands interface are explicitly included in the network.
Maintain and enhance ecologic and hydrologic connections and processes across landscapes, watersheds, and groundwater basins	Undeveloped stream valleys are explicitly included in the network. Headwater material contribution zones* are delineated. Areas of historic and projected groundwater recharge and runoff * are mapped and reported. The Conservation Suitability layer* steers the network toward hydrologically intact portions of many watersheds.
Conserve drought refugia and arid areas that can serve as sources for the expansion of drought-adapted native species	Steam valleys and riparian zones are integrated into the network, and wetlands are prioritized at the highest level (90% of all occurrences per landscape unit). Locally rare mesic and arid vegetation types are prioritized at high levels (75– 90%).

Fire, an intrinsic component of our semi-arid landscapes (Figure 2.2), poses immense threats to people and property. The North Bay fires of 2017 devastated communities and resulted in 44 deaths and more than 8,900 destroyed structures. At the same time, fire rejuvenates many ecosystems, providing ecological benefits to a landscape deprived of fire. Bay Area ecosystems are well-adapted to fire, and the mixed mosaic of fire severity cleared out accumulated fuels, stimulated fresh new growth, and germinated fire-following species that had not been seen for decades. Wildfires also have negative ecological impacts. In the 2017 fires, watersheds were overloaded with sediment and debris and many mature trees in high severity burn patches were lost. Open space with no structures to protect provides battle lines for containment (*e.g.*, opportunities for backfires), as well as fuels management with shaded fuel breaks and prescribed fire.

Figure 2.2 ■ Map of Wildland Fire Threat in the Bay Area. This shows the probability estimate of fire occurring within a 25-year period (2001-2025).

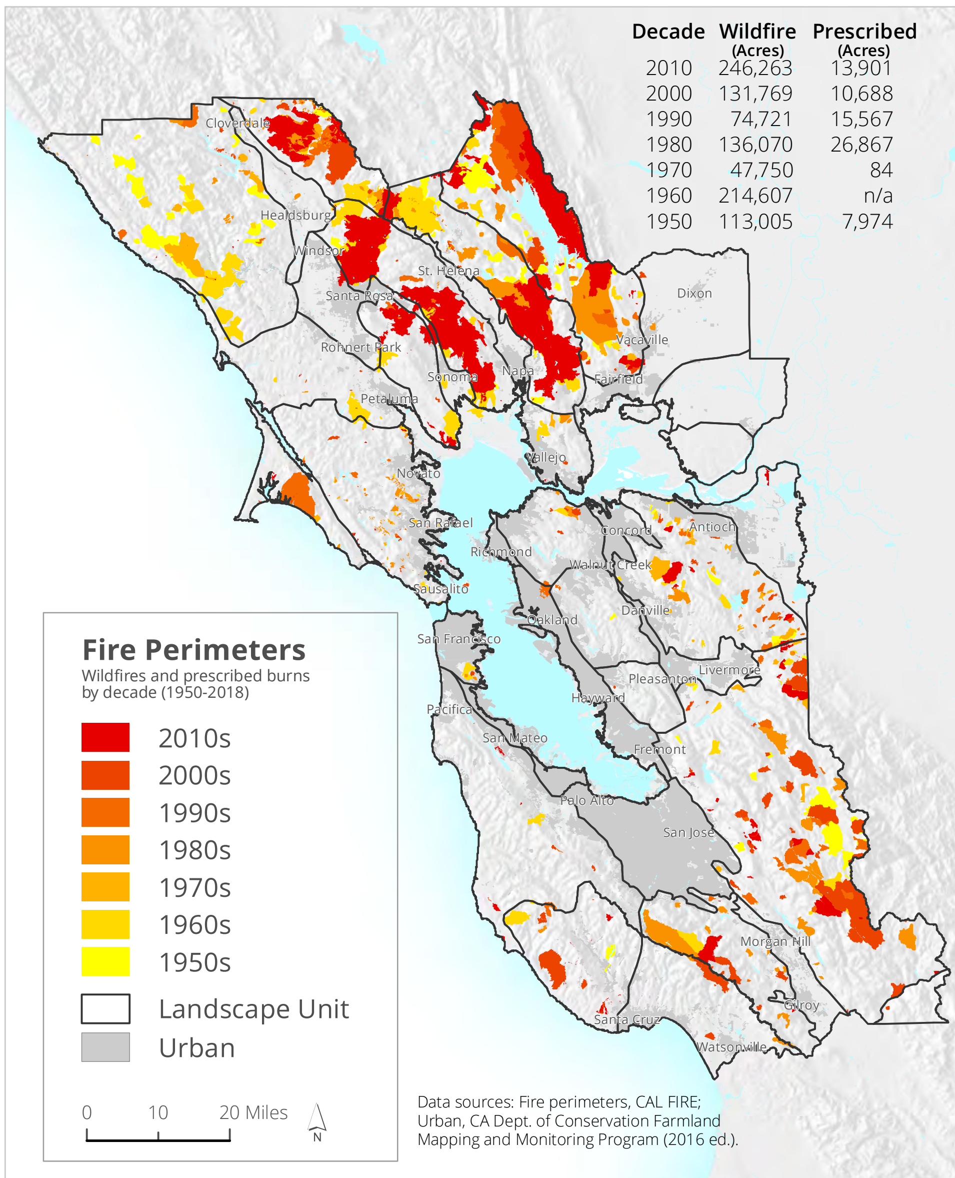


The fire history map (Figure 2.3) shows that 18% of the Bay Area has burned at least once, and many areas have burned multiple times since 1950. The most vivid example is the congruence of the Handly Fire (1964) and the Tubbs Fire (2017) — the dry northeast winds that drive the largest fires have somewhat predictable patterns on the landscape. For much of the Bay Area, the question is not if it will burn, but when will it burn, and with what impacts.

As detailed in Chapter 3, the design of CLN 2.0 has incorporated the best available data on landscape integrity and connectivity, including room for sea level rise. Conserving the network is itself a climate adaptation strategy. Thus the network — and associated climate datasets — will help local and regional land conservation and decisionmakers prepare and protect the region in a changing climate.

Aerial view of smoke from the 2017 Atlas and Nuns fires in Napa and Sonoma Counties, viewed from near the south end of Lake Berryessa. Photo cc Dickylon.

Figure 2.3 ■ Map of Fire History by Decade in the Bay Area.



Corridors and Landscape Connectivity

As mentioned above, ensuring species have clear pathways to access habitat is a key strategy to conserve biodiversity, maintain healthy ecosystems, and facilitate adaptation of wildlife populations to rapid changes (Gray *et al.* 2018).

The CLN considered connectivity at several scales. At the finest scale is connectivity within landscape units, which is addressed by prioritizing large contiguous blocks of conservation lands in permeable habitat. Next is connectivity between landscape units, which often involves corridors and landscape linkages across developed valley bottoms, typically at chokepoints dictated by urbanization and highways. At the broadest scale is connectivity to lands outside of the study area.

Using the conservation planning software Marxan, the CLN project team used a number of methods and tools (Figure 2.4) to ensure that the network and ancillary datasets promotes landscape connectivity at various scales.

Once connectivity zones are identified, on-the-ground work is necessary to truly understand how and which species are moving through the landscape, across corridors, and through chokepoints. This level of ground-truthing is not currently within the scope of the CLN. However, there exist several efforts throughout the Bay Area by local land conservation partnerships that focus on existing corridors and landscape-scale chokepoints. These groups are developing and implementing strategies to remove barriers and facilitate species movement into adjacent habitat. Figure 6.2 in Chapter 6 lists these efforts.

Figure 2.4 ■ Tools and Methods for Promoting Landscape Connectivity in the CLN.

Scale	Strategies	Methods and Tools
Within landscape units	■ Set high goals (>50% of undeveloped land) ■ Automatically add to the network all planning units that are currently protected (10% or more of the planning unit area) ■ Identify gaps and manually add planning units to network as connectors	■ Selection of an efficient set of core network areas by landscape unit using Marxan and its Boundary Length Modifier to upweight physical adjacency of selected planning units ■ Delineation of a CLN category (Connectors) that, guided by a least-cost path connectivity analysis, connects core network areas, as discussed in Chapter 3
Between landscape units	■ Maintain existing connectivity ■ Delineate wildlife corridors through developed valley bottoms ■ Identify multiple routes where feasible	■ Use of a conservation suitability input in the Marxan analysis often results in core network areas that straddle multiple landscape units. ■ Delineation of a CLN category (Connectors) that, guided by a least-cost path connectivity analysis, connects between and across core network areas. ■ Package Bay Area Critical Linkages, Omniscape, and human activity/impact datasets with CLN 2.0 Regional Land Conservation Database
Pinch-points (also known as chokepoints or bottlenecks)	■ Identify obvious areas where animal movement is funneled within linkages — narrow spots, riparian zones, and passages across highways and through developed valleys — and use on-the-ground observations to confirm wildlife use.	■ Package "Pinch-points" dataset — based on local observations, reports, and studies — with CLN 2.0 Regional Land Conservation Database ■ Visual inspection by local agencies and organizations to determine existing infrastructure and potential barrier mitigation
Outside 10-county study area	■ Ensure that the network extends to the boundaries of all 10 counties and connects with protected and unprotected natural areas	■ Package Bay Area Critical Linkages, Omniscape, and human activity/impact datasets with CLN 2.0 Regional Land Conservation Database

Salt marsh harvest mouse, a federally endangered species endemic to the Bay Area, uses both uplands and baylands habitats. Photo by M. Bias, US Department of the Interior.

Connecting Upland and Bayland Conservation

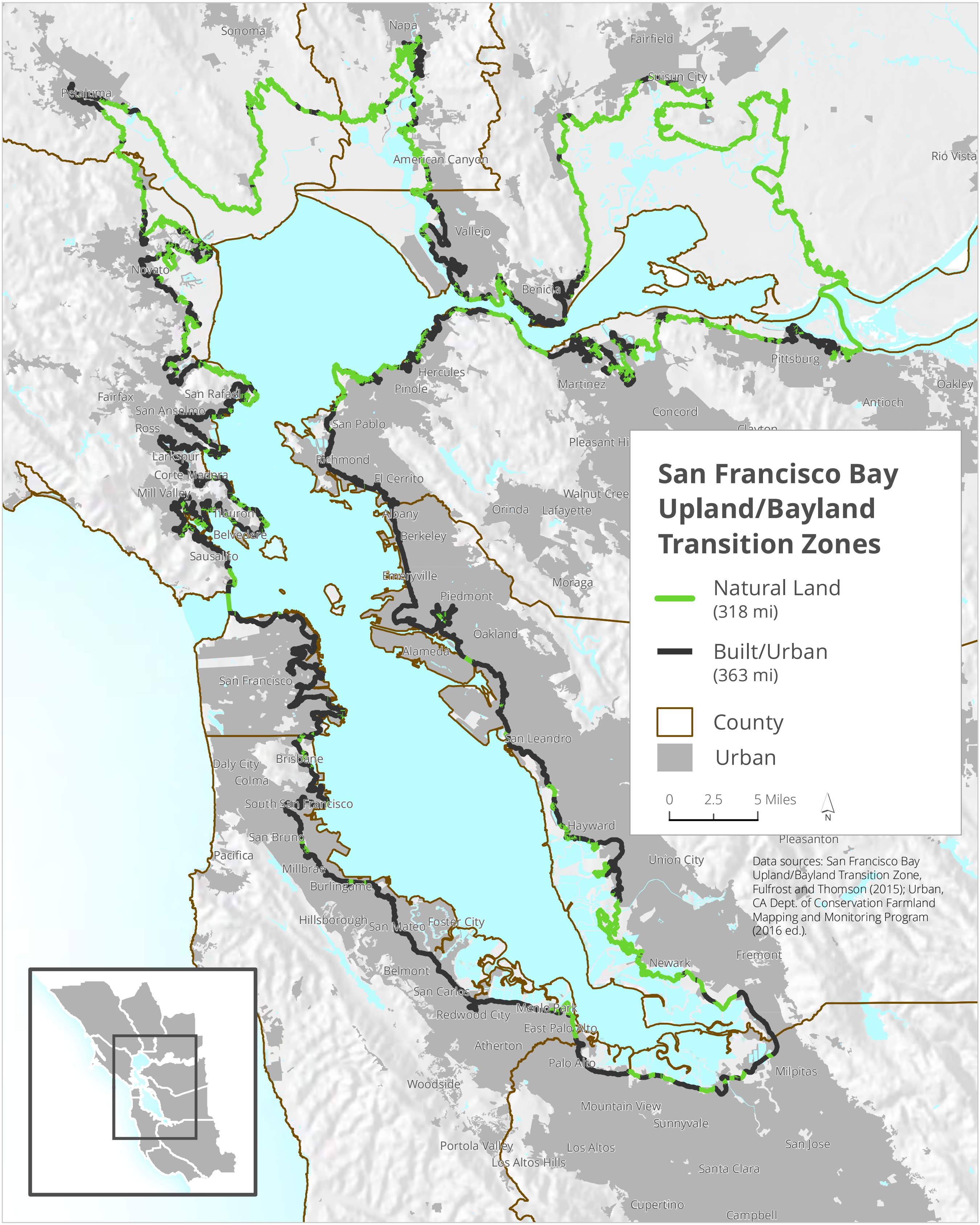
Despite operating within different policy, planning, and regulatory contexts, San Francisco Bay tidal habitats and uplands share species (*e.g.*, anadromous fish and waterfowl), hydrology, and sediment flows. Many species split their time between the two zones (*e.g.*, salt marsh harvest mouse; USFWS 2013). The transition zone, or ecotone, between terrestrial and tidal zones is fluid. Baylands also depend on upland watersheds for sediment, freshwater inputs, and hydrologic and hydraulic processes. The transition zone provides a physical and ecological connection between the baylands and local watersheds.

Sea level rise will affect both zones. Sea level rise will drown tidal marshes that are not able to accrete sediment in pace with rising sea levels. The presence of salt water will convert upland habitats to tidal habitats. Low-lying natural upland/bayland transition zones (*e.g.*, Fulfrost and Thomson 2014) provide space for baylands (Figure 2.5) and coastal estuaries — especially tidal marshes and tidal reaches of rivers and streams — to migrate in response to sea-level rise.

The Baylands Goals Science Update lists as a regional priority the restoration of estuary-watershed connections that nourish the baylands with sediment and freshwater while also protecting natural and working lands adjacent to the baylands. That document also highlights the need to "plan for the baylands to migrate" as one of ten regional strategies to promote resilience of the baylands landscape. It calls for an inventory of intact patches of wetland and non-wetland habitat types that adjoin the baylands — including grasslands, seasonal wetlands, and forests — and protection of those areas to prevent further degradation and a loss of transition zone extension and enhancement opportunities (Baylands Goals Project 2015).

Linking the baylands and uplands in CLN 2.0 is important for fostering complexity and resilience of both the uplands and baylands. Streams that drain to the San Francisco Bay and their associated riparian zones are fundamental connections between the two zones. The design of CLN 2.0 has explicitly prioritized those connections by delineating and incorporating stream valleys into the network, as discussed in Chapter 6.

Figure 2.5 ■ Map of Natural Upland/Bayland Transition Zones Where Baylands Migration is Possible.



Similarly, the addition of Headwater Contribution Zones to the CLN 2.0 suite of conservation data promotes the conservation of the source areas of water and sediment that will eventually find their way to the Bay. The network itself covers 42% of the area that drains to the bay. The Upland and Bayland projects prioritize similar actions such as limiting impervious surfaces and removing barriers to fish passage (Baylands Goals Project 2015). Figure 2.6 lists ten of the Baylands Goals' regional strategies to address sea level rise and promote resilience across the two biomes, and related actions for upland land managers.

Figure 2.6 ■ Shared Bayland-Upland Strategies for Climate Resilience.

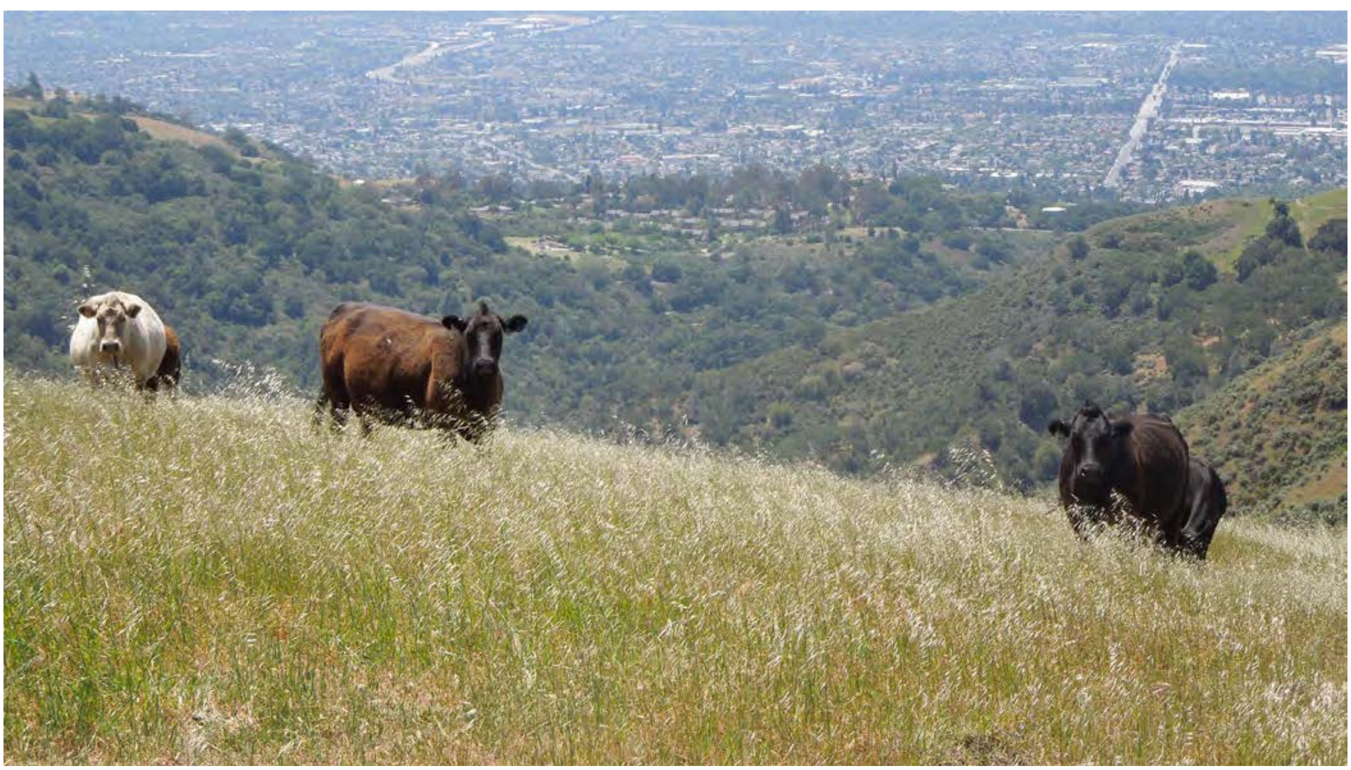
Strategies from Baylands Goals Science Update 2015	Actions for Upland Land Managers
1. Restore estuary-watershed connections.	Seek opportunities in parks and preserves and with landowners to restore natural sediment delivery processes via creeks (*e.g.*, removal of dams, improvements to in-stream structures such as culverts). Explore ways to transport sediment trapped behind dams for use in baylands restoration and management.
2. Design complexity and connectivity into the baylands landscape.	Protect, restore, and steward an upland transition zone around the perimeter of the baylands (particularly gently sloped adjacent uplands) and all riparian connections between the baylands and surrounding watersheds in order to facilitate movement and migration of plants and wildlife.
3. Restore and conserve complete tidal wetlands systems.	Create high-water refuge areas on uplands for wildlife such as salt marsh harvest mouse. Protect and steward natural and working lands adjacent to the baylands to create the habitat mosaics needed for species that combine baylands and terrestrial habitats in their home range (*e.g.*, Northern Harrier, dabbling ducks, and vernal pool species).
4. Restore baylands to full tidal action prior to 2030.	Work with baylands managers to identify the highest priority baylands for restoration and marsh maintenance, and identify and implement a set of critical upland conservation actions needed for the baylands.
5. Plan for the baylands to migrate.	Identify and protect existing and projected transition zone lands and future flood areas, focusing on broad, gently sloped, and minimally developed areas.
6. Actively recover, conserve, and monitor wildlife populations.	Control invasive plants and animals in future transition zones, participate in regional and subregional wildlife monitoring programs in order to assess the impacts of conservation actions, and promote actions that benefit native wildlife populations.
7. Develop and implement a comprehensive regional sediment-management plan.	Participate in regional sediment-management work that matches suitable dredged or excavated sediment from local rivers and streams, flood-control channels, local reservoirs, and other watershed sources to appropriate bayland sites.
8. Invest in planning, policy, research and monitoring.	Collaborate with bayland managers on integrated, whole-watershed planning, policy, research, and monitoring projects.
9. Develop a regional transition zone assessment program.	Co-develop and participate in a collaborative program of potential upland transition zone site assessment, project tracking, performance evaluation, applied research, and public reporting. Use the unique connections to the public that park departments, open space districts, and land trusts, resource conservation districts, water agencies, and other land organizations have to regularly explain to the public the status of sea level rise and bayland transition.
10. Improve carbon management in the baylands.	Promote native vegetation cover in watersheds that contribute organic matter to stream systems that drain to the Bay.

Conservation Importance of Private Rangelands and Forestlands

Working lands support habitat and biodiversity, and keeping them in production is central to achieving regional habitat conservation goals. Rangelands and other private lands are an important component of the CLN, comprising 45% of the 2.0 network. These landowners are critical partners to protecting the remaining 1.1 million acres necessary to meet the Conservation Lands Network 2.5 million acre goal. The Rangelands Focus Team provided much-needed information and perspective on these issues.

The voluntary sale or donation of property development rights through conservation easements by range and forest landowners can ensure their operational viability while the lands continue to support invaluable habitat and provide landscape connectivity and services. Other programs offer technical and financial resource assistance to improve the health of private working lands. Regional land conservation success depends on support for and expansion of programs offered by the Natural Resources Conservation Service, US Fish and Wildlife Service, California Department of Forestry and Fire Protection (CAL FIRE), the California Department of Fish and Wildlife, and California Wildlife Conservation Board, as well as property tax relief programs like the Williamson Act.

Rangelands (Figure 2.7) support many listed species. Grazing of livestock — cattle in particular — is essential for managing heavily invaded annual grasslands for native biodiversity, as well as maintaining vernal pools and providing stock ponds for imperiled amphibians (USFWS 2006). The inception and growth of the California Rangeland Conservation Coalition has been a powerful cooperative bridge that has found common ground between rangeland users and biodiversity advocates that historically have been in conflict. Conservation forestry is being implemented in many coastal coniferous forests, and carbon offset credits through the California Air Resources Board contribute funding for stewardship on these lands.



Cattle grazing at Sierra Vista Open Space Preserve, Santa Clara County. Photo by Cassie Kifer.

Figure 2.7 ■ **Map of Bay Area Rangelands.** In the 10-county Bay Area, rangelands cover approximately 1.9 million acres, or 41% of the region. Rangelands are grassland, woodland, and shrubland vegetation types that are suitable for livestock grazing. Not all rangelands are grazed. Map by GreenInfo Network for California Rangeland Trust, funded by the S.D. Bechtel, Jr. Foundation.

The CLN 2.0 Explorer now calculates the amount of suitable grazing land, as mapped by the State Department of Conservation, for a given area of interest. This will help conservation organizations and landowners determine a given parcel's eligibility for rangeland conservation funds such as those available through the Rangeland, Grazing Land and Grassland Protection Program of the Wildlife Conservation Board.

Urban Areas and the CLN

Due to the dense human population in the Bay Area, the Conservation Lands Network maps include quite a bit of gray shading: urban areas. Although urban areas are often considered solely a threat to biodiversity (Hooke *et al.* 2012, Cunningham and Beazley 2018), innovative approaches offer conservation opportunities in urban areas.

Four entire landscape units on the Bayshore were designated as Urban, and the urban areas within other landscape units were given a 0% goal in Marxan. Intact natural vegetation adjacent to urban areas has low conservation suitability, due to high population density, many roads, and high parcelization within the planning unit. However, if an urban area contained "must have" targets — *e.g.*, stands of intact riparian vegetation — then the planning units were chosen, the converted lands were excised, and the remaining lands were tagged as Edge habitat in the network (for details, see Figure 3.1).

A new report from the San Francisco Estuary Institute synthesizes research and offers a science-based framework for supporting nature in cities.

Making Nature's City: A Science-based Framework for Building Urban Biodiversity *(SFEI 2019) can help urban designers and residents support biodiversity inside city limits. It is available at* www.sfei.org.

While the CLN does not target urban areas, these developed lands can contribute to regional biodiversity. They can provide connectivity and even breeding habitat for species that can handle the rigors of urban life — the re-population of coyotes into San Francisco is a stunning example, as are local colonies of Acorn Woodpecker where oak trees are still at sufficient densities. On the downside, they can act as population sinks, with high mortality and reduced reproductive success. Still, sound stewardship for urban parks and open spaces is important, and native biodiversity in cities and suburbs offers numerous educational opportunities.

The full gamut of urban conservation is beyond the scope of this report, but three examples provide some insights into the possibilities.

- Urban riparian corridors, often heavily modified or channelized, can serve as local habitat for many animals; anadromous fish often must move through urbanized creeks to reach spawning grounds. Many urban streams were buried in culverts decades ago, but daylighting those streams has provided pockets of habitat and desperately needed open space. Innovative flood control projects such as those on the Guadalupe River in downtown San Jose and the Napa River in downtown Napa, provide park space where visitors can see salmon and beaver.
- Re-Oaking Silicon Valley is a path-breaking report that envisions systematically replacing non-native urban trees with the native oaks that used to extend across now urbanized valley floors, as well as other native trees, shrubs, and ground cover. Non-native trees, shrubs, and ground cover (especially lawns) can be attractive, but often require supplemental irrigation, pesticides, and fertilizers that can pollute urban watersheds. Importantly, these non-natives do not support coevolved insect food webs, to the detriment of many birds and pollinators. Native plant gardens are catching on across the region.
- Urban plantings of butterfly hostplants are also becoming popular. In western San Francisco, the Green Hairstreak Corridor Project is planting hostplants along medians and in front yards to connect two small patches of buckwheat that still support this striking butterfly. At slightly larger scales, the endangered Mission Blue Butterfly now flies again over lupine patches at Twin Peaks, and the Chalcedon Checkerspot can be found in the Presidio once again.

Support for Sound Stewardship Practices

Conservation is a long game. While land acquisition and conservation easements are critical, thoughtful and ongoing management of lands and ecosystem processes is required, now more than ever. Active stewardship is required to manage many things, including connectivity, resilience to climate change, invasive species, human activity, disease, fire, succession, and availability of water.

The CLN 2.0 Stewardship Focus Team and the Policy, Land Use, and Funding Focus Team were formed to discuss these overarching issues and ensure that the network addressed them. The Conservation Lands Network regional goals call for vast increases in stewardship funding and resources. The network itself provides a framework for coordinating actions across jurisdictions and ecosystems, and provides baseline data for measuring the effectiveness of stewardship efforts.

Learning From Nature: Adaptive Stewardship and a Long-term Habitat Plan in Santa Clara Valley

Stewardship for biodiversity in a profoundly changing environment requires constant monitoring and adoption to new scientific information, as can be demonstrated by the evolution over the last four decades of grassland management in the South Bay.

Cattle grazing at Coyote Ridge. Photo by Stuart Weiss.

Nutrient-poor serpentine grasslands are among the crown jewels of Bay Area biodiversity, supporting more than a dozen threatened and endangered species and a popular annual super-bloom. In the 1980s, biologists observed that wildflowers in ungrazed areas on Coyote Ridge were being rapidly overrun by non-native annual grasses, extirpating populations of the threatened Bay Checkerspot Butterfly.

Livestock grazing has proven to be the only effective landscape-scale method for controlling these fast-growing grasses. Grazing cattle — and ranchers — control those non-natives, and are essential to maintaining biodiversity on these hillsides.

In the 1990s, the driver of the grass invasions became clear: the brown smog cloud wafting south from Silicon Valley was bathing Coyote Ridge in potent nitrogen fertilizer.

The scientific connection between smog and habitat degradation was the nexus for mitigation in the 2000s, starting with power plants and widening Highway 101. Mitigation packages included land acquisition and importantly, long-term funding for monitoring and adaptive management that mandates appropriate grazing regimes.

The early mitigations morphed into the Santa Clara Valley Habitat Plan, a 50-year $665 million HCP/NCCP adopted in 2013. The plan will secure and steward virtually all of the remaining serpentine grasslands in Santa Clara County under oversight by the US Fish and Wildlife Services and the California Department of Fish and Wildlife. The Santa Clara Valley Open Space Authority oversees much of the management, now extending over more than 3,000 contiguous acres on Coyote Ridge.

The congruent interests of ranchers and conservationists are a foundation for the California Rangeland Conservation Coalition, formed in 2005. With lessons learned over many decades at Coyote Ridge and elsewhere, conservation grazing is now a common stewardship technique used to benefit butterflies, wildflowers, Burrowing Owl, California Red-legged Frog, California Tiger Salamander, and many other species.

Adaptive Stewardship, New Approaches, and a Call for Increased Capacity

Land stewardship that provides resilience to increasing ecosystem threats posed by wildfire, drought, and disease requires long-term commitment and funding, as well as a willingness to experiment and correct course as needed.

As eloquently outlined in a recent white paper by the California Landscape Stewardship Network (Robins *et al.* 2019), rapid environmental changes require a major shift from the current thinking on land management (driven by risk-averse regulatory and permitting paradigms) to a model that incentivizes land conservation organizations to undertake larger, more complex actions commensurate with the threats at hand. This includes, among other things, adapting elements of the attitudes and tools developed over millennia by Native Californian cultures, such as controlled burning.

With steady increases in protected areas over the past 30 years, Bay Area conservation organizations are responding to an unprecedented load of land and natural resource management responsibilities by increasing allocation of staff and resources to land stewardship. But the needs far outweigh the available resources (Blue Earth Consultants 2016). This deficit is dangerous at a time when the natural resources that people depend on are at risk due to climate change. Land managers are integral to creating the landscape resilience that is necessary (Beller *et al.* 2015). What is clearly needed right now is a many-fold increase in funding for land stewardship.

The call for a significant increase in stewardship capacity resonated with the Steering Committee, Stewardship Focus Team, and other focus teams. So did the idea of a Bay Area Stewardship Initiative that would bring together public land managers, wildlife agencies, tribes, scientists, local "Friends of" groups, ranchers, advocates, and other interested parties. The Initiative would assess regional stewardship needs, capacity, successes, failures, ongoing challenges, and responses, and would focus on generating sufficient long-term funding. Sharing hard-won lessons could benefit efforts to steward for biodiversity regionally.

Restoration along the Napa River, Napa County. Successful restoration and removal of barriers has filled the river with native fish and allowed Chinook salmon and steelhead access to the upper watershed. Photo by Environmental Science Associates.

Following removal of non-native Eucalyptus from an area of Oakland's Garber Park, a citizen stewardship group replants to make the oak woodland more resistant to invasive species colonization. Photo by Lech Naumovich.

Subregional groups are heading in the right direction. Through collaborations such as One Tam, the Peninsula Working Group, and the Santa Cruz Mountains Stewardship Network, organizations are coordinating efforts across jurisdictions. Building on these and other initiatives, as well as the wealth of practitioner experience and scientific expertise in numerous private and public institutions, the California Land Stewardship Network (calandscapestewardshipnetwork.org) is scaling the innovations of subregional collaborations and helping usher in a new approach to land stewardship.

Other well-established collaborations (*e.g.* San Francisco Bay Joint Venture and San Francisco Bay Bird Observatory) help accomplish the CLN goals, often working across the three regional planning frameworks — Upland, Bayland, and Subtidal. Indeed, implementation of the goals and recommended conservation actions depends upon these and other groups. Emerging local and regional climate adaptation planning is an excellent opportunity to integrate habitat and community resilience planning.

Organizational infrastructure for stewardship is in place. Land conservation organizations throughout the region have been working for a half-century toward multiple conservation and societal goals such as protection of habitat and water supplies. Resource Conservation Districts (RCDs), for example, are an indispensable part of the stewardship infrastructure on both private and public lands. They provide funding through the Farm Bill and technical expertise via the National Resource Conservation Service. The permit coordination programs of the RCDs can greatly streamline regulatory permitting, so that more time and money can go directly to resource management.

The Conservation Lands Network provides a spatial framework for integrating stewardship into regional conservation projects. The CLN 1.0 report included extensive discussions of stewardship needs for various taxa, and a whole chapter (Chapter 9) addressing key viability factors such as climate change, nitrogen deposition, fire, invasive species, and disease. This report builds on that by highlighting many taxon-specific management issues. The CLN Explorer provides data key for stewardship, including connectivity, adjacency to converted lands, vegetation vulnerability to drought, nitrogen deposition, and Total Maximum Daily Loads, along with basic climate and hydrological inventories.

California State Initiatives and Plans

California is a world leader in conservation. Statewide, many policies, initiatives, legislation, and plans relate to the goals of the CLN with respect to biodiversity, land use, resource management, and climate mitigation and adaptation. The goals and objectives of the CLN complement and support these plans at a regional and operational level.

State policies and plans that are most relevant to the Conservation Lands Network are listed in Figure 2.8.

Figure 2.8 ■ Statewide Plans Relevant to Conservation Lands Network Goals and Objectives.

Document/Plan	Topics	Agency
California Agricultural Vision	Agricultural sustainability	California Department of Food and Agriculture
California Biodiversity Initiative	Biodiversity	California Natural Resources Agency, California Department of Food and Agriculture
State Wildlife Action Plan	Biodiversity	California Department of Fish and Wildlife
Safeguarding California	Climate change adaptation	California Natural Resources Agency
General Plan Guidelines	Climate change and sustainability	Office of Planning and Research
California Healthy Soils Action Plan	Climate change mitigation and adaptation	California Department of Food and Agriculture
Climate Change Indicators for California	Climate change mitigation and adaptation	California Environmental Protection Agency Office of Environmental Health Hazard
Scoping Plan – Natural and Working Lands Implementation Plan	Climate change mitigation and adaptation	California Air Resources Board
Forest Carbon Plan	Climate change mitigation, resource management	California Natural Resources Agency, CAL FIRE, CalEPA
Integrated Conservation and Development Program	Conservation and development planning	Strategic Growth Council
Sustainable Groundwater Management Act	Water resources, climate change adaptation	California Department of Water Resources

Scientists monitor several listed butterfly species as part of the San Bruno Mountain HCP/NCCP. Photo by Stuart Weiss.

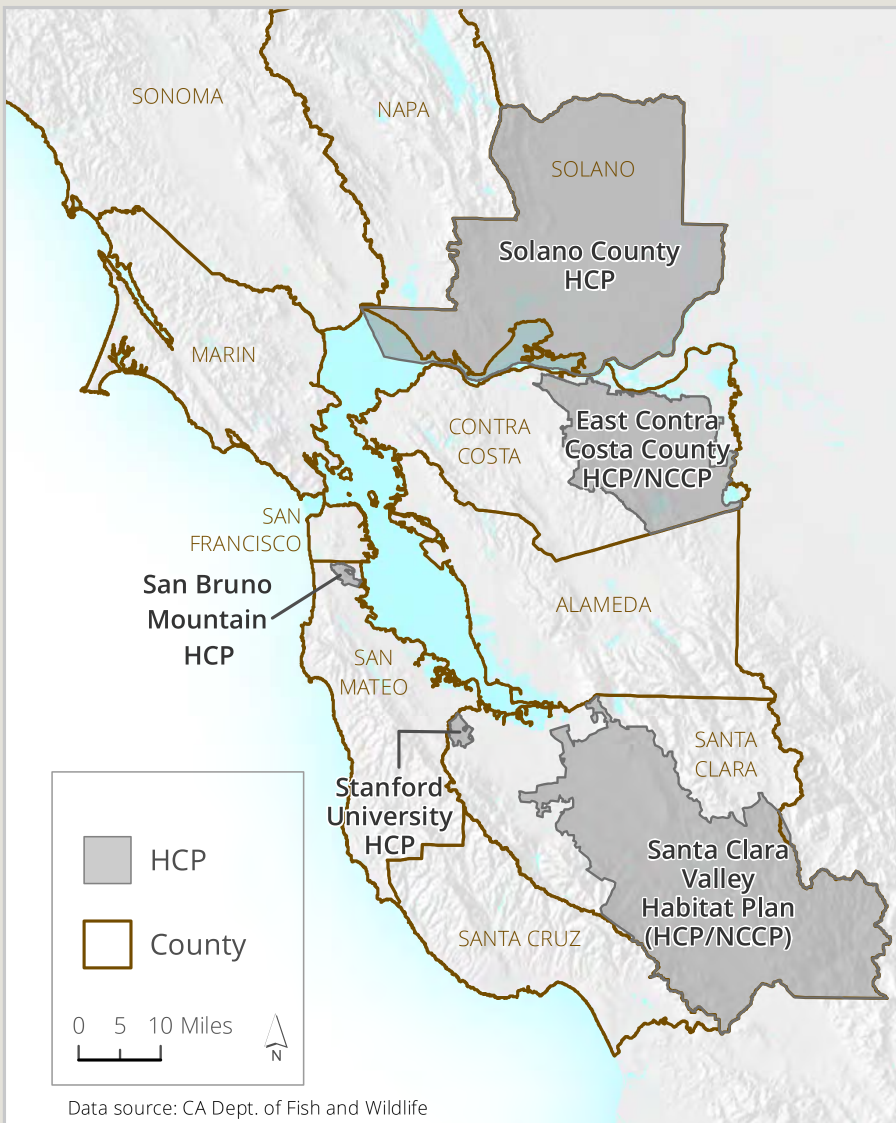
Conservation Plans: Important for Protecting Biodiversity

Federal and state laws provide opportunities to mitigate impacts of projects and regional-scale development through Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs). These plans provide rigorous scientific and legal frameworks for biodiversity conservation, and are important mechanisms for implementing the vision of the Conservation Lands Network.

As mitigation for development, HCPs and NCCPs target threatened and endangered species and natural communities at subregional scales. These plans mandate funding for land protection, monitoring, restoration, and long-term stewardship, generated from local development fees, ongoing conservation efforts, and federal, state, and foundation grants. Because of scientific and legal oversight from wildlife agencies, regional HCPs and NCCPs are the platinum standard for biodiversity conservation.

The very first Habitat Conservation Plan was enacted in 1982 at San Bruno Mountain in San Mateo County. Today, the Bay Area has three regional-scale HCPs (Solano County, East Contra Costa County, and Santa Clara Valley), one that covers the nine counties that touch the Bay (PG&E) and numerous smaller plans including the San Bruno Mountain HCP/NCCP and the Stanford HCP (Figure 2.9). Together, these plans ultimately will conserve some of the most biologically valuable lands in the region and provide for stewardship endowments in perpetuity.

Figure 2.9 ■ Map of Habitat Conservation Plans of the Bay Area. In addition to these shown, the PG&E Habitat Conservation Plan covers the nine counties that touch the Bay.



California plantain at Edgewood Park and Natural Preserve, San Mateo County. Photo by Kathy Korbholz.

The Conservation Lands Network 2.0

Conservation Lands Network 2.0 (Figure 2.11) identifies areas that support irreplaceable rare and endemic biodiversity, while also encompassing vast tracts of intact common vegetation types. It meets the conservation goals set for the vast majority of nearly 2,035 coarse- and fine-filter habitat and species targets, is compact, and explicitly includes stream valleys throughout the study area.

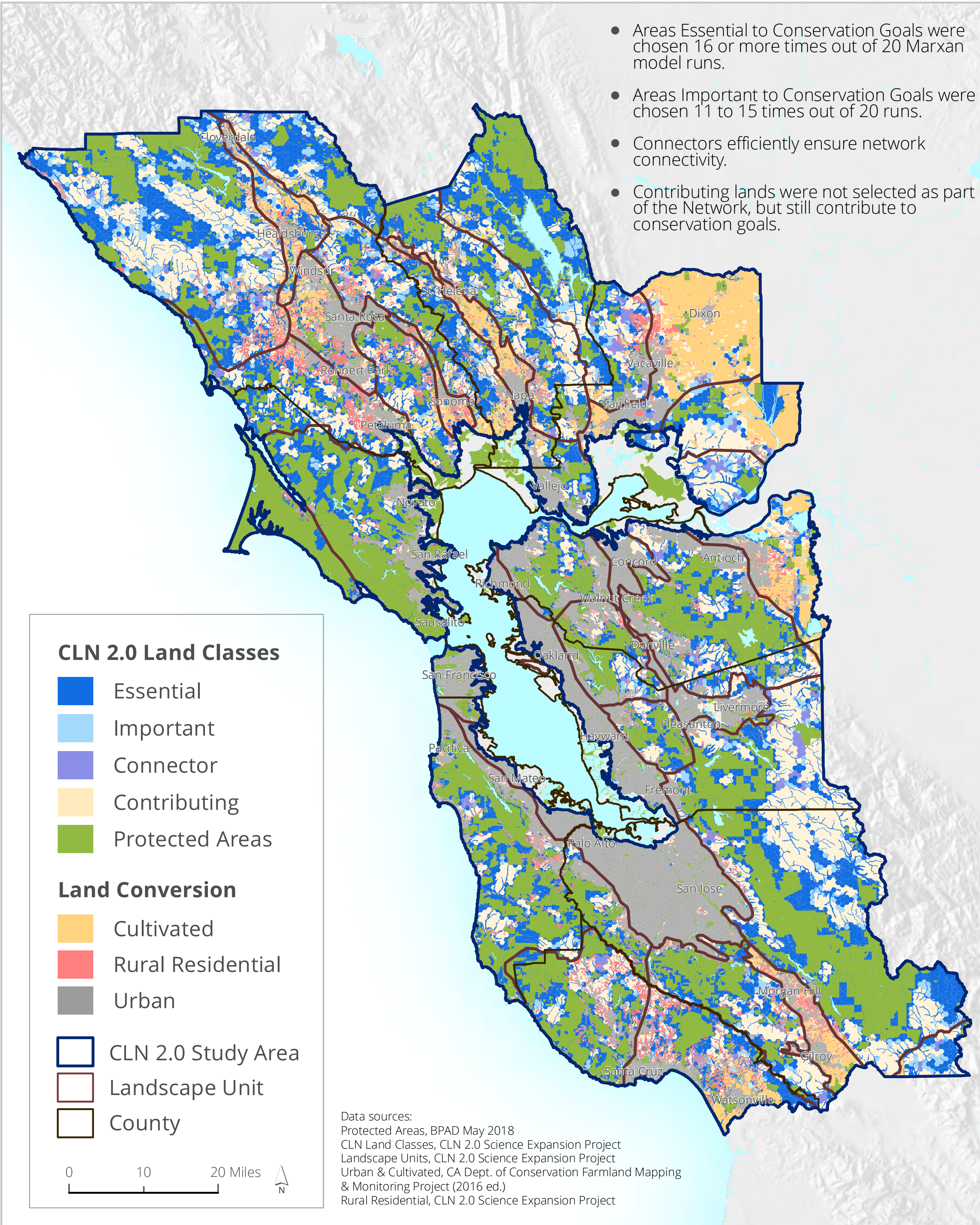
Of the approximately 4.5M acres in the study area, the Conservation Lands Network encompasses roughly 2.4M acres, which includes 1.2M acres of existing protected land (BPAD 2018). These and other land categories are summarized in Figure 2.10. The 1M acres of Essential Areas identified by the CLN generally contain high-value conservation targets, are located adjacent to existing protected lands, or play key roles in local connectivity. The 150,000 acres of Important Areas are common vegetation types and may be interchangeable with other potential conservation lands with similar biodiversity values. The 50,000 acres in Areas that Ensure Network Connectivity are important for making the Network a tool for promoting landscape resilience.

Realizing the vision of the Conservation Lands Network is a long-term process that will take decades. Over time, the configuration of the Network will change as lands are conserved and habitat goals are revised. However, the overall shape and size will likely remain recognizable. The CLN has built-in flexibility; as new, more accurate data are developed and more lands conserved, it can be updated to reflect the best opportunities for biodiversity conservation. It is also possible that some of the design rules for the CLN may change over time. For example, climate change may lead to adjustments in how targets are chosen and prioritized.

Figure 2.10 ■ Conservation Lands Network 2.0 Acreage. These figures represent upland (not bayland) habitats with the 10-county study area, a total of approximately 4.5 million acres.

Land Type	**Acres** Rounded to the nearest 10,000
Natural lands (uplands) within CLN 2.0	
Existing Protected Lands (BPAD 2018)	1,220,000
Essential Areas still to be protected	1,000,000
Important Areas still to be protected	150,000
Areas that Ensure Network Connectivity still to be protected	50,000
Conservation Lands Network total	2,430,000
Areas that Contribute to Conservation Goals	770,000
Converted lands (uplands) in the study area	
Urban (includes golf courses)	770,000
Cultivated Agriculture	370,000
Rural Residential	200,000
Converted lands total	1,350,000
Total lands (uplands) within the study area	**4,540,000**

Figure 2.11 ■ **Map of the Conservation Lands Network 2.0, a regional vision for land and habitat conservation in the Bay Area.**
A high-resolution, zoomable version of this map is available at BayAreaLands.org.



Using the Conservation Lands Network

The CLN 1.0 report includes an extensive discussion of how to use the Conservation Lands Network (Chapters 11 and 12). Those chapters remain relevant.

The network includes a number of tools, all available at BayAreaLands.org, that allow users to assess the biogeographic characteristics and conservation value of an area of interest, generate and share reports, download datasets, and more.

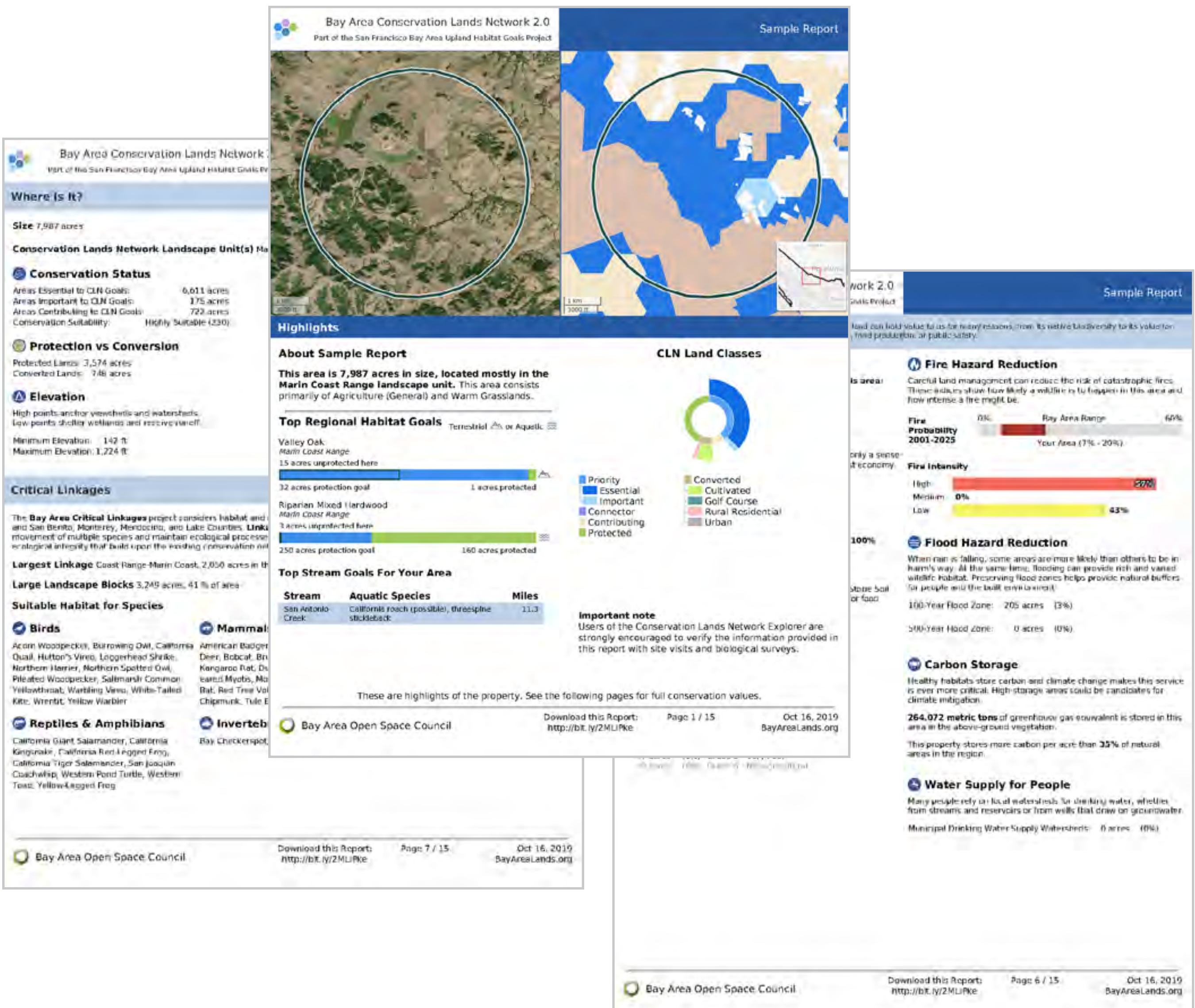
Tool	Can be used to
CLN Explorer An online, interactive, layered map showing a network of essential lands and underlying biogeographic and human landscapes	■ Characterize habitat types and features in a given landscape ■ Assess the regional conservation significance of a given area of interest, aiding decisionmaking and prioritization for acquisition and stewardship projects
Conservation Portfolio Report A detailed, quantified report of conservation values in a user-defined point or area; part of the Explorer	■ Describe the natural resources and other conservation values of any area of interest. ■ Quantify the contribution of a given area to regional habitat conservation goals and regional landscape resilience goals ■ Determine where and when to make conservation investments ■ Assess societal benefits of a particular area, e.g., hazard risk reduction, viewsheds ■ Communicate to funders, partners, and the press the regional significance of acquisition and stewardship projects
Progress Dashboard A high-level summary of goals and successes	■ Show regional and county-level progress toward goals
Downloadable databases ~100 up-to-date environmental datasets including biotic inventories, climate, geographic data, and political boundaries	■ Download and integrate biogeographic databases to create or add to a GIS database ■ Jump-start projects with a well-organized and symbolized GIS project ■ Conduct additional custom analyses for specific purposes
CLN 2.0 Report A description of the CLN goals, some of the conservation resources at stake, success stories and challenges, and conservation actions to protect landscape-level ecological function	■ Understand the goals and methods of the Conservation Lands Network ■ Identify specific conservation and stewardship actions recommended by the CLN 2.0 Team ■ Learn more about highlighted species and habitats in the Bay Area

Enhanced Conservation Portfolio Report

One of the most popular parts of the Conservation Lands Network is the Conservation Portfolio Report (Figure 2.12). With feedback from users ranging from resource managers to conservation funders, the team made a number of enhancements that make the report more informative and easier to use.

- Three reports were consolidated into one for easier downloads.
- Graphical representation of metrics makes information easier to understand.
- More drawing tools including circles, lines, and buffers gives the user finer control over the area of interest.
- Link sharing lets users share map extent, zoom level, and layer configurations as URLs, as well as in PDF reports.

Figure 2.12 ■ Sample Conservation Portfolio Report. This report, generated at BayAreaLands.org, details a range of conservation information about the user's selected area, including natural resources, contribution of the area to regional habitat, connectivity, and resilience goals, and societal benefits such as recreation, flood hazard reduction, and carbon storage. The entire sample report can be viewed at http://bit.ly/2MLIPke.



CHAPTER
3
Methodology: Science Expansion & Network Update

Cooley Ranch, Sonoma County. Photo by Stephen Joseph.

The Conservation Planning Process

Conservation Lands Network 2.0, called the Science Expansion, built on the successes of CLN 1.0 with updated and new data, a new gap analysis, and improved web tools.

An interdisciplinary team of more than 100 leading biologists, ecologists, practitioners in land conservation, and subject matter experts together:

- Assessed the user experience of the CLN 1.0 report, data, and online tools
- Updated the Bay Area Protected Areas Database to include newly conserved lands
- Refreshed the CLN input data using best available scientific data and expert knowledge

- Re-ran Marxan (the conservation planning software), and redesigned the network
- Collated and interpreted co-benefit reporting data and metrics related to climate change and conservation co-benefits such as ecosystem services valuation
- Developed key performance indicators and an online dynamic Progress Dashboard;
- Enhanced the website and the user interface of the CLN Explorer, based on input from the user assessment; and
- Launched a communications campaign to educate CLN target audiences about the enhanced and expanded Conservation Lands Network.

San Bruno Elfin. Photo by Liam O'Brien.

The CLN 2.0 team followed the conservation planning process established in CLN 1.0:

- The Vegetation Focus Team updated coarse-filter (vegetation) targets and assigned conservation goals (percentage targets for protection).
- With updated datasets, the team ran a gap analysis using Marxan to create a first cut of the network.
- The taxonomic focus teams (vegetation, mammals, birds, riparian/fish, and amphibians, reptiles and invertebrates) updated target species, habitats, and streams lists and ranks, reviewed the network for coverage of habitats, and recommended refinements.
- The taxonomic focus teams and the data subcommittee of the Steering Committee used their expert knowledge to review the validity of new data: stream valleys, headwater contribution zones, groundwater recharge for fish, and vegetation vulnerability to drought.
- The taxonomic focus teams created recommended conservation actions, with particular attention to population persistence in the face of climate change and human environmental impacts.
- A new Rangeland Focus Team addressed key issues regarding ranching and biodiversity conservation; many of the recommendations were incorporated into the taxonomic focus team conservation actions.
- A new Stewardship Focus Team addressed overarching stewardship needs and resources.
- A new Policy, Funding, and Land Use Focus Team addressed those topics at a high level, contributed ideas to the Regional Conservation Goals, and made suggestions on which policies should be included in the Explorer output.

The detailed methodological steps of this analysis are discussed in Chapter 3, as well as in Appendix B of the CLN 1.0 report at BayAreaLands.org. This chapter discusses changes incorporated into the network revision as part of the CLN 2.0 process.

The team incorporated new datasets, including those representing regional connectivity, landscape resilience, drought vulnerability, co-benefits, water supply, farmland classes, political boundaries, and more. Underlying datasets were updated, including roads, parcels, urbanized land, and protected status. All non-proprietary data are freely available for download at BayAreaLands.org.

What's New in CLN 2.0

Key Changes to the Network

Geographic Expansion and New Acreage Goals

A major update in CLN 2.0 is the expanded study area, which now includes Santa Cruz County, for an additional 284,800 acres. Expanding to Santa Cruz County was a natural move: it allows the network to fully incorporate the Santa Cruz Mountains biogeographic area, shared by San Mateo and Santa Clara counties.

The increased regional acreage goal (from 2 million to 2.5 million) is both a response to the addition of Santa Cruz County and representative of the vision of conserving half the Bay Area's lands. The time horizon was moved from 2030 to 2050, both to align with climate change projections and to set a realistic target date for the goal.

Revised Land Categories

The Conservation Lands Network categorizes lands within the network according to conservation value. The CLN 2.0 team modified the categories used in CLN 1.0, as described in Figure 3.1. Detailed methods for the designation of the land categories are in Appendix A.

Figure 3.1 ■ **Changes in Land Category Descriptions from CLN 1.0 to CLN 2.0.**

CLN 1.0 Land Category	CLN 2.0 Land Category	Description of Change	Implications
Areas Essential to Conservation Goals Planning units selected by Marxan at least 16 times out of 20 runs	**Areas Essential to Conservation Goals** Planning units selected by Marxan at least 16 times out of 20 runs, plus Stream Valleys	Stream Valleys were added post-Marxan, adding 101,572 acres of 57 different kinds of natural habitats (including 44 habitats considered upland).	Conservation of these lands should be a priority. They represent the most efficient pathway to achieving the conservation target goals, and promote connectivity and climate resilience.
Areas Important to Conservation Goals Planning units selected by Marxan 11-15 times out of 20 runs	**Areas Important to Conservation Goals** Planning units selected by Marxan 11-15 times out of 20 runs	No change.	These lands represent high conservation suitability and should be pursued wherever possible.
Fragmented Areas Essential or Important planning units with 25% or more of converted land	**Areas Essential to Conservation Goals** **Areas Important to Conservation Goals** **Edge Habitat (tag)**	Planning units are labeled by their original land class (Essential or Important) in CLN 2.0, regardless of % converted. Planning units are also tagged in the GIS attributes as "Edge Habitat" if the total converted proportion is 25% or greater. Many Edge planning units have high priority targets, but others are locked in according to the 10% protected rule, and may not have high priority targets. The Edge tag is meant to direct the user to probe into why that particular area was chosen, as well as highlighting the need for detailed ground surveys.	The Steering Committee determined that the term Fragmented implied lesser importance. Edge Habitat planning units can be especially important because: ■ Despite being in close proximity to development, the planning unit has high priority targets that cannot be met elsewhere, or ■ Areas of the network that are adjacent to converted lands have targets that are at particular risk from human impacts.

CLN 1.0 Land Category	CLN 2.0 Land Category	Description of Change	Implications
Areas For Further Consideration	**Areas that Ensure Network Connectivity ("Connectors")**	The Areas for Further Consideration (AFC) category was refined and renamed in CLN 2.0. In CLN 1.0, the project team designated as AFCs lands that were deemed to be important for inter- and intra-network connections, based on their expert opinion. The CLN 2.0 Steering Committee requested that a more objective analysis be used to designate network connectors. A least-cost paths method was used to select Connectors. Methodological details can be found in Appendix A.	Conserving Connectors between the core network areas (Essential and Important) facilitates ecological flows of animals and plants. It is important to note that the Connectors are not necessarily the only ways to connect core network areas, but they are the most efficient.
Other Lands	**Areas that Contribute to Conservation Goals** All natural areas that were selected 0-9 times	Name change in CLN 2.0.	While not identified as Essential or Important to achieve the habitat goals, it is true that all remaining natural lands in the Bay Area contain one or more CLN 2.0 conservation targets and contribute to regional goals.
Converted Lands	**Converted Lands**	No change.	

Rancho Cañada del Oro Open Space Preserve, Santa Clara County. Photo by Derek Neumann.

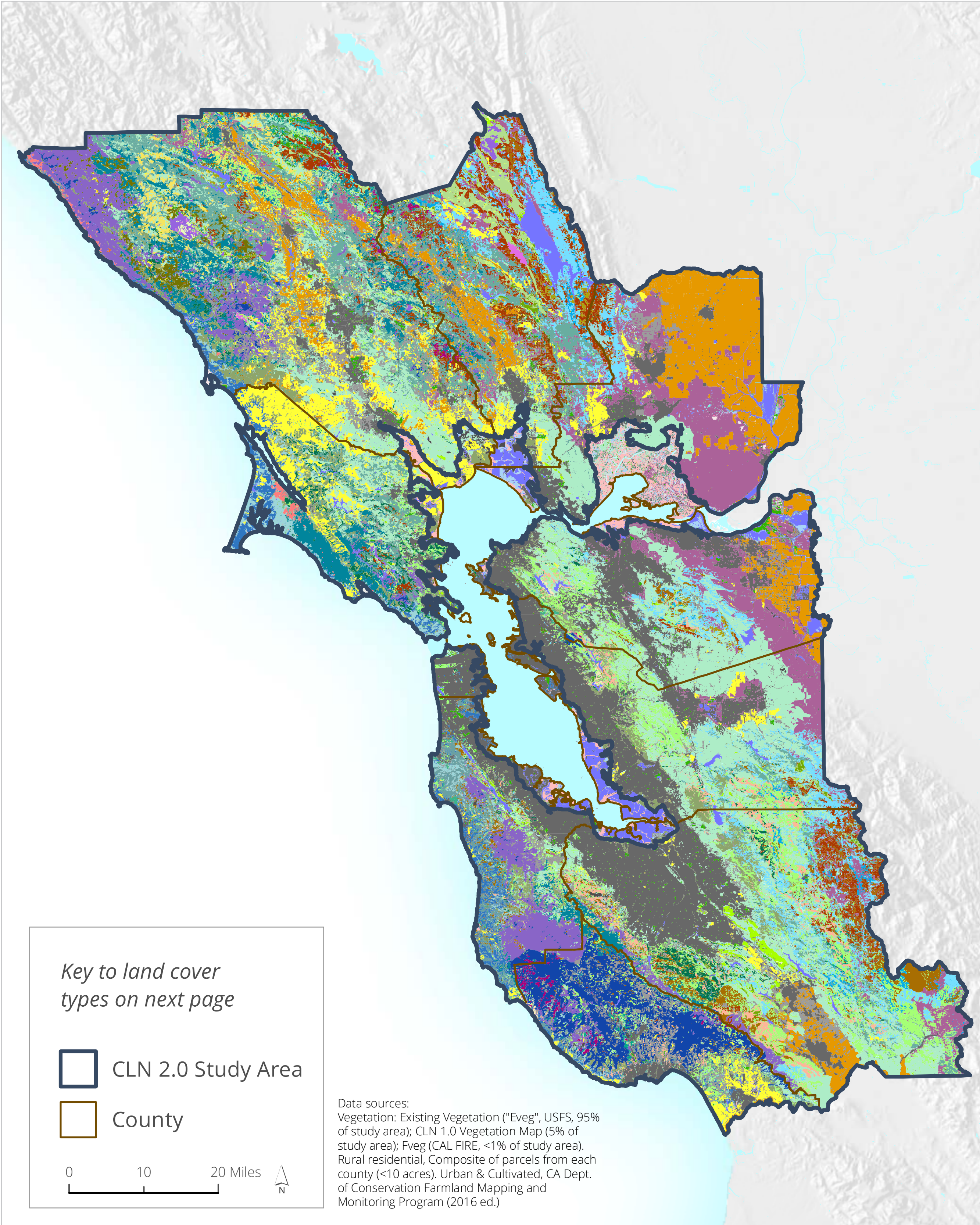
New Coarse-filter Conservation Targets

Coarse-filter conservation targets were based on a combination of 80 mapped natural vegetation communities (see Figure 3.3) and 36 subregions (landscape units; Figure 3.2). The individual vegetation type-landscape unit combinations formed 1,282 localized conservation targets, which served to represent the diversity of habitats in the Bay Area at the landscape unit scale.

The USFS Existing Vegetation (Eveg) dataset was used as the source of the vegetation communities map for CLN 2.0. Eveg uses the same classification system as the CLN 1.0 coarse-filter target map. Mapping methods were improved in the interim which resulted in new finer-scale polygons and additional vegetation classes being used. For example, CLN 2.0 has three willow classes that were labeled as Central Coast Riparian Forest in CLN 1.0. The bulk of the vegetation types were labeled the same (or experienced minor label change, *e.g.*, Coastal Terrace Prairie changed to Coastal Prairie). In all, there is a difference of 31 vegetation types between CLN 1.0 and CLN 2.0 (see Figure 3.4).

Figure 3.2 ■ Map of Landscape Units in Conservation Lands Network 2.0.

Figure 3.3 ■ **Map of Land Cover Types.** The 80 natural vegetation types were used for create the coarse-filter for CLN 2.0.



- Agriculture (General)
- Alkaline Flats
- Alkaline Mixed Grasses
- Alkaline Mixed Scrub
- Barren
- Beach Sand
- Bishop Pine
- Black Oak
- Blue Oak
- Blueblossom Ceanothus
- California Bay
- California Buckeye
- California Juniper (shrub)
- California Sagebrush
- California Sycamore
- Canyon Live Oak
- Ceanothus Mixed Chaparral
- Chamise
- Coast Live Oak
- Coastal Bluff Scrub
- Coastal Mixed Hardwood
- Coastal Prairie
- Cool Grasslands
- Coulter Pine
- Coyote Brush
- Cultivated
- Douglas-Fir - Ponderosa Pine
- Dune
- Eucalyptus
- Fremont Cottonwood
- Grand Fir
- Gray Pine
- High Water Line/Gravel/Sand Bar
- Hot Grasslands
- Interior Live Oak
- Interior Mixed Hardwood
- Intermittent Lake or Pond
- Knobcone Pine
- Lower Montane Mixed Chaparral
- Madrone
- Manzanita Chaparral
- McNab Cypress
- Mixed Conifer - Pine
- Moderate Grasslands
- Montane Mixed Hardwood
- Monterey Cypress
- Monterey Pine
- Non-Native/Ornamental Grass
- Non-Native/Ornamental Conifer
- Non-Native/Ornamental Conifer/Hardwood
- Non-Native/Ornamental Hardwood
- Non-Native/Ornamental Shrub
- North Coast Mixed Shrub
- Oregon White Oak
- Pacific Douglas-Fir
- Perennial Grasses and Forbs
- Pickleweed - Cordgrass
- Playa
- Ponderosa Pine
- Pygmy Cypress
- Red Alder
- Redwood
- Redwood - Douglas-Fir
- Riparian Mixed Hardwood
- Riparian Mixed Shrub
- Rural Residential
- Salal - California Huckleberry
- Saltbush
- Sargent Cypress
- Scrub Oak
- Serpentine Barren
- Serpentine Chaparral
- Serpentine Conifer
- Serpentine Grasslands
- Serpentine Hardwood
- Serpentine Riparian
- Serpentine Scrub
- Shreve Oak
- Tamarisk
- Tanoak (Madrone)
- Tule - Cattail
- Ultramafic Mixed Conifer
- Upper Montane Mixed Chaparral
- Urban
- Valley Oak
- Vegetated Dune
- Vernal Pool
- Warm Grasslands
- Wedgeleaf Ceanothus
- Water
- Wet Meadows
- White Alder
- Willow
- Willow (Shrub)
- Willow - Alder

Figure 3.4 ■ **Coarse-filter Vegetation Type Descriptions.** Vegetation types updated in CLN 2.0 are marked with an asterisk (*).

Vegetation Type	Description
Barren [Rock/Soil/Sand/Snow]	
Alkaline Flats *	Small barren areas in dry, inland locations; flooded in winter but dry out completely by late summer, creating saline or alkaline conditions in which vascular vegetation is effectively absent
Barren	Area of no vegetation cover: large rock outcrops in mountains, and barren areas in urban areas
Beach Sand *	Coastal or estuarine sand
Dune	Sandy soils with some active sand movement supporting low stands of diverse native perennials and beach grass, sometimes with small swale wetlands
Coniferous Forests	
Bishop Pine	Overstory dominated by Bishop pine
Coulter Pine	Open stands of Coulter pine with shrub and grass understory
Douglas-Fir - Ponderosa Pine	Dense to moderate stands of Douglas-fir sharing canopy dominance with ponderosa pine
Grand Fir	Dense forest dominated by grand fir
Gray Pine	Dense to open mixed stands of gray (aka foothill) pine and blue oak with an understory of shrubs and grasslands
Knobcone Pine	Dense to moderate stands of knobcone pine, often with shrub understory
Mixed Conifer - Pine	Dense forests with pines, firs, and other conifers with secondary hardwoods and shrub understory
Monterey Cypress	Planted stands of Monterey cypress
Monterey Pine	Native stands of Monterey pine (San Mateo County coast), and planted stands in other areas
Pacific Douglas-Fir	Overstory dominated by Douglas-fir, with montane hardwood species as secondary canopy cover and occasional redwoods in mesic pockets
Ponderosa Pine	Inland forests with overstory ponderosa pine
Pygmy Cypress	Scattered stands on Sonoma County coast occurring up to 1650ft, confined to poorly-drained acid soils derived from sandstones
Redwood	Dense forest dominated by redwood
Redwood - Douglas-Fir	Overstory dominated by redwood with a secondary canopy cover of Douglas-fir and tanoak
Ultramafic Mixed Conifer *	Moderate stands of Douglas-fir and manzanita on mineral-poor soils
Hardwood Forests	
California Bay	Dense stands dominated by California bay with secondary canopy of diverse hardwoods
California Buckeye *	Dense to moderate stands dominated by California buckeye
Coastal Mixed Hardwood	Dense to moderate stands of coast live oak, California bay, and Oregon oak, with no single dominant species
Interior Mixed Hardwood	Dense to moderate stands of Oregon oak, canyon live oak, and blue oaks, with lesser amounts of California bay and coast live oak
Madrone	Dense to moderate stands dominated by madrone
Montane Mixed Hardwood	A diverse array of oaks, madrone, buckeye, bay, and other hardwoods with scattered conifers and dense canopy cover; composition varies substantially with local climate
Tanoak (Madrone)	Dense to moderate stands dominated by tanoaks with secondary cover of montane hardwoods, Douglas-fir, and redwood
Herbaceous	
Alkaline Mixed Grasses *	Herbaceous species adapted to alkaline and hyper-saline soils
Coastal Prairie	Diverse grasslands with native perennial grasses and forbs, scattered shrubs
Cool Grasslands	Grasslands dominated by annuals, with varying amounts of native perennials, where July maximum temperatures are less than 23° C
Hot Grasslands	Grasslands dominated by annuals, where July maximum temperatures are greater than 31° C
Moderate Grasslands	Grasslands dominated by annuals, with varying amounts of native perennials, where July maximum temperatures are between 23° and 27° C
Perennial Grasses and Forbs	Grasslands that have been explicitly identified as having a large proportion of native perennial grasses
Pickleweed - Cordgrass	Tidally influenced wetlands with Spartina, rushes, and other salt-tolerant plants
Vegetated Dune *	Sandy soils with some active sand movement supporting low stands of diverse native perennials and beach grass, sometimes with small swale wetlands
Vernal Pool *	Seasonal, depressional wetland with various vernal pool-adapted herbaceous plants
Warm Grasslands	Grasslands dominated by annuals, with varying amounts of native perennials, where July maximum temperatures are between 27° and 31° C
Wet Meadows	Low-growing vegetation in wet areas dominated by sedges, rushes, and grasses

Oak Forests / Woodlands	
Black Oak	Dense to open stands dominated by black oak; other montane hardwoods, and conifers present as secondary canopy cover
Blue Oak	Dense to open nearly pure stands of blue oak with largely grassland understory
Canyon Live Oak	Dense stands of canyon live oak
Coast Live Oak	Dense to open stands dominated by coast live oak and secondary cover by other oaks and hardwoods
Interior Live Oak	Dense to open stands of interior live oak with scrubby or grassland understory
Oregon White Oak	Moderate to open stands dominated by Oregon oak
Valley Oak	Moderate to open stands dominated by valley oak
Shreve Oak *	Dense stands of Shreve oak mixed with Douglas-fir, knobcone pine, and California bay
Riparian	
California Sycamore	Moderate to open stands of California sycamore along streams
Tule - Cattail	Stands of tule, bulrushes, and cattails along freshwater shorelines
Fremont Cottonwood *	Moderate to open stands of Fremont cottonwood along streams
Red Alder *	Dense to open stands of red alder along streams
Riparian Mixed Hardwood *	Dense to moderate stands of tree willow, cottonwood, white and red alder, with no single dominant species
Riparian Mixed Shrub *	Dense to moderate stands of shrub willow and shrubby alder, with no single dominant species
White Alder *	Dense to moderate stands of white alder along streams
Willow - Alder *	Dense to open stands of tree willow along streams sharing dominance with white and red alder
Willow (shrub)*	Dense to moderate stands of shrub willow
Willow *	Dense to moderate stands of tree willow
Serpentine variants	
McNab Cypress	Dense to moderate stands of McNab cypress on serpentine rock
Sargent Cypress	Dense to moderate stands of Sargent cypress on serpentine rock
Serpentine Barren	Barren / rock on serpentine rock
Serpentine Chaparral	Chaparral on serpentine rock dominated by leather oak
Serpentine Conifer	Coniferous forest on serpentine rock
Serpentine Grasslands	Grassland on serpentine rock
Serpentine Hardwood	Hardwood types (oaks, montane hardwoods, etc.) on serpentine rock
Serpentine Riparian	Riparian forest on serpentine rock
Serpentine Scrub	Coastal or semi-desert scrub on serpentine rock
Shrublands	
Alkaline Mixed Scrub *	Succulent shrub lands dominated by the halophytes iodine bush or several seepweed species
Blueblossom Ceanothus *	Dense shrub stands dominated by blueblossom
California Juniper (shrub)	Dense shrub stands dominated by California juniper
California Sagebrush *	Moderate to open stands dominated by California sagebrush
Ceanothus Mixed Chaparral *	Dense shrublands with diverse species, including ceanothus, manzanita, *Prunus*, toyon, and other shrubs; composition varies substantially with local climate
Chamise	Dense shrub stands dominated by chamise
Coastal Bluff Scrub	Coastal scrub types (saltbush, heather goldenbush) dominate
Coyote Brush *	Dense to open stands dominated by coyote brush
Lower Montane Mixed Chaparral *	Dense to moderate stands of chamise, ceanothus, manzanitas, and shrubby California buckeye
Manzanita Chaparral *	Dense to moderate stands dominated by manzanita species
North Coast Mixed Shrub *	Dense to open stands of manzanita, bush chinquapin, shrub tanoak
Salal - California Huckleberry *	Salal and California huckleberry occurring on moist, productive soils
Saltbush *	Moderate to open stands dominated by saltbush
Scrub Oak	Dense to moderate stands of coyote brush, ceanothus, poison oak, sage, sagebrush, and diverse other shrubs with grassy openings
Upper Montane Mixed Chaparral	Diverse dense shrub community at elevations above 3000ft; various species of manzanita, ceanothus, and other shrubs
Wedgeleaf Ceanothus *	Dry and disturbed sites dominated by wedgeleaf ceanothus

New Fine-filter Targets

Fine-filter targets are species or small-scale habitats such as ponds. Incorporating data for fine-filter targets in Marxan ensures that the network captures species and habitats that may not be adequately covered by coarse-filter targets. The CLN 2.0 team retained all CLN 1.0 fine-filter targets with updated presence data, and added six new datasets, shown in Figure 3.5.

A well-managed cattle pond near Pacheco Pass, Santa Clara County. Photo by Stuart Weiss.

Figure 3.5 ■ Fine-filter Target Datasets in CLN 2.0. Datasets new in CLN 2.0 are marked with an asterisk (*).

Target	Type	Source	Target Count	Occurrence Count (points) or Acreage (polygons)
Rare plants	Point	California Natural Diversity Database (CNDDB; CDFW)	1,636	2,879 points
Ponds	Point	Bay Area Aquatic Resource Inventory (SFEI); National Wetland Inventory (NWI)	36	9,891 points
Northern Spotted Owl areas	Point	CDFW	9	3,664 points
Alameda Whipsnake	Point	Swaim Biological	5	84 points
Santa Rosa Plain listed plants	Point	CNDDB; Laguna de Santa Rosa Foundation	5	102 points
California Tiger Salamander	Point	CNDDB; David Cook	17	422 points
Vernal pools	Point	NWI	5	37 points
Water bird colony sites *	Point	San Francisco Bird Observatory	8	40 points
Old-growth redwood	Polygon	Save the Redwoods League	6	25,241 acres
Vernal pools (Napa County) *	Polygon	CDFW	18	43,536 acres
Santa Cruz cypress *	Polygon	Jodi McGraw Consulting	2	405 acres
Sandhills habitat *	Polygon	Jodi McGraw Consulting	2	5,892 acres
Large diverse conifer forests Sonoma County *	Polygon	Sonoma Veg Map	3	8,137 acres
Maritime chaparral *	Polygon	CNDDB; Todd Keeler-Wolf	12	21,789 acres

Updated Conservation Suitability Index to the Marxan Analysis

As in CLN 1.0, the project team used a conservation suitability index data layer in the Marxan analysis (Figure 3.6). This is a calculated value for each planning unit (250ac-hexagon), based on three measures that contribute to and represent habitat degradation and fragmentation. While the definition and calculation of this index remained the same as in CLN 1.0, each factor was re-analyzed with updated input data that also included Santa Cruz County.

Population density: Population density is an estimate of average population per acre within each planning unit. CLN 2.0 again used the USGS Dasymetric Mapping Tool, which spatially allocates population values to land use classes (*e.g.*, low, medium, and high density land use classes). Population values were acquired from the 2016 US Census estimate. The 2011 National Land Cover Dataset was used for the land use input.

Distance to roads: As with CLN 1.0, Tiger Line data were used for road density. Since CLN 1.0, this dataset has seen significant expansion in mapped roads, especially ranch roads.

Parcel density: Parcel density is the number of parcels per planning unit. Data on parcels for Solano County have become available since CLN 1.0, and updated parcel data were used for all 10 counties in the study area.

Making the Final Connections

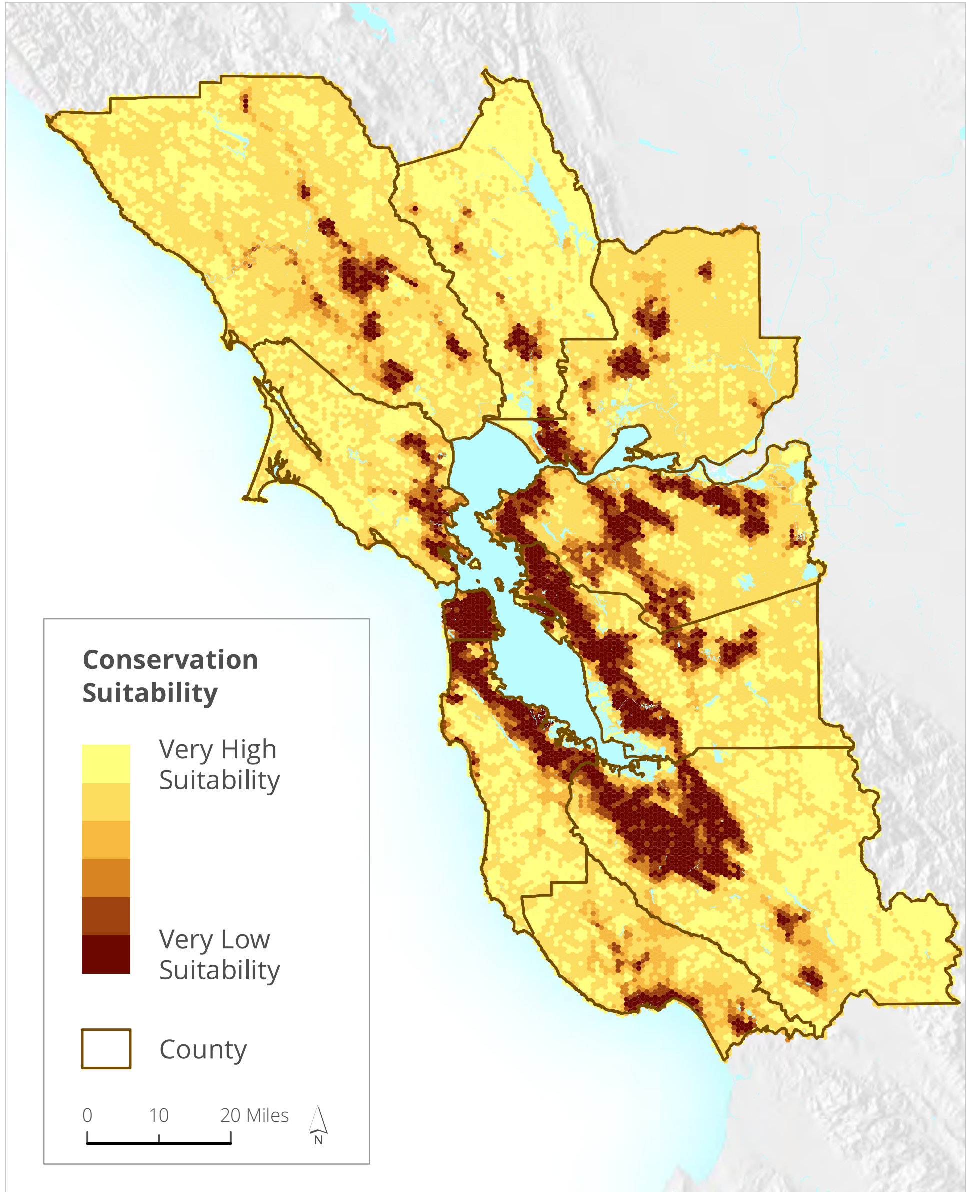
Connectivity is a central principle of conservation network design. Ecological flows of animals and plants between core areas need to be maintained, which is often difficult in highly modified landscapes. Conservation corridors between core areas ("Connectors") should follow high permeability areas, be as short as possible, and be at least 1.2mi (2km) wide (Beier 2017).

The CLN design process attempts to build in connectivity within and between landscape units using Marxan tools: locking in protected lands and adjacent areas and rewarding compactness through the Boundary Length Modifier. While this is a great first step, building a truly connected network requires ex post facto adjustments after the core areas have been delineated.

In CLN 1.0, this final connectivity was manually added via designation of "Areas for Further Consideration" (AFCs), planning units that would create connectivity across obvious gaps. The rationale for each AFC was explained in Chapter 10 of the CLN 1.0 report.

In CLN 2.0, the Steering Committee advised adoption of a more objective method. The CLN 2.0 team focused on core areas — discontinuous areas greater than 300ac — and calculated the most efficient path between them (via a least-cost paths analysis) that avoids impermeable (developed) areas. The planning units within .3mi (.5km) of those paths were designated as "Areas that Ensure a Connected Network" or "Connectors." This worked well, as planning units are approximately 0.6mi (1km) wide, and two of them together provide a reasonable width for a corridor, in line with the 1.2mi width suggested by Beier (2017). These core areas are also linked by stream valleys, which tend to be quite narrow and are suitable only for some species.

Figure 3.6 ■ **Map of Conservation Suitability across the Bay Area.** Conservation suitability is a metric of conservation value based on population density, distance to roads, and parcel density.



Long-tailed weasel in culvert under Highway 101. Wildlife camera photo by Pathways for Wildlife

Science Update: New Datasets

In addition to updating the many datasets carried over from CLN 1.0, CLN 2.0 provided an opportunity to expand this vast set of conservation datasets. The subject matter experts on the CLN 2.0 team identified and developed a number of new datasets to fill gaps and meet new opportunities for funding and partnership.

Watersheds and Fish

- **Stream valleys** — Geomorphically-derived stream valleys, a representation of the zone that influences or is influenced by the stream over time, are classified based on current land use data as 1) natural/semi-natural, 2) urbanized, or 3) converted to agriculture. The purpose is to help shift conservation strategy to include long-term stream needs, promoting the protection of intact stream valleys and restoration of altered stream valleys.
- **Headwater contribution zones** — An estimate of the zones of primary water, sediment, and nutrient contribution to Bay Area streams. Conservation organizations can use this information to identify areas important for maintaining, restoring, or enhancing watershed function in the upper watershed (the headwaters) where goals are to minimize impervious surfaces and draws on groundwater.
- **Groundwater recharge for fish** — An overlay of priority fish-bearing watersheds with high groundwater recharge zones as mapped by the California Basin Characterization Model (Flint *et al.* 2018), a downscaled climate model tailored to the Bay Area. These data can help identify areas important for maintaining baseflow for fish during the Bay Area's dry season.

Drought

- **Vegetation Vulnerability to Drought** — A metric of drought stress at a fine scale, indicating a relative risk of existing vegetation loss as aridity advances over the landscape. Specifically, it is an estimate of the proximity to the edge of the climatic "comfort zone" for a given stand of vegetation, based on the climate variable Climatic Water Deficit. This dataset indicates vulnerability to drought across the CLN 2.0 vegetation targets. The intent is to help inform stewardship project managers of vegetation stands that may require extra consideration/effort (*e.g.*, managing soils for maximum moisture retention and below-ground flow, or restoring hydrologic connectivity lost to road building or other diversions).
- **Landscape Resilience** — An index that indicates the presence and accessibility of microhabitat options by quantifying both the permeability of the landscape and the diversity in potential "wetness" and "heat" based on topography (provided by The Nature Conservancy).

Landscape Connectivity

- **Omniscape** — An assessment of local habitat permeability (the degree to which a site is conducive to wildlife movement) across the entire study area (provided by The Nature Conservancy, TNC 2018).
- **Natural shorelines** — Areas where sea level rise and unimpeded landward expansion of tidal marshes can occur (provided by San Francisco Estuary Institute).

Omniscape

Produced by The Nature Conservancy, Omniscape analyzes possible pathways to other natural habitat from any given spot on the landscape.

Omniscape is a continuous surface that represents permeability. It uses an electrical flow-type algorithm to find multiple flow paths of least resistance across the landscape. It classifies the landscape onto two axes — permeability and channelization.

The benefit of Omniscape is that, for the first time in the Bay Area, the whole landscape contains relative values for connectivity to complement the discrete habitat corridors produced for the Bay Area Critical Linkages project (Penrod *et al.* 2013).

The Omniscape dataset (Figure 3.7) greatly advances our ability to interpret the relative importance of a given parcel to landscape connectivity in the Bay Area. Users can find it in the CLN 2.0 Explorer and Conservation Portfolio Report.

Visual Character

- **Visibility** — Areas visible from major roads and populated places. The purpose is to help residents advocate for and maintain the visual character of their communities.

Risk of Loss

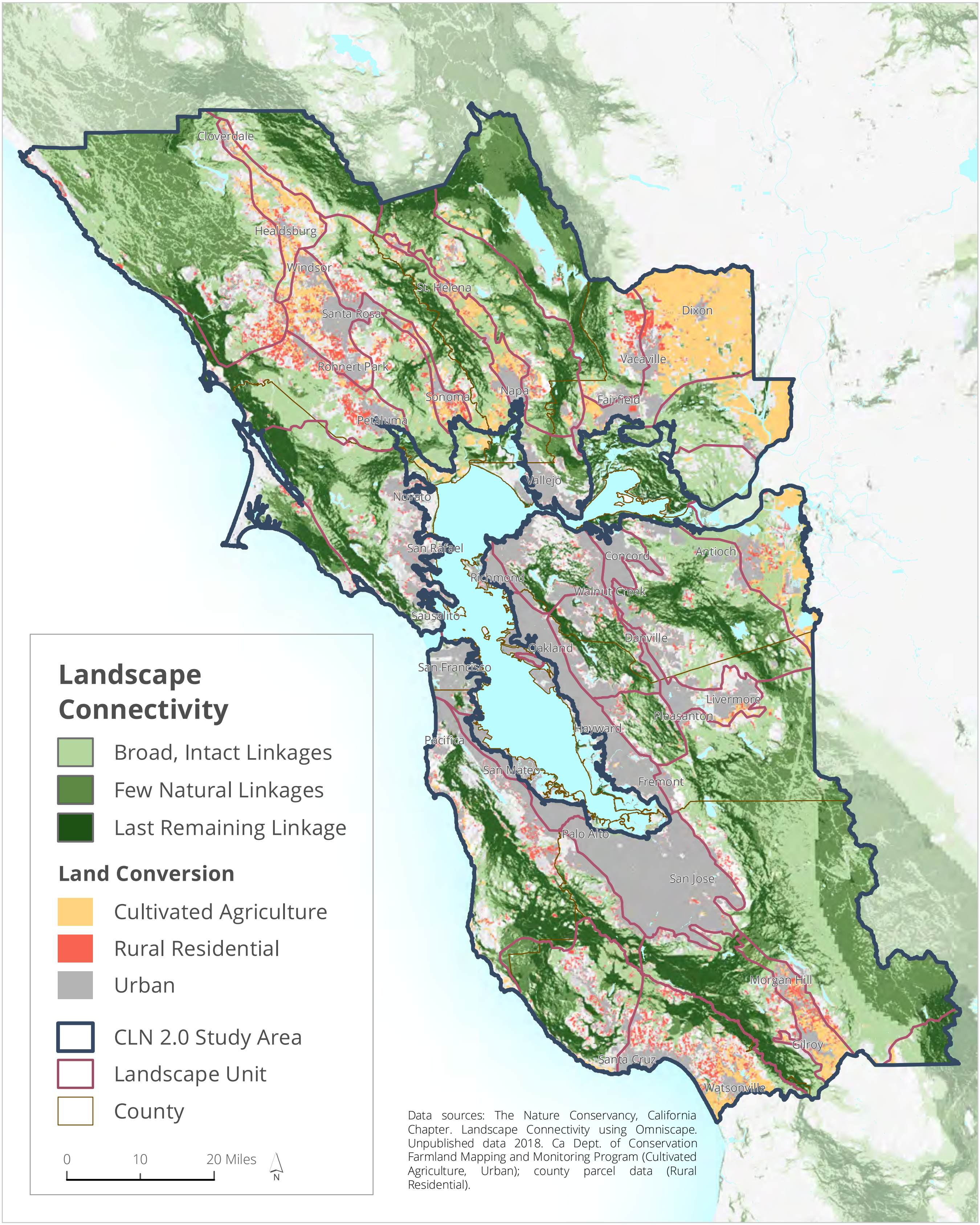
- **Subdivision potential** — An assessment of exurban and rural parcel subdivision potential based on residential zoning density (dwelling units per unit area) and existing structures.
- **Lands At Risk of Urban Sprawl** — Areas that face near- and medium-term threat of urban expansion (provided by Greenbelt Alliance).

Policy Protection

- **Environmental policies** — USFWS critical habitat, and local watershed and stream protection ordinances (provided by Greenbelt Alliance).

Martin Luther King Regional Shoreline in Oakland. Photo cc Damon Slough.

Figure 3.7 ■ Map of Landscape Connectivity as Analyzed with Omniscape.



Vulnerability to Drought: A Stewardship Inventory Tool

The CLN project team analyzed the climatic water deficit (drought stress) limits of each natural vegetation type in the CLN 2.0 vegetation map, and calculated the distance to those limits across the whole study area at a 270m scale. The results show how far away a given patch of vegetation is from its "comfort zone" (as defined by the 95th percentile of the entire distribution of that vegetation type sampled across the CLN 2.0 study area).

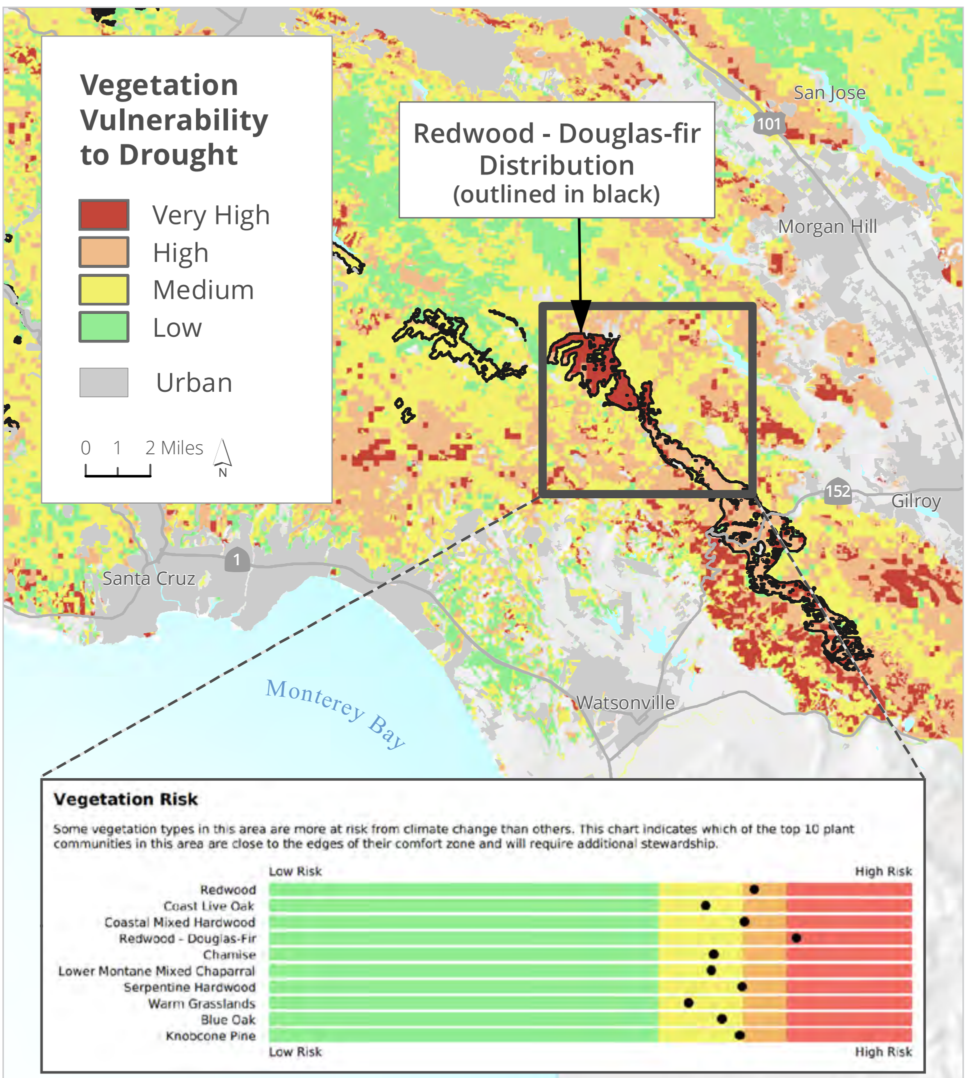
Areas found to be Very High Risk and High Risk represent the "trailing edge" of species distributions with regard to drought stress — these are the areas to watch in coming decades.

This dataset is based on a hypothesis with a solid premise: that each vegetation type has a maximum drought stress tolerance, as estimated by climatic water deficit (CWD). Increasing CWD is a robust climate projection. The power of this approach is that it is scenario-neutral (*i.e.*, not tied to any particular climate future), and employs empirical observations of CWD limits that make ecological sense.

The sample output from a Conservation Portfolio Report (Figure 3.8) serves as an example, showing that the stands of Redwood-Douglas-Fir forests on the eastern slope of Sierra Azul generally at Very High risk — that is, they are already in the top 5% climatic water deficit of that vegetation type.

Having identified that Redwood-Douglas-Fir forests here are at the edge of their drought tolerance, the next step is to examine the local topography. Are there mesic north-facing slopes, and canyon bottoms/lower slopes within that stand? These are the likely refugia. Conversely, does the vegetation type extend into more locally arid sites, like south-facing slopes and convex ridgetops? These are the sites most at risk.

Figure 3.8 ■ Sample Portion of Conservation Portfolio Report Showing Vegetation Vulnerability to Drought. Vegetation vulnerabililty to drought is a function of the distance to vegetation-specific climatic water deficit (drought stress) limits sampled across the study area. This sample shows Redwood-Douglas-Fir forests on the eastern slope of Sierra Azul, where the vegetation vulnerability to drought ranges from low to very high risk.



Data sources: CLN 2.0 Science Expansion Project. Vegetation: CLN 2.0 Vegetation Map; Climatic Water Deficit: CA Basin Characterization Model (Flint and Flint 2014); Urban: CA Dept. of Conservation (FMMP 2016).

Tracking Progress

Because the goals for the CLN conservation targets are specific and quantitative, progress can be measured by the acreages and occurrences captured by new protected lands (Figure 3.10). In 2014, the CLN 1.0 Progress Report did just that. Over three years (2011 to 2013), 100,556 acres were newly conserved by fee title or easement, per the 2010 and 2013 editions of the Bay Area Protected Areas Database (BPAD), and progress was reported on vegetation communities, rare communities, lands at risk, stream miles, recharge and runoff, and publicly accessible lands. Progress metrics were reported for different geographies as appropriate — counties (Figure 3.9), landscape units, and hydrologic areas. Conservation progress toward vegetation communities between CLN 1.0 and 2.0 (a total of 144,246 acres, per BPAD editions 2010 and 2018), is shown in Figure 1.3; additional progress metrics can be found at BayAreaLands.org.

Figure 3.9 ■ Protected Acreage, 2010 to 2018, as a Portion of Each County. The blue lines indicate county-level CLN 2.0 acreage goals. Note that some protected lands (for example, baylands) are outside the CLN study area. For specifics, see current BPAD data at **BayAreaLands.org.** Data sources: Bay Area Protected Areas Database (BPAD) 2010 and 2018 editions.

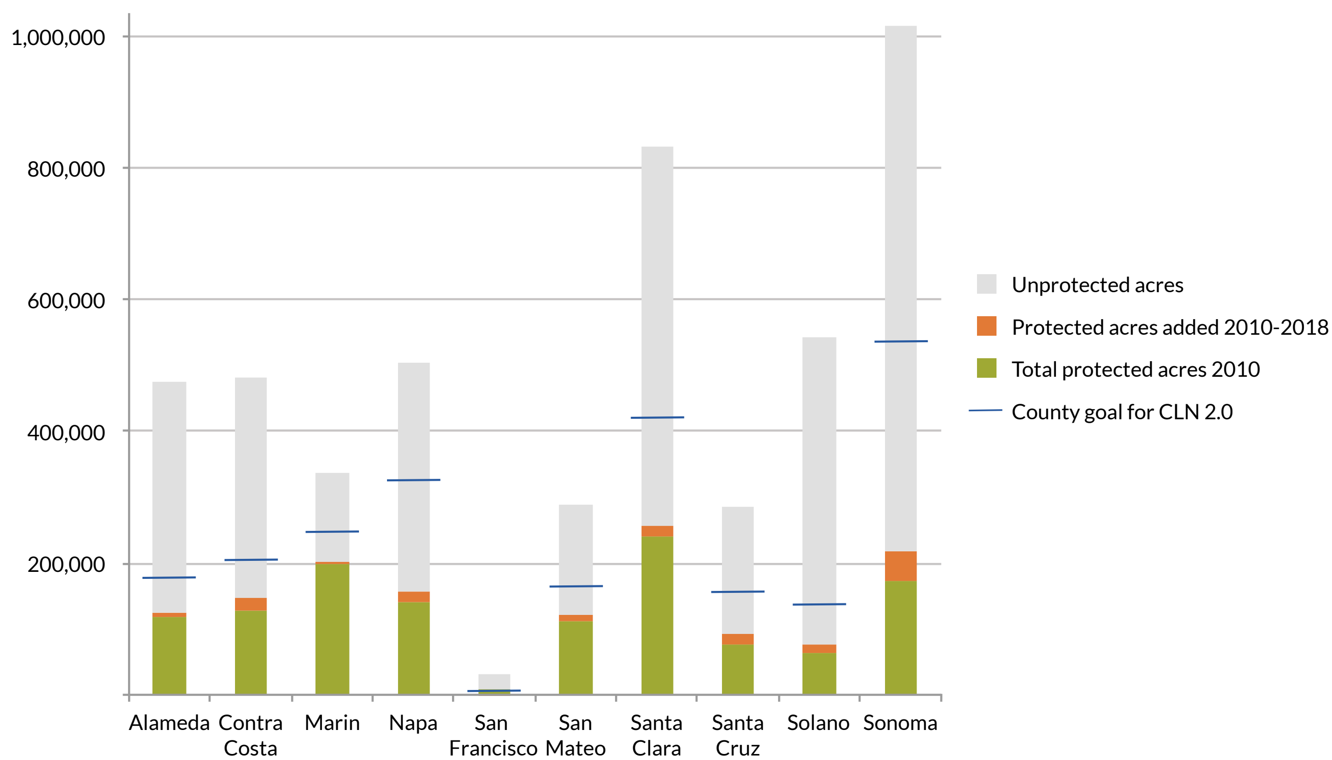
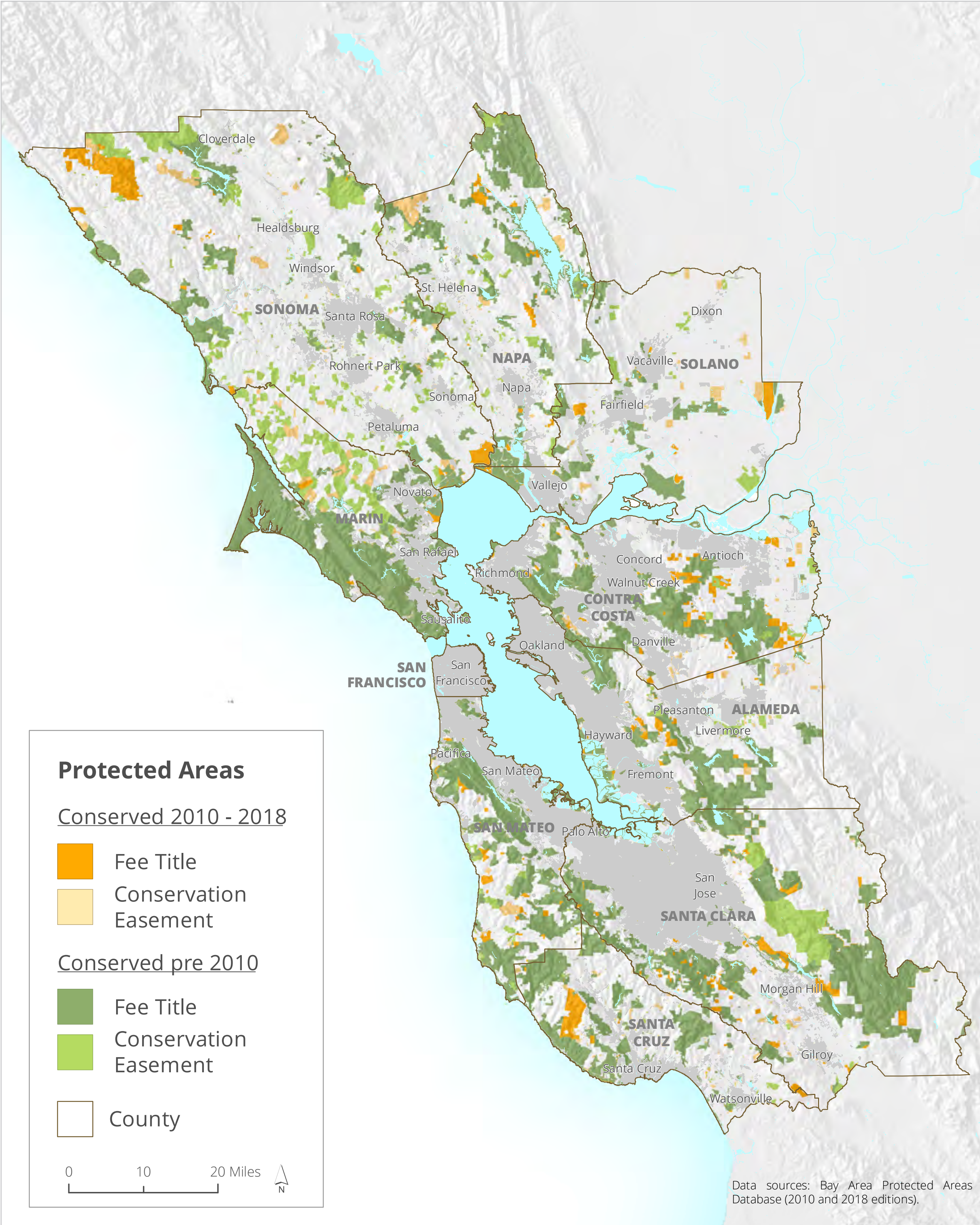


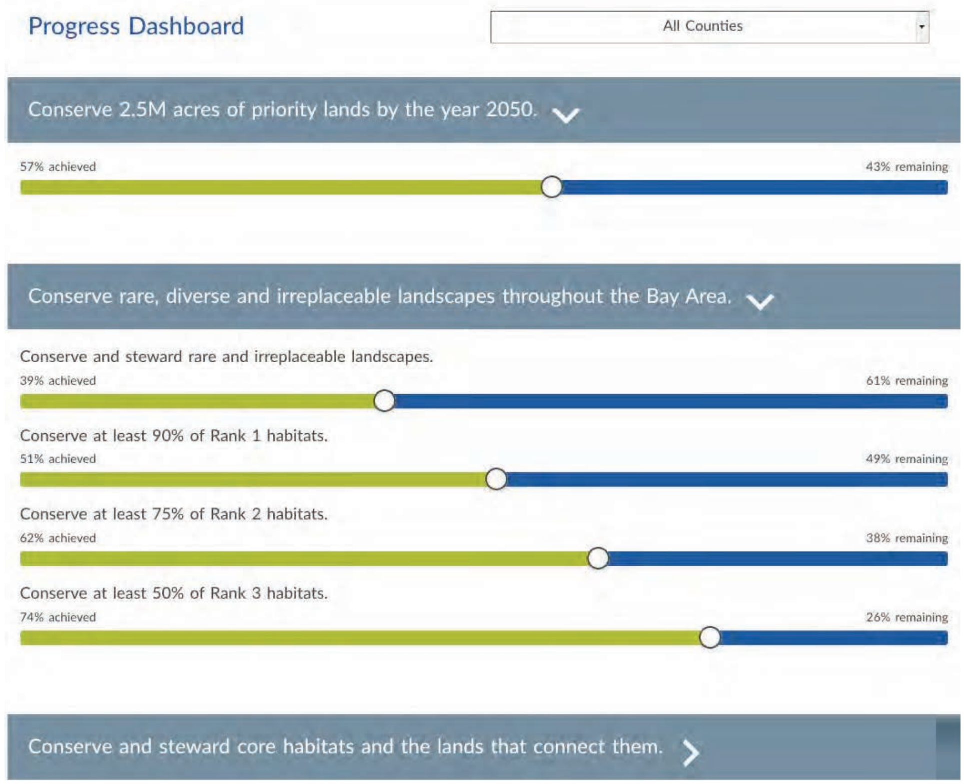
Figure 3.10 ■ Progress in Protected Areas, 2010 and 2018. Data from Bay Area Protected Areas Database (BPAD).



Progress Dashboard of Regional Conservation Goals

An online Progress Dashboard is new for CLN 2.0 (Figure 3.11). This provides a high-level, dynamic summary of success at the regional and county levels, and is designed for quick updates on an annual basis. The Conservation Lands Network team intends to compile more detailed progress metrics, as was done in the 2014 CLN 1.0 Progress Report, within several years of the launch of CLN 2.0.

Figure 3.11 ■ **Sample Progress Dashboard, Part of BayAreaLands.org.** The dashboard shows progress toward all of the CLN 2.0 goals by region and by county.



CHAPTER

4 Vegetation

Bishop Pine at Point Reyes. Photo by Stuart Weiss.

Overview

The complex vegetation of the Bay Area consists of more than 3,000 plant species that are the trophic foundation for the region's ecosystems, providing food and structure for the entire food web. Diverse vegetation mosaics reflect climatic variability at multiple scales, including the coastal-inland temperature/fog gradients, wet windward slopes versus rain-shadowed leeward slopes, sunlight differences between north- and south-facing slopes, frost pockets in protected valleys, and other topographic microclimates. Vegetation differences are accentuated by the Bay Area's semi-arid Mediterranean-type climate with its cool rainy season and long dry season, where a delicate water balance determines productivity, physiognomy, and species range limits.

Diverse climates are underlain by a tectonically active geologic mosaic, including nutrient-poor serpentine, rocky peaks, landslides, and rich alluvial deposits. Over time, broad biogeographic shifts from glacial to interglacial have left disjunct pockets of many species in the nooks and crannies of the mountains. Dynamic agents — including landslides, millennia of indigenous people "tending the wild" with fire and plantings, and more modern large-scale grazing and logging — have further shaped the current vegetation of the Bay Area (Anderson 2005, Barbour *et al.* 2007, Mooney and Zavaleta 2016).

Much has been lost. Conversion to urban and agricultural lands has eliminated natural vegetation from 31% (1.5M acres) of the 10-county Bay Area, concentrated in the rich valley bottoms but extending up into the foothills and mountains (Figure 4.1). Less intensive rural residential development impacts 5% of the Bay Area (222,350 acres). Even where forest canopy remains in the Bay Area, in many locations the middle and understory trees and shrubs have been replaced with structures, garden plants, and pavement. Once-common vegetation types such as valley oak woodland and riparian forest are now rare. Old-growth conifer forests along the coast have nearly vanished. More than 121 plant species in the Bay Area and Santa Cruz County are listed for federal and state protection, and many others are at risk.

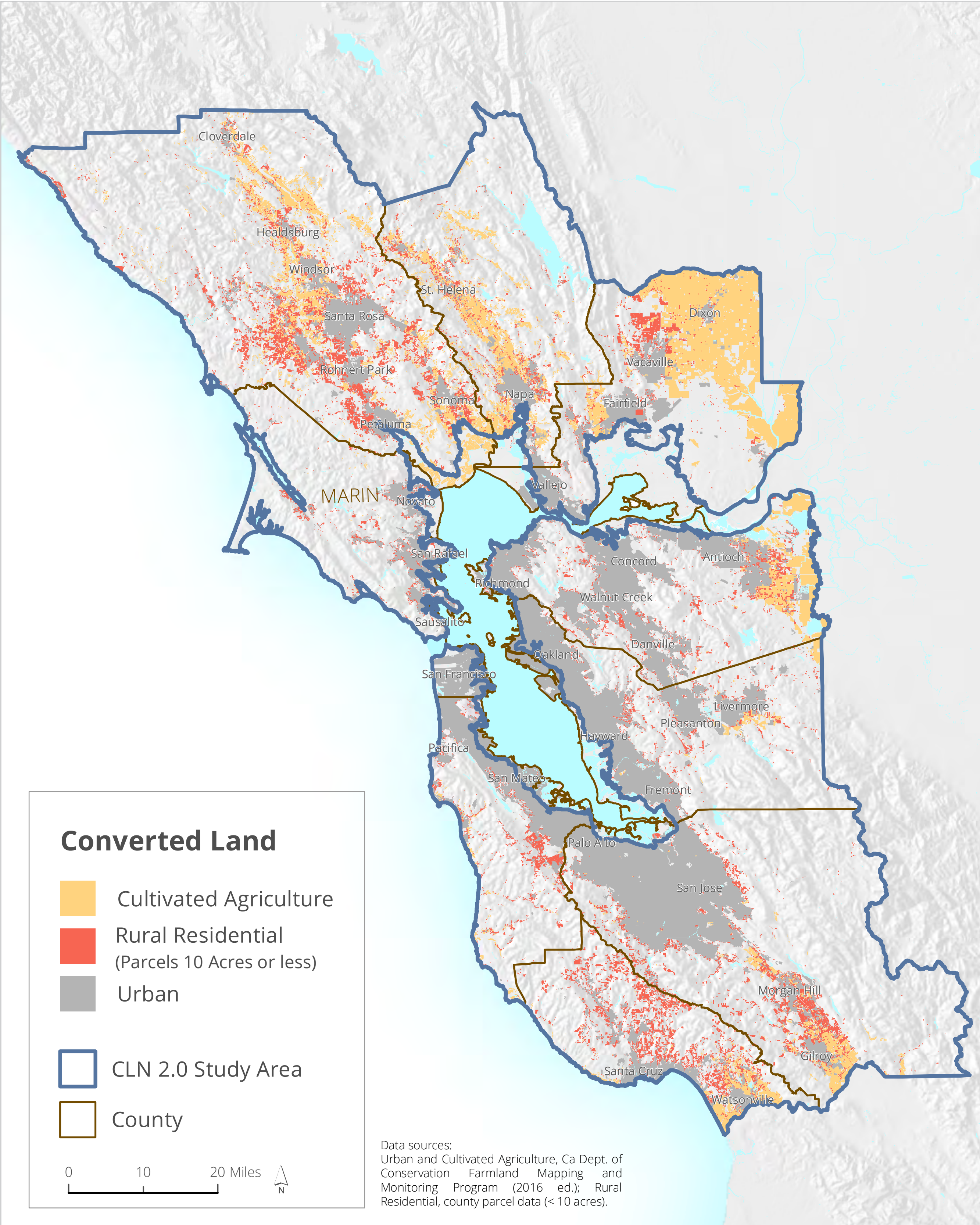
Smooth lessingia at Anderson Reservoir near Morgan Hill. Photo by Steve Rottenborn.

Despite the intense pressures of eight million people, more than 3.3M acres in the Bay Area are still in natural or semi-natural plant cover. Remote rugged mountain ranges still support near-wilderness where natural processes can play out across largely undeveloped landscapes. Some 1.4M acres have been protected from development (BPAD 2018). But in these protected lands, plant species are still at risk from numerous interacting factors including invasive species, nitrogen deposition from smog, aridification, intensifying wildfires and other effects of climate change, and vegetation succession in the absence of native ungulates, indigenous burning practices, and other natural disturbance regimes. Effective and adequately-funded stewardship is imperative to help sustain biodiversity through these challenges.

The gradients of vegetation composition are classified by scientists into plant assemblages, usually named for their dominant species (Sawyer *et al.* 2008). This classification, and the maps based on it, help define and illustrate ecological diversity and thus provide the foundation of the coarse-filter part of the CLN approach described in Chapter 3. The adoption of the USFS Existing Vegetation (Eveg) map in CLN 2.0 improved precision and accuracy over CalVeg, which was used in CLN 1.0. Like all vegetation maps, Eveg is imperfect, but it is still extremely useful at the ecoregional scale of the Conservation Lands Network.

The Eveg database formed the basis for the CLN 2.0 coarse-filter conservation targets. The goal of the vegetation coarse filter is to design a network that captures ecological diversity at local and regional scales, includes high representation of rare and important vegetation communities, and maintains connectivity within landscape units. Rare plant species and special habitats are considered as fine-filter targets.

Figure 4.1 ■ Map of Converted Lands in CLN 2.0.

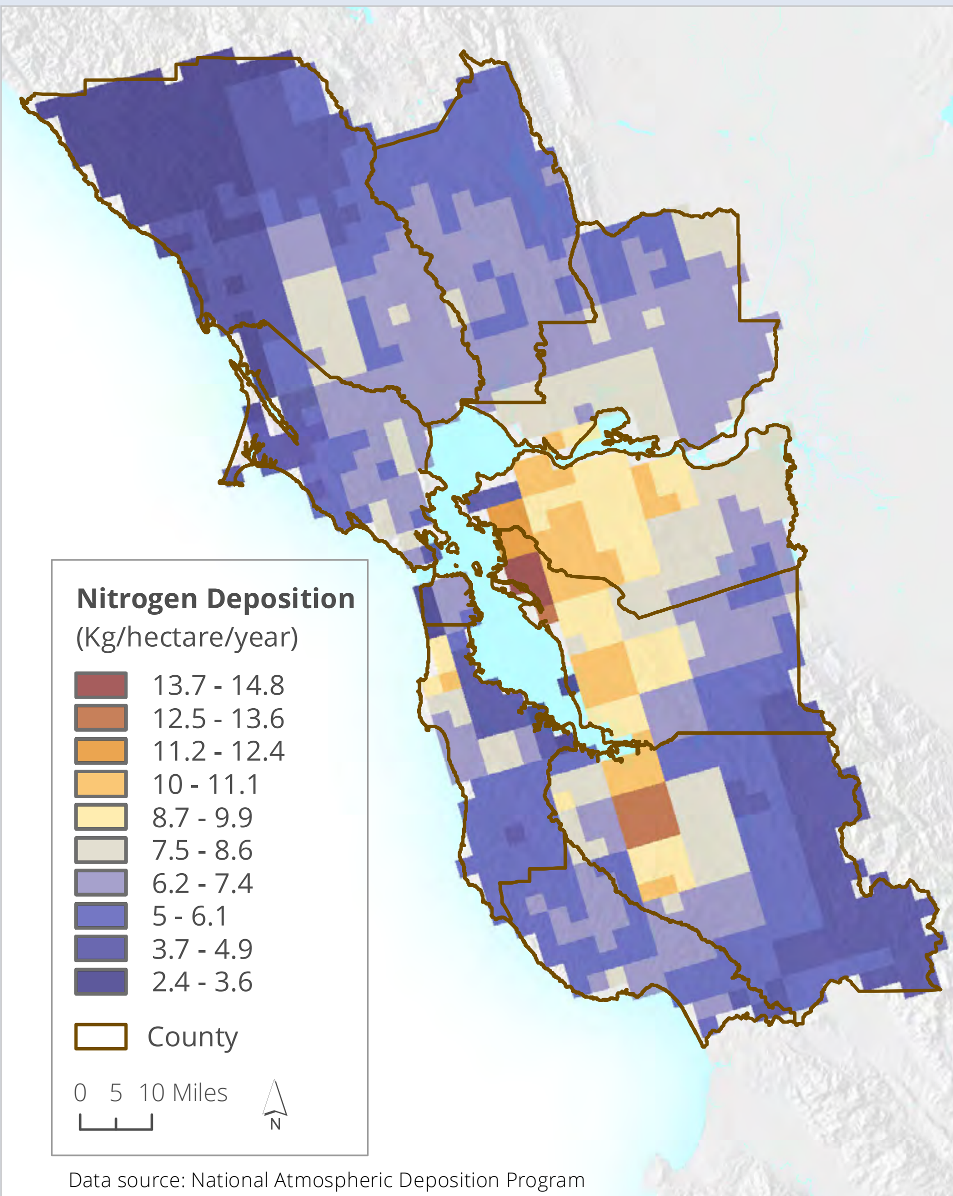


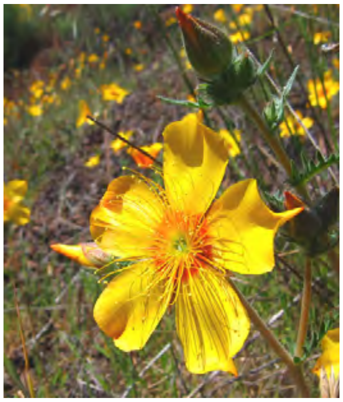
Grasslands are the most heavily modified vegetation type in the Bay Area as a result of non-native invasive grasses and forbs, many of which are such an integral part of the ecosystem that they might be better described as "naturalized" (Stromberg *et al.* 2007). California grasslands are the archetype of a "novel ecosystem" (Hobbs *et al.* 2009, Hallet *et al.* 2013), consisting of new species assemblages and modified ecosystem processes that are largely irreversible. Despite domination by the naturalized invasives, the region's grasslands still support a wealth of native biodiversity, albeit still under threat. The succession of grasslands to shrublands in the absence of fire and grazing indicates the anthropogenic origins dating to pre-contact periods of many grasslands, especially near the coast where climate and soils favor scrub and forest (Anderson 2005, Lightfoot and Parrish 2009, Cunningham 2010).

Many grassland-dependent species, including many listed species, are at risk from conversion to dense woody vegetation. Once grasslands are converted to scrub, it is extremely difficult to convert back to diverse native-dominated grassland. Woody plant control through mechanical and chemical means has been implemented on San Bruno Mountain to maintain essential patches of rich coastal prairie that support endangered butterflies (Weiss *et al.* 2015). Deliberate planning is needed to identify which areas to maintain as grassland in the coastal vegetation matrix, so that the limited resources available can be effectively deployed.

Atmospheric nitrogen deposition — fertilization from smog — intensifies annual grass growth. Across much of the Bay Area, nitrogen deposition levels exceed the grassland "critical load" of nitrogen (6kg/ha per year, Fenn *et al.* 2010) that leads to excessive annual grass growth and thatch buildup that smother remnant native plants and increase fine-fuel loads (see Figure 4.2). Nutrient-poor, species-rich serpentine grasslands are at particular risk (Weiss 1999). Livestock grazing has proven to be the only management method for annual grass control over large areas; in smaller areas (< 100 acres), rotational mowing has proven effective.

Figure 4.2 ■ Map of Nitrogen Deposition Patterns in the Bay Area.





Lindley's blazing star, a California endemic. Photo by Cait Hutnik.

Vegetation Conservation Targets and Network Protection

With these conservation targets in mind, the Vegetation Focus Team:

- Examined the new vegetation map based on Eveg data, and considered its suitability as a coarse filter that captures the broad habitats of the Bay Area and Santa Cruz County;
- Reviewed enhancements to Eveg, including serpentine variants; climatic stratification of grasslands; tall, structurally complex forests in Sonoma County; and others;
- Set vegetation rarity rankings for the 1,282 coarse-filter conservation targets used in the Marxan network analysis based on global, regional, and local rarity (see Appendix B for a full list of coarse-filter targets);
- Reviewed the coarse-filter network generated by Marxan; and
- Reviewed the fine-filter plant species targets for inclusion, provided additions and subtractions, and contributed species distribution data based on expert knowledge.

Coarse-filter conservation targets were derived from combining vegetation types with landscape units, as described in Chapter 3.

Key Focus Team Determinations for Vegetation Mapping

- Eveg, with the CLN 2.0 enhancements described below, represents ecological diversity at the appropriate resolution for a coarse filter, and offers improvements over the map product used in CLN 1.0 while retaining enough similarity to be used in the Marxan analysis with the same parameters as CLN 1.0.
- Fine-scale vegetation mapping with the *Manual of California Vegetation* (MCV) classification system would offer advantages over Eveg of greater floristic and spatial detail. While several Bay Area counties have been mapped at a fine scale using the MCV system (*e.g.*, Napa County, Sonoma County, and parts of the San Francisco Peninsula), total coverage (25%) is still inadequate to be used as a consistent inventory across the CLN 2.0 study area. Efforts are currently underway to map fine-scale vegetation in Marin and San Mateo counties. This will bring the total percent coverage of fine-scale vegetation maps to nearly half of the study area. Future updates to the CLN framework should utilize fine-scale maps.

Vegetation Data Sources

Dataset	Source	Use(s) in CLN 2.0 Network Design
CLN 2.0 Vegetation Map (polygons)	A composite of: ■ Existing Vegetation Map, Eveg (USFS, various updates 2001-2007) – 95% of study area ■ CLN 1.0 Vegetation Map – 5% of study area ■ Fveg (Cal FIRE 2015) – <1% of study area Modifications: ■ Added serpentine overlay (California Geological Survey; see below) ■ Climate stratification of grasslands (California Basin Characterization Model; see below)	The foundation of the coarse-filter conservation targets; described in detail in the following section
Serpentine geology (polygons)	California Geological Survey (2017)	Used to estimate presence of serpentine soils. Intersected with the vegetation map to add serpentine variants (*e.g.*, serpentine grassland, serpentine hardwood, etc.).
Average July maximum temperature, 1981-2010 (grid)	California Basin Characterization Model (2014)	Used to add variation to the large, single 'annual grasslands and forbs' vegetation class
Patches of maritime chaparral, which are characterized by the presence of certain indicator *Arctostaphylos* species (polygons)	■ Sonoma Veg Map (Sonoma County Vegetation Mapping and LIDAR Consortium) ■ CNDDB (multiple indicator *Arctostaphylos* stands), ■ Todd Keeler-Wolf (East Bay sites)	Use as fine-filter vegetation targets (occurrences in 12 landscape units)
Rare plant occurrences (points)	■ California Natural Diversity Database (CNDDB) (CDFW) ■ Laguna de Santa Rosa Foundation (Santa Rosa Plain listed plant species)	Use as fine-filter vegetation targets (1,641 total targets in all 36 landscape units)
Santa Cruz cypress stands (polygons)	Jodi McGraw Consulting	Use as fine-filter vegetation targets (2 targets; occurrences in 2 landscape units)
Sandhills (polygons)	Sandhills Conservation and Management Plan (McGraw 2004	Use as fine-filter vegetation targets (2 targets; occurrences in 2 landscape units)
Old-growth redwood (polygons)	Save the Redwoods League	Use as fine-filter vegetation targets (6 targets; occurs in 6 landscape units)
Tall complex conifer forests in Sonoma County	Bay Area Open Space Council using Sonoma County Vegetation Mapping and LIDAR Program data	Use as fine-filter vegetation targets (3 targets; occurs in 3 landscape units)

CLN 2.0 Vegetation Types

Foundational vegetation map

The foundation of the CLN 2.0 vegetation map, based on Eveg, included 85 vegetation cover types. Two modifications (see below) were made to improve its use as a habitat inventory; this resulted in 10 more unique vegetation types, for a total of 95 cover types in the final coarse-filter vegetation map (Figure 3.3). Of the 95 cover types, 80 were deemed natural and used to create the coarse-filter targets; the remaining 15 cover types were either non-native or non-vegetation (e.g., urban).

Modifications to grasslands using climate

As in CLN 1.0, the large Annual Grasslands class was stratified into four classes (Cool, Moderate, Warm, and Hot, according to mean July maximum temperature), to better represent the variability that is found within grassland communities of the region (see Chapter 4 in the CLN 1.0 report).

Average maximum temperature (June, July, and August) data from the California Basin Characterization Model (BCM) (Flint and Flint 2014) were used to stratify the grasslands. The BCM is based on PRISM, which was used in CLN 1.0; the BCM is a finer scale (270m grid versus 800m).

In order to maintain the spatial distribution of grassland climate types used in CLN 1.0, the team adjusted the temperature breaks chosen in the 1981-2010 July maximum temperature map upwards by ~1° C in order to account for observed temperature increases since the 1961-1990 averages used in CLN 1.0.

New geologic/serpentine overlay

Since serpentine habitats, which house unique assemblages of plants, are not well-mapped in Eveg, the CLN 2.0 again intersected a serpentine geology map with the vegetation map to create serpentine habitat classes (this is described in Chapter 4 in the CLN 1.0 report).

A new geology layer, published by the California Geological Survey (CGS) in 2017, was used in place of the USGS geology layer used in CLN 1.0. The Vegetation Focus Team visually inspected the two datasets and determined the CGS map better represented known stands of serpentine habitat.

Serpentine grasslands at Edgewood Park Natural and Preserve, San Mateo County. Photo by Frances Freyberg.

CLN 2.0 Coarse-filter Conservation Targets

The same process was used to identify and rank conservation targets as in CLN 1.0:

1. Select representative portions of each vegetation type across its range.
2. Rank vegetation types by rarity (Figure 4.3).
3. Set conservation goals for Rank 1 (90% protection), Rank 2 (75% protection), and Rank 3 (50% protection) targets.
4. Select and apply plant fine-filter targets to the coarse-filter analysis.

This process is described in detail, including rarity ranking, in Chapter 4 of the CLN 1.0 report.

The unique ecosystem at Antioch Dunes National Wildlife Refuge in Contra Costa County provides protection for three endangered species: Lange's Metalmark Butterfly, Antioch Dunes Evening primrose, and Contra Costa Wallflower. Photo by Stuart Weiss.

Figure 4.3 ■ Map of Coarse-filter Conservation Vegetation Targets by Rarity Rankings.

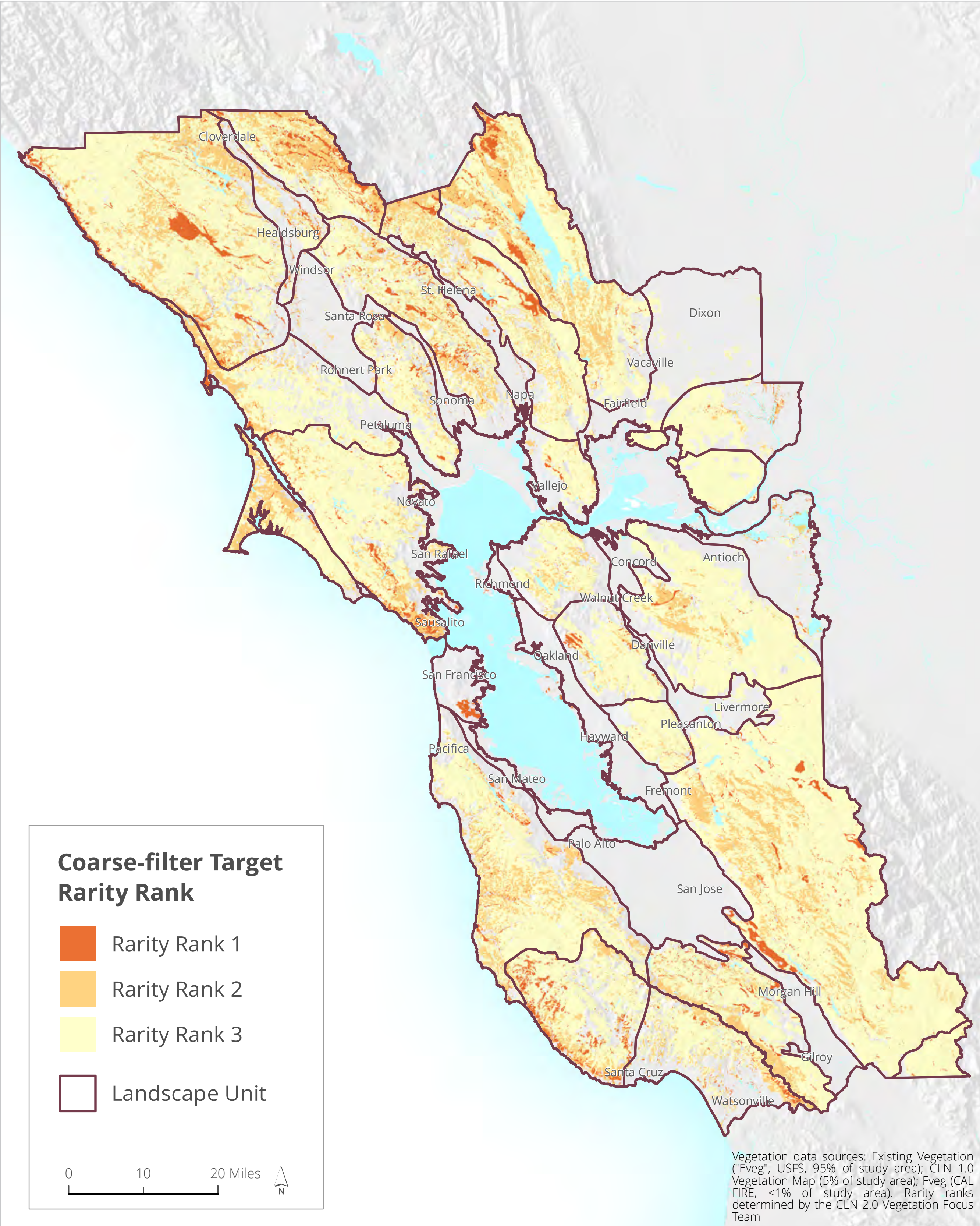


Figure 4.4 ■ **Vegetation Type Acreage Goals.** This table shows total acreage goals for each vegetation type (except those in Rarity Rank 4), the amount already protected (BPAD 2018), and the additional acreage required to meet the goals. A more detailed table showing acreage goals for vegetation types within each landscape unit is in Appendix B.

Vegetation Type	Total acres	CLN 2.0 acreage goals by Rarity Rank			Total acreage goals	Protected acres, 2018	Acres remaining to meet goals
		Rank 1 90% goal	Rank 2 75% goal	Rank 3 50% goal			
Agriculture (General) *	66,875	-	-	33,438	33,438	27,342	8,658
Alkaline Flats	41	16	17	-	33	10	23
Alkaline Mixed Grasses	628	89	397	-	485	211	274
Alkaline Mixed Scrub	285	256	1	-	257	44	212
Barren	6,284	-	4,713	-	4,713	1,695	3,054
Beach Sand	332	-	249	-	249	299	1
Bishop Pine	6,947	3,258	2,495	-	5,753	4,214	2,059
Black Oak	4,278	2,400	1,208	-	3,608	776	2,835
Blue Oak	189,203	1,060	6,808	89,474	97,342	74,744	26,575
Blueblossom Ceanothus	16	-	12	-	12	12	2
California Bay	47,464	6	12,651	15,295	27,952	28,349	6,149
California Buckeye	110	-	83	-	83	41	41
California Juniper (shrub)	191	-	143	-	143	191	-
California Sagebrush	37,399	718	4,761	15,126	20,606	22,411	1,428
California Sycamore	255	229	-	-	229	100	135
Canyon Live Oak	7,180	150	5,260	-	5,410	2,034	3,382
Ceanothus Mixed Chaparral	5,076	-	3,807	-	3,807	542	3,265
Chamise	96,023	448	22,029	33,076	55,554	47,844	9,074
Coast Live Oak	228,279	31	20,931	100,168	121,130	104,337	25,421
Coastal Bluff Scrub	5	-	4	-	4	5	-
Coastal Mixed Hardwood	59,588	-	31,598	8,729	40,327	29,853	13,160
Coastal Prairie	2	2	-	-	2	-	2
Cool Grasslands	59,633	13,978	33,077	-	47,055	37,906	12,537
Coulter Pine	258	232	-	-	232	67	172
Coyote Brush	61,684	-	22,328	15,957	38,285	44,026	5,130
Douglas-Fir - Ponderosa Pine	9,565	27	7,151	-	7,178	3,453	3,726
Dune	679	562	41	-	603	411	205
Fremont Cottonwood	1,133	1,020	-	-	1,020	47	973
Gray Pine	32,604	501	24,036	-	24,537	13,519	11,062
Hot Grasslands	278,152	-	11,799	131,210	143,009	63,060	79,968
Interior Live Oak	9,030	-	6,773	-	6,773	4,922	2,126
Interior Mixed Hardwood	276,375	-	9,784	131,665	141,449	87,226	57,042
Intermittent Lake or Pond	240	-	180	-	180	154	56
Knobcone Pine	13,157	10,173	1,390	-	11,564	6,823	4,810
Lower Montane Mixed Chaparral	144,740	-	31,490	51,376	82,867	47,232	36,560
Madrone	1,549	-	1,162	-	1,162	78	1,090
Manzanita Chaparral	265	-	199	-	199	110	99
McNab Cypress	9,715	8,744	-	-	8,744	5,602	3,234
Mixed Conifer - Pine	445	-	334	-	334	328	57
Moderate Grasslands	91,954	-	37,027	21,292	58,319	44,555	17,567
Montane Mixed Hardwood	38,177	-	4,438	16,130	20,568	10,222	10,346
Monterey Cypress	104	-	78	-	78	73	6
Monterey Pine	2,571	531	-	991	1,521	1,879	400

Vegetation Type	Total acres	CLN 2.0 acreage goals by Rarity Rank			Total acreage goals	Protected acres, 2018	Acres remaining to meet goals
		Rank 1 90% goal	Rank 2 75% goal	Rank 3 50% goal			
North Coast Mixed Shrub	2,128	-	1,596	-	1,596	1,404	275
Oregon White Oak	37,603	1,405	27,031	-	28,436	5,440	22,997
Pacific Douglas-Fir	163,489	-	12,996	73,080	86,077	73,017	27,626
Perennial Grasses and Forbs	1,927	812	769	-	1,581	848	740
Pickleweed - Cordgrass	1,336	854	290	-	1,144	964	222
Playa	48	-	36	-	36	-	36
Ponderosa Pine	3,197	1,283	1,329	-	2,612	1,735	1,026
Pygmy Cypress	113	102	-	-	102	113	-
Red Alder	173	94	52	-	146	103	48
Redwood	119,731	1,606	5,592	55,245	62,443	53,170	9,458
Redwood - Douglas-Fir	173,832	4,107	10,309	77,762	92,177	63,607	31,958
Riparian Mixed Hardwood	8,482	7,634	-	-	7,634	3,633	4,008
Riparian Mixed Shrub	703	633	-	-	633	167	466
Salal - California Huckleberry	11	-	8	-	8	11	-
Saltbush	0	-	0	-	0	-	0
Sargent Cypress	2,971	2,674	-	-	2,674	2,319	528
Scrub Oak	9,252	-	6,939	-	6,939	3,130	3,810
Serpentine Barren	1,068	961	-	-	961	801	168
Serpentine Chaparral	40,020	11,637	20,317	-	31,954	19,993	12,002
Serpentine Conifer	7,858	7,072	-	-	7,072	3,526	3,552
Serpentine Grasslands	16,473	14,826	-	-	14,826	7,561	7,265
Serpentine Hardwood	14,865	13,379	-	-	13,379	5,145	8,251
Serpentine Riparian	65	58	-	-	58	14	44
Serpentine Scrub	614	546	5	-	552	338	232
Shreve Oak	130	117	-	-	117	102	15
Tanoak (Madrone)	25,343	-	378	12,420	12,797	5,922	6,887
Tule - Cattail	4,238	191	3,020	-	3,210	2,277	940
Ultramafic Mixed Conifer	6	6	-	-	6	0	5
Upper Montane Mixed Chaparral	11	-	8	-	8	8	1
Valley Oak	6,448	5,803	-	-	5,803	2,620	3,184
Vegetated Dune	93	84	-	-	84	84	-
Vernal Pool	127	113	1	-	114	110	4
Warm Grasslands	484,321	2,814	7,481	235,610	245,905	152,011	96,517
Wedgeleaf Ceanothus	27	-	20	-	20	0	20
Wet Meadows	163	137	8	-	145	86	62
White Alder	340	306	-	-	306	185	135
Willow	1,570	1,413	-	-	1,413	682	754
Willow - Alder	1,037	933	-	-	933	566	384
Willow (Shrub)	2,493	2,244	-	-	2,244	1,165	1,079

** Agriculture (General) in the Coastal Grasslands and Marin Coast Range were considered important grasslands.*

Redwood sorrel in Armstrong Redwoods State Natural Reserve, Sonoma County. Photo cc John Andrew Rice.

New Fine-filter Datasets

1. Tall complex forest stands in Sonoma County

Remnant old-growth redwood forest stands are a conservation priority and were a CLN 1.0 fine-filter conservation target in the Marxan analysis. CLN 1.0 used a dataset that the Save the Redwoods League (SRL) maintains indicating locations of old-growth redwood stands. The CLN 2.0 project team compared the old-growth redwood dataset with new vegetation mapping in Sonoma County (Sonoma Veg Map 2017), which contains LIDAR-derived forest size and structural information, and found omissions in the SRL data. This is not surprising given the high level of LIDAR detail from which Sonoma Veg Map benefited (see Figure 4.5). It was determined that, where high-quality data exist, the SRL data should be supplemented and the combination be used as a fine filter in the CLN 2.0 Marxan analysis.

Each forest and woodland polygon in the Sonoma Veg Map contains several relevant attributes: vegetation type, stand area, average tree height, and the standard deviation of tree height. The last attribute is a useful metric of size diversity. The greater the standard deviation, the greater range of heights present. The CLN 2.0 project team used a combination of these attributes to produce a complement to the SRL data. The team selected vegetation polygons from the Sonoma Veg Map that met the following criteria:

- Douglas-fir (*Pseudotsuga menziesii* alliance) or Redwood (*Sequoia sempervirens* alliance) vegetation types
- Tall stands (average tree height >= 90ft) with a range of heights (SD > 30ft)
- Stands 40ac or larger

The above selection resulted in a polygon dataset of 71 stands of Douglas-fir and redwood, called Tall Complex Forest Stands in Sonoma County (see Figure 4.5), comprising 8,136ac mostly near the coast, with some inland stands identified in Annadel State Park and Jack London State Historic Park. When compared with SRL's old-growth redwood polygons, only limited agreement was found (see Figure 4.6). Assessing the strengths of each dataset would require extensive fieldwork and is beyond the scope of the CLN 2.0 study. Instead, it was decided that the two datasets complemented each other well and that merging them would maximize the probability of a comprehensive inventory in CLN 2.0 of late seral stage forests in Sonoma County. Future updates of the CLN would benefit from having spatial data for late seral stage forests for the entire study area.

Old-growth and tall complex forests have been reduced by more than 90% by historical logging, and have been a focus for conservation starting in the early 20th century with Big Basin Redwoods State Park. Old-growth redwood parks are iconic, but stands of redwoods and Douglas-fir with complex structures also support interior forest species.

Data representing tall complex forests (see description above), which include older second-growth stands, were used as fine-filter targets in the CLN 2.0 Marxan model with a 90% goal. Approximately 8,000 acres were mapped in Sonoma County. In addition to supporting unique canopy communities, these forests are some of the largest carbon stores on earth. Conservation forestry in second-growth stands can accelerate the development of key old-growth characteristics: large well-spaced trees, open understories with diverse herb and shrub communities, and coarse woody debris on the forest floor. Conservation forestry has been implemented in many sites, including Buckeye Forest, Jenner Headlands, and San Vicente Redwoods. Revenue from highly selective harvests and carbon credits can pay for rehabilitation of roads and streams, undoing some of the damage from unbridled historical logging practices. LIDAR has been flown recently in Marin and San Mateo Counties, so more stands will be identified in the coming years.

Figure 4.5 ■ Map of Old-growth Redwood and Tall Complex Forests in Sonoma County.

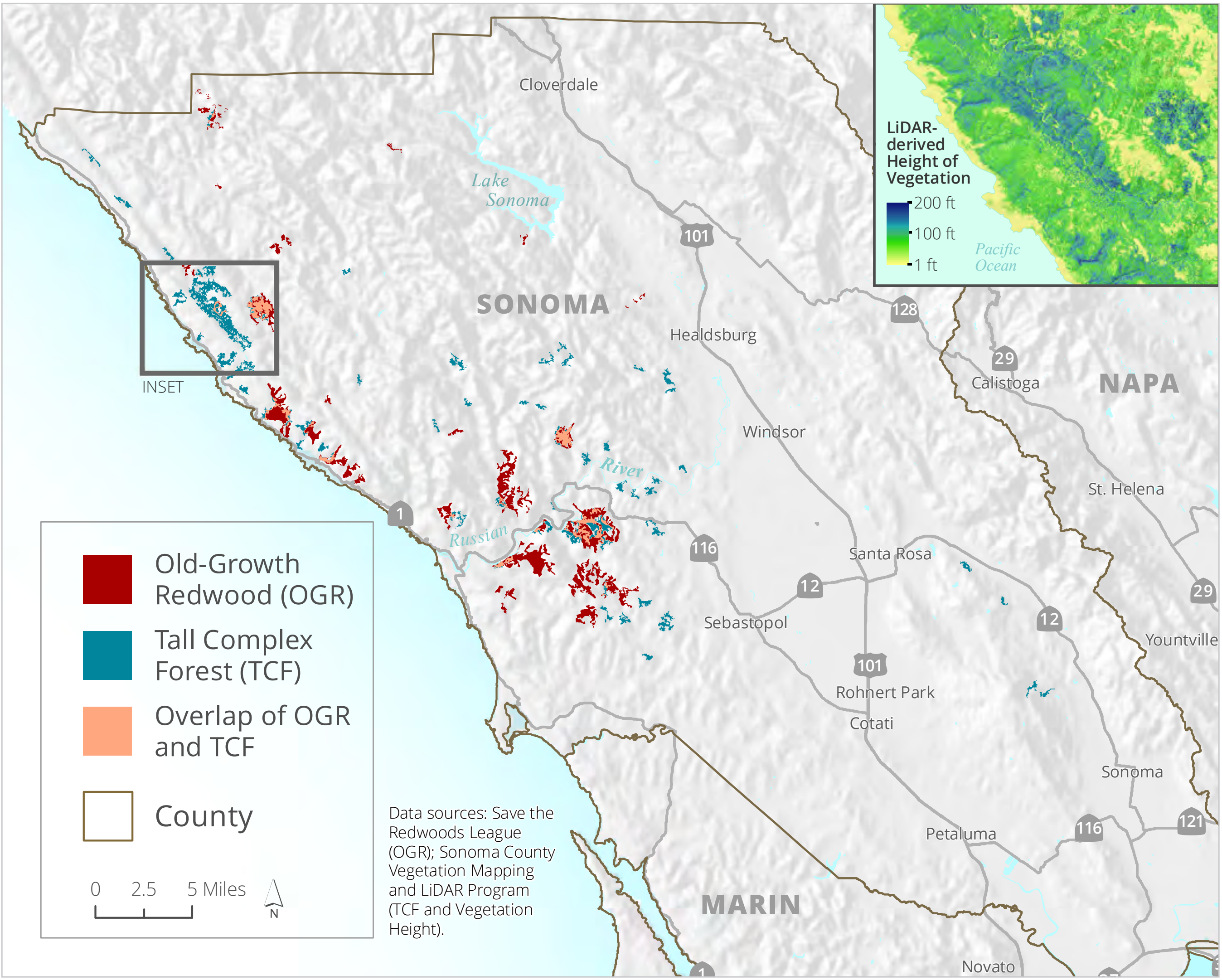


Figure 4.6 ■ Comparison of Old-growth Redwood and Tall Complex Forests in Sonoma County.

Lands	Acres	% of Total
Areas identified as both old-growth redwood by SRL and tall complex forest stands by CLN 2.0	1,949	12%
Additional areas identified only as old-growth redwood by SRL	8,085	50%
Additional areas identified only as tall complex forest stands by CLN 2.0	6,177	38%

2. Maritime chaparral

Maritime chaparral is a shrub community that occurs in isolated patches on nutrient-poor soils within the fog belt. It is recognized for its high species richness (including many endemics) and association with *Arctostaphylos* varieties.

The focus team determined that maritime chaparral is underrepresented in the CLN 2.0 course-filter vegetation map, likely due to its patchy distribution among similar vegetation types (see Figure 4.7). In order to ensure maritime chaparral representation in CLN 2.0, the Focus Team recommended the creation of a dataset to be used as a fine-filter target in the Marxan analysis.

Maritime Chaparral. Photo by Andrea Williams.

Three data sources were used to generate the fine-filter target data input: Sonoma Veg Map (where the map class was 'California Maritime Chaparral Alliance'), Todd Keeler-Wolf (five East Bay sites), and the California Natural Diversity Database records for the following stands of sensitive *Arctostaphylos* species:

- *A. andersonii*
- *A. bakeri* subsp. *bakeri*
- *A. bakeri* subsp. *sublaevis*
- *A. franciscana*
- *A. glutinosa*
- *A. hookeri* subsp. *hookeri*
- *A. imbricata*
- *A. montana* subsp. *montana*
- *A. montana* subsp. *ravenii*
- *A. montaraensis*
- *A. ohloneana*
- *A. pacifica*
- *A. pajaroensis*
- *A. pallida*
- *A. regismontana*
- *A. silvicola*
- *A. stanfordiana* subsp. *decumbens*
- *A. virgata*

The combination of the datasets above resulted in 207 stands comprising 21,952 acres from Sonoma County to Santa Cruz County.

Figure 4.7 ■ Map of Maritime Chaparral in the Bay Area. This plant community was used as a fine-filter dataset to ensure that it was adequately represented in CLN 2.0.

Baker's manzanita (*Arctostaphylos bakeri* subsp. *sublaevis*) was one of several *Arctostaphylos* species used to identify stands of maritime chaparral for addition to the network. Photo cc John Game.

Vegetation and Climate Change

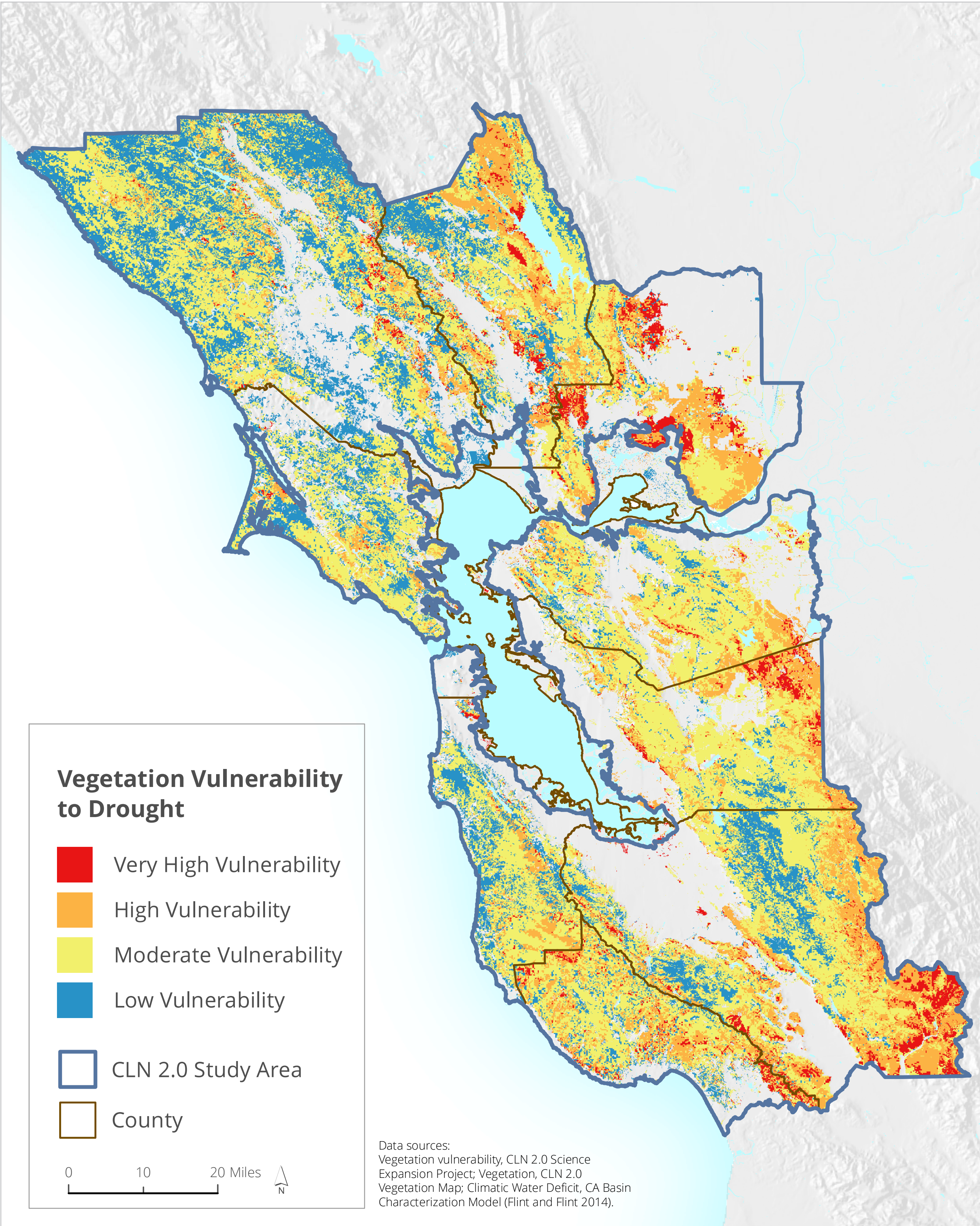
Climate change promises to drastically rearrange the vegetation mosaic of California and around the globe (Ackerly *et al.* 2010, Torregrosa *et al.* 2013, Ackerly *et al.* 2015). Higher summer temperatures increase evaporative demand and annual drought stress, even if precipitation increases. The Basin Characterization Model, the climate and hydrology platform for CLN 2.0, projects landscape aridification, with the only question being the rate. Climate whiplash — higher variability in precipitation at all time scales (Swain *et al.* 2018a, Dong *et al.* 2018) — will further intensify droughts, and increase risks of megafloods from long-lasting atmospheric rivers (Swain *et al.* 2018). Because much of the region's vegetation is already in a delicate balance with available water, even small increases in drought stress can drive transitions toward more arid vegetation. CLN 2.0 estimates this effect with the Vegetation Vulnerability to Drought layer (Figure 4.8).

The impact of drought stress on vegetation patterns

For CLN 2.0, the link between climate change-induced drought stress and vegetation is explicitly considered by identifying stands of vegetation already close to their drought stress limits. Broad changes in physiognomy are projected at the landscape unit scale - conifer forests are projected to decline while shrublands are projected to increase (Ackerly *et al.* 2015). While greatly reduced under the most severe climate change scenarios, pockets of mesic vegetation are still projected to remain in all landscape units through the end of the century.

The state-listed endangered Coast Yellow Leptosiphon *(Leptosiphon croceus).* This tiny wildflower occupies just a few hundred square meters of coastal prairie on the edge of a coastal bluff in Moss Beach, San Mateo County (CNPS 2017, Corelli 2016). It is a tragically excellent example of threats from sea level rise on the outer coast, where each foot of sea level rise can result in as much as 150ft of cliff retreat. Intensive conservation efforts — similar to those needed for other endangered plants —includes production of seeds and identification of suitable introduction sites on nearby public lands. Photo by Stuart Weiss.

Figure 4.8 ■ Map of Vegetation Vulnerability to Drought. The Vegetation Vulnerability to Drought layer is a part of the CLN 2.0 Explorer at BayAreaLands.org.



Sweeney Ridge, San Mateo County. Photo by Stuart Weiss.

As climate changes, the plant assemblage at any one location is transient, but the Bay Area's geology, diverse topography, and climatic gradients are a broad stage and may offer strong resilience at a landscape scale (Ackerly *et al.* 2015, Lawler *et al.* 2015). Species may not have to migrate far to track climate, perhaps just across the canyon or to the next ridge closer to the ocean. Mesic-adapted species may be able to retreat to cool moist microsites, such as north-facing slopes receiving groundwater flow from slopes above, and riparian zones. Small stands of arid-adapted species already occupy arid microsites in mesic landscapes, ready to expand. It is important to note that edaphic communities such as Sandhills and various serpentine communities — and the endemics they support — are trapped on islands of substrates, and must rely on the very local topoclimatic gradients to find refugia. The CLN's 90% conservation goal for these rare vegetation types reflects the goal of conserving as much remaining climatic variation as possible.

Vegetation types that rely on cool coastal climates and fog, such as maritime chaparral and Bishop pine, may be particularly susceptible to climate change. But the Pacific Ocean is a great buffer on temperature increases. Fog can ameliorate climate change by shading and fog drip; However, changes in fog frequency are extremely uncertain (Torregrosa *et al.* 2014). Coastal fog has a relatively stable spatial pattern driven by coastal topography, and areas with relatively higher fog frequency should remain so into the future (Torregrosa *et al.* 2016).

In CLN 1.0, the combined strategy of delineating subregional landscape units to localize conservation targets, setting high percentage conservation goals (50%, 75%, and 90%) for targets, and defining locally rare vegetation captured the full range of mesoclimatic diversity at the 270m scale (Heller *et al.* 2015). Locally mesic vegetation within arid landscape units and locally arid vegetation within mesic landscape units received high percentage goals (75% or 90%). Finer-scale topoclimatic variability is automatically captured in rugged terrain. The goal of conserving large contiguous areas within each landscape unit provides the maximal "stage" for rearrangement of vegetation on local scales.

One of the region's most endangered plants, the native pallid manzanita, is particularly at risk from Sudden Oak Disease. Photo by Lech Naumovich.

Threats to Vegetation and Recommended Conservation Actions

Building on the recommendations of the CLN 1.0 report, the Vegetation Focus Team identified six key influences on Bay Area vegetation, specific threats, and recommended conservation actions. The influences, here in alphabetical order, are:

- Chemicals and pollutants
- Climate change
- Habitat connectivity
- Invasive species
- Land use and management
- Pests and disease

Chemicals and pollutants

Threats	Conservation actions
Atmospheric nitrogen deposition Atmospheric nitrogen deposition fertilizes grasslands and boosts the growth of non-native annual grasses. Serpentine grasslands in Santa Clara County, where annual nitrogen deposition is on the order of 10lbs/acre, are rapidly overgrown by annual grasses and thatch, leading to reductions in native forb cover and extirpation of the threatened Bay Checkerspot Butterfly (Weiss 1999). Vernal pool native plant communities are vulnerable to overgrowth by grasses (Marty 2005). The open dunes at Antioch Dunes National Wildlife Refuge have largely disappeared under cover of annual grasses. This can lead to increased fuel loads and intensified fires.	■ Include a nitrogen deposition analysis in environmental review (CEQA) and HCP/NCCP planning. ■ Use well-managed livestock grazing to remove excess grass and prevent thatch buildup. ■ In smaller areas, consider using timed mowing to manage grasses. ■ Mitigation under the Endangered Species Act for increased N-emissions from specific projects (*e.g.*, power plants), or widespread development can provide funds to manage grasslands and vernal pools. The Santa Clara Valley Habitat Plan has a one-time Nitrogen Fee based on car trips generated by projects.

Well-timed mowing at Edgewood Park and Natural Preserve successfully controlled invasive grasses in the section on the right, allowing native wildflowers to thrive. Photo by Stuart Weiss.

Climate change

Threats	Conservation actions
Increased risk of fire and risk of higher-intensity fire The 2017 North Bay fires followed a near record wet rainy season, which led to high productivity and fuel loads, followed by the hottest summer on record, which reduced fuel moisture. This confluence of extremes is increasingly likely as climate continues to change. Due to their high flammability, rapid growth, and accumulation of high volumes of leaf litter, Monterey pine and eucalyptus can increase the incidence of fire. While Monterey pine is not native to the study area except in southwestern San Mateo County, and eucalyptus is not native to California, both can provide habitat for birds and Monarch Butterfly. These benefits must be weighed against the potential increased wildfire risk. Trees and shrubs that are killed by pests and disease (for example, tanoak killed by SOD) can result in an understory of dead, dry fuel that can increase the likelihood of intense fires.	■ Build understanding that California is a fire-adapted system that requires intentional work toward fire resilience. ■ Use prescribed fire and targeted understory woody plant removal at the wildland-urban interface (shaded fuel breaks) for ecosystem and fire risk reduction co-benefits. ■ Encourage the adoption of improved fire-resistant building practices and codes. ■ Support community planning that avoids placing new developments near highly fire-prone vegetation communities. ■ Clear dead wood and reduce fuel loads through prescribed burning, manual removal, etc. ■ Replace non-native, fire-prone species with native, fire-resistant species. ■ Where native fire-dependent vegetation is present, allow wildfires to burn if feasible, or use prescribed fire to mimic natural regimes. ■ Support urban infill where possible, and plan for fire protection along the urban/wildland interface.
Increased risk of disease and pests Climate impacts can also be observed in higher disease impacts and transmission. Warm wet springs allow greater transmission of SOD. Drought makes pines susceptible to bark beetle outbreaks.	■ Aim for early detection of new diseases and quarantine to limit spread. ■ Support diverse food webs, which can reduce the risk of pest outbreaks (*e.g.*, bird predation on insects). ■ Support robust native plant communities, including understory diversity, to help affected stands recover and maintain ecosystem functions.
Increased temperatures Projected temperature increases will shift grassland composition, with decreases in the extent of Cool grasslands in particular. Climate change might cause Moderate to Cool grasslands to become more rare. As grasslands warm over time, the current CLN may over-represent how many cool grasslands remain. Future models might require stratification of grasslands along a gradient that takes these projections into account. Other temperature-sensitive plant communities and species may decline over time.	■ Manage grasslands such as coastal prairies with this potential transition in mind. ■ Identify the coolest stands of grasslands (*e.g.*, north-facing slopes) and treat as potential refugia. ■ Protect habitat connectivity to support potential distribution shifts in response to temperature change. ■ Protect potential temperature refugia such as riparian corridors. ■ Support research on how to sustain the vegetation types most vulnerable to temperature increases, such as coast redwood stands.
Increased drought stress Regardless of precipitation futures, plants will experience more drought stress (climatic water deficit) due to warming. This may cause large-scale shifts in plant community composition through either selective mortality within stands, or stand-replacing fires.	■ Identify stands at risk that are close to drought tolerance limits. ■ Monitor vegetation for drought mortality and for post-fire changes in composition. ■ Protect areas that maintain habitat connectivity. ■ Consider restoration planting with future climates in mind.

Habitat connectivity

Threats	Conservation actions
Habitat fragmentation Vegetation communities that are fragmented by development or land conversion face some of the same risks as wildlife populations: reduced genetic diversity, reduced resilience and ability to migrate/adapt with changing climate, and increased disease susceptibility (Fahrig 2003).	■ Protect large landscape-scale habitat blocks and enhance connectivity between them.

Invasive species

Threats	Conservation actions
Crowding out native species California grasslands are a prime example of an ecosystem that has been transformed by invasive species occupying space that could otherwise be used by native species. Shrubs such as French and Scotch broom can invade grasslands and dominate woodland/forest understories. Nitrogen fixation from those shrubs increases soil fertility and acidity, effects that can last decades.	■ Manage consistent control programs to reduce invasive species cover below damaging levels. ■ Restore native species. ■ Control spreading foci before controlling core infestations. ■ Practice early detection and rapid response to prevent new invasions. ■ Use sanitation measures to prevent spread to new areas, *e.g.*, washing vehicles and cleaning boots. ■ Educate gardeners and place regulations on nurseries to prevent ornamental plantings of highly invasive species.
Changing fire regimes Introduced annual grasses increase fine fuel loads and carry fire better than native perennial grasses. Annuals dry out at least a month sooner, and extend the fire season. Invasive shrubs increase fuel loads and self-perpetuate under fire (*e.g.*, broom and gorse).	■ Use grazing to reduce grass fuel loads. ■ Restore native perennials to delay the start of fire season.
Control measures impact native species Applications of herbicides and fire intended to manage non-natives can impact desirable native plant species. Insects are particularly vulnerable to fire.	■ Use best management practices to minimize negative impacts. ■ Where rare insects occur, do not treat entire habitats at once. Use rotational treatments to allow for recolonization (hopefully into better quality habitat after treatment).
Diversion of resources away from other stewardship needs Weed management can be costly, and a big sink for stewardship resources, especially if treatments are haphazardly applied and ineffective in the long run without follow-up treatments of the last remnants of invasives.	■ Develop well-planned and thought out goals and methods for initial reduction of weeds, then follow-up to prevent rebound. Follow-up is a good use of volunteer resources.

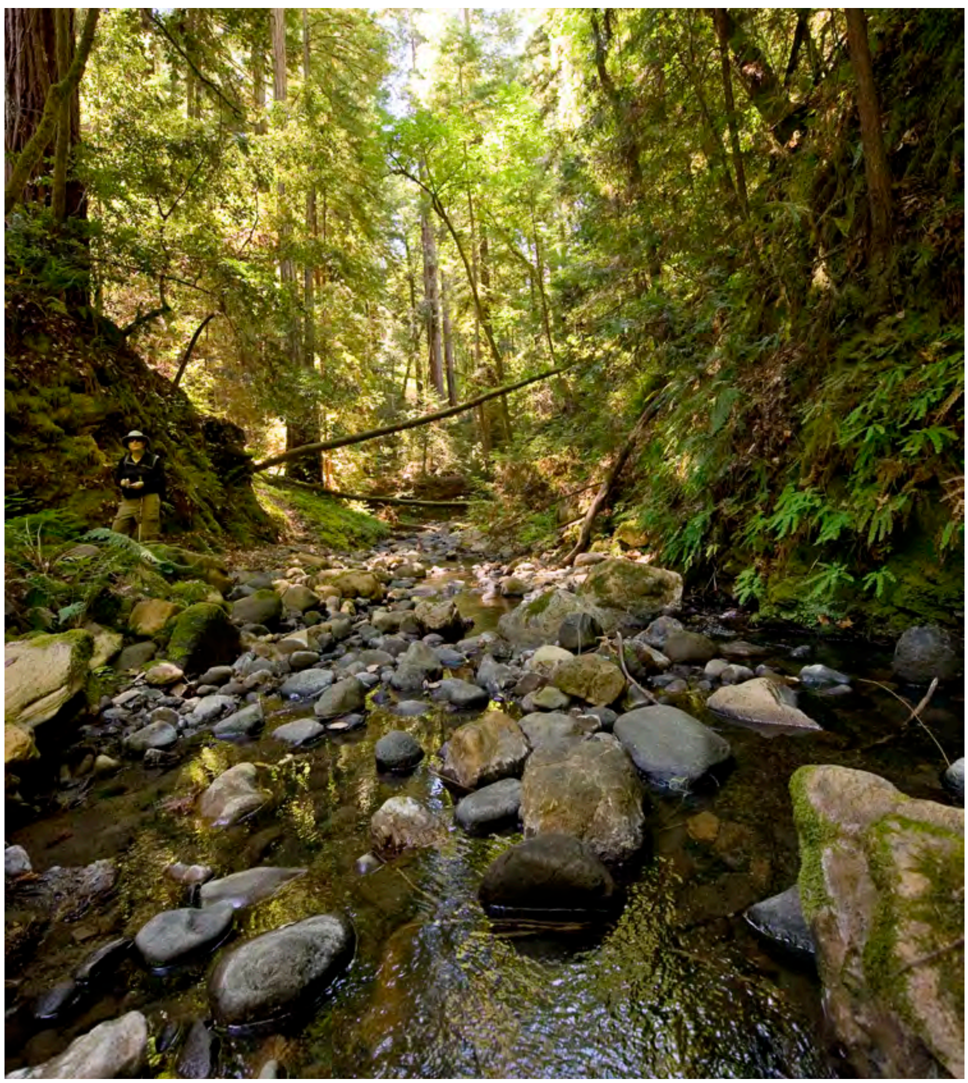
Scientists monitor native species at San Bruno Mountain in San Mateo County.
Photo by Lech Naumovich.

Land use and management

Threats	Conservation actions
Habitat conversion/ urbanization Vegetation communities, particularly grasslands and shrublands on low (buildable) slopes, face significant development pressures as the percentage of converted landscape continues to grow. Sometimes it is hard to determine the functions and values of isolated, remnant patches of native vegetation among heavily modified landscapes (*e.g.*, grassland patches among rural residential parcels on the Santa Rosa Plain, oak stands in San Jose). Although not a fully functional component of a connected system, these patches may provide important refugia for rare plants (*e.g.*, Burke's Goldfields) and vegetation communities (*e.g.*, vernal pools) as well as many other ecosystem services (*e.g.*, carbon sequestration, shade, habitat for common wildlife, soil and water preservation, etc.).	■ Identify and highlight the multiple benefits of land conservation and restoration projects, particularly green infrastructure. For instance, when building support for perennial grassland and wetland/meadow restoration, call out the resulting benefits of floodplain infrastructure protection, floodwater storage and groundwater recharge, and carbon sequestration. ■ Raise awareness of the unique role grassland and shrubland play in the region's ecology and agricultural economy, and of the need to protect remaining grasslands and shrublands in areas with development pressure, such as on low slopes.
Changes in vegetation Successionary disturbance drivers (indigenous fire practices, flooding, native ungulate grazing) have been greatly altered in the Bay Area in order to accommodate and protect human settlements. Vegetation succession has thus been similarly altered.	■ Mimic disturbance where natural regimes have been halted due to nearby buildings/structures and settlements.
Grazing Grazing can be a valuable tool for protecting native diversity in some vegetation types, such as certain grasslands. Livestock species, amount and timing of grazing, the existing plant community composition, and invasive species control practices all affect grazing outcomes. Overgrazing — excessive exposure to heavy grazing without recovery time — can be detrimental to vegetative cover, native composition, and the underlying soil and hydrology. Grazing within riparian areas in particular can reduce recruitment of understory vegetation, which, with time, reduces canopy cover along the riparian corridor. Lack of grassland grazing by native ungulates or livestock can lead to build up of thatch, especially in grasslands with robust non-native cover; this in turn can suppress growth of native forbs and grasses.	■ Educate on how well-managed livestock grazing can be used to benefit native biodiversity, in particular in grassland systems. ■ Support the development of site-specific grazing plans that provide in-depth guidance on appropriate grazing regimes and areas to protect from grazing. Strongly encourage the use of monitoring and adaptive management to help ensure that conservation targets are being met. ■ Use livestock grazing to limit thatch build up and prevent non-native Eurasian grasses from outcompeting native grasses and forbs. ■ Protect recruiting trees in riparian areas, woodland edges, and oak savannas to sustain canopy and woodland formation. ■ Protect wetlands from overgrazing, which may reduce plant diversity and water quality and result in undesired erosion.
Recreation impacts Extensive trail development for hiking, biking, and equestrian use, or development of active recreation facilities in open spaces, can result in losses or fragmentation of native plant communities and the wildlife they support. Trail use and maintenance activities can spread invasive species into native habitats.	■ Encourage the consideration of native vegetation health and habitat connectivity — for common as well as for rare or sensitive species — in park and open space preserve planning. ■ Encourage the decommissioning of unneeded trails and roads, with active restoration as needed to recover native plant cover. ■ Encourage maintaining selected areas within each park or preserve as unfragmented habitat zones. ■ Support focusing active recreation facilities (*e.g.*, ball fields, disc golf courses, developed camping/huts, ziplines) outside of high quality or highly connected native vegetation. ■ Educate park operations staff on practices to prevent the spread of invasive species, and keep this education current as species of concern and best management practices change. ■ Support public education built in to recreational opportunities, to spread awareness of the values of, and threats to, native vegetation diversity.

Pests and disease

Threats	Conservation actions
Sudden Oak Death (SOD), other *Phytophthora* pathogens, and other diseases and pests Understanding of SOD and *Phytophthora* pathogens has greatly changed over the last 10 years. In CLN 1.0, it was assumed that tanoak stands were key refugia from introduction of the SOD pathogen. It has since been shown that SOD has significantly affected tanoak across the whole region. When mature tanoak die, they often resprout as a thicket, changing the community composition and function. Tanoak will likely be replaced by bay or conifers, which affects the species composition in the area. Some species are at risk of being completely killed by these pathogens (*e.g.*, Pallid Manzanita). Bishop pine stands along the coast are dying due to a combination of factors, including senescence of even-aged stands, drought, and spread of fungal and beetle pests. Without wildfire, regeneration may not occur and stands may be replaced by other vegetation types. This may result in a loss of native cover and diversity. Numerous other diseases and pests, such as fungal cankers and bark beetles, can become epidemic, driven by fire suppression, stresses from climate change and other factors.	■ Conduct additional research on *Phytophthora* pathogens, their spread, and anticipated successional changes. ■ Use fine-filter analyses to assess understory and co-dominance composition of species like tanoak (*e.g.*, understory of Douglas-fir forests) to better predict potentially affected areas. ■ Consider restoration actions to restore disease- and pest-affected areas into viable and functional habitat types. ■ Support monitoring and research of forest health trends and emerging diseases, and use CLN and vegetation mapping data to help track and understand changes and patterns over time.

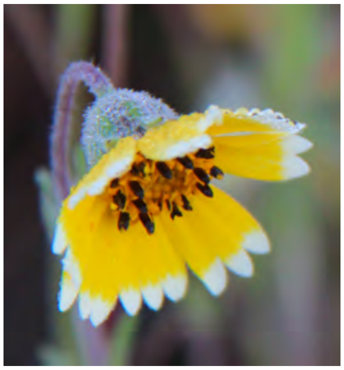


Old-growth forest along Peters Creek, next to Portola Redwoods State Park. Photo by Paolo Vescia and Save the Redwoods League.

Data Gaps and Limitations

- The vegetation data available across the whole region have some floristic and spatial limitations in representing ecological diversity. Accuracy estimates would set limits on the confidence in the map. Accuracy information would include:
    - Cover type dominance and co-dominance
    - Cover type secondary dominance
    - Purity of stand and/or degree of stand mixture
- Use new fine-scale vegetation mapping projects as opportunities to supplement the *Manual of California Vegetation* classification system to include localized alliance descriptions and/or novel classes.
- Conduct a correlation of quantitative stand structure metrics (*e.g.*, diameter at breast height, size class, canopy height, canopy density) so they match across datasets.
- Gather spatial data for late seral stage forests across the entire study area.
- Conduct an assessment of function, quality, condition, health, and successional state (also known as "demographics") of vegetation in the region.
- Embed carbon equivalents and sequestration data in vegetation maps to facilitate quantification of potential CO2 emissions that would result from the clearing of vegetation.
- Evaluate habitat loss and conservation trends. In particular, assess the types of habitats and landscapes that have been lost and conserved over the past 10 years and determine the causes of the steepest declines and conservation gains.
- Complete consistent fine-scale vegetation mapping for the Bay Area (*e.g.* Thorne *et al.* 2004).

Blue-eyed grass on Coyote Ridge, Santa Clara County. Photo by Cait Hutnik.



Tidytips at Edgewood Natural Park and Preserve. Photo by Frances Freyberg.

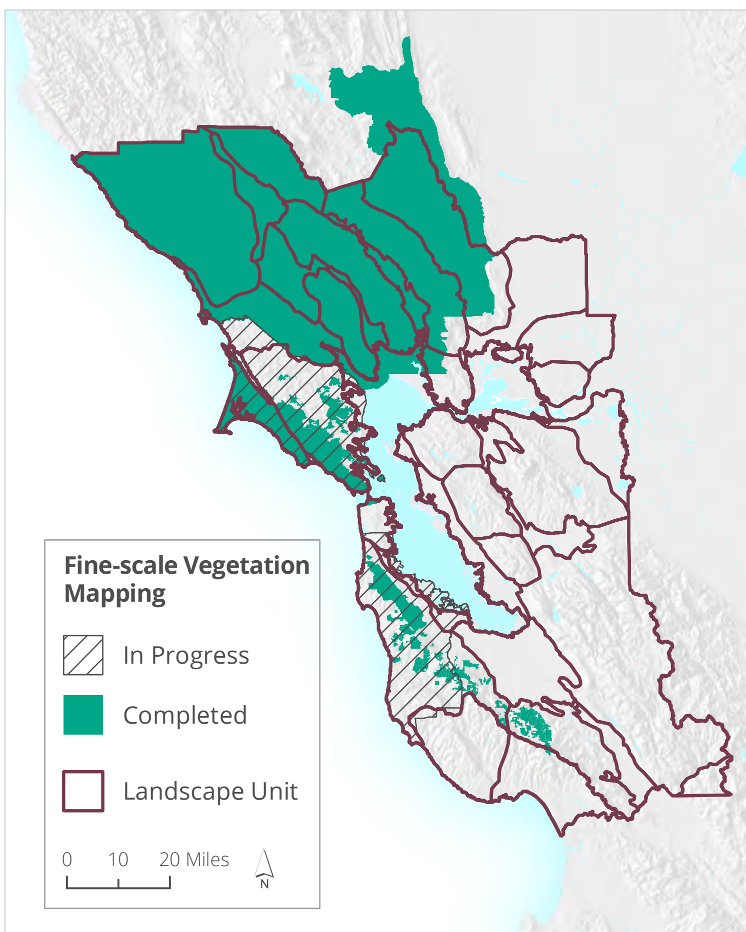
The need for a consistent, fine-scale vegetation inventory for the entire Bay Area

The lack of fine-scale vegetation maps for the majority of the study area is a significant data gap. These maps, available for about a quarter of the region (see Figure 4.9) use the *Manual of California Vegetation* (MCV) classification system, while Eveg, which is available for the rest of the study area, uses the CalVeg classification system.

The MCV system, which is geared toward accounting for the fullest range of habitat types, provides greater detail and precision than CalVeg, which is optimized for identifying and classifying merchantable timber stands. However, using this finer-scale information for only portions of the study area would be problematic. Options to incorporate the fine-scale maps into the CLN 2.0 Marxan analysis included merging with Eveg or creating a patchwork of fine- and medium-scale vegetation mapping. Either of these options may have worked well if the fine-scale vegetation maps matched the landscape units, since rarity and habitat goals are set by landscape unit. However, many landscape units would contain both classification systems and artificially increase the number of conservation targets within those landscape units. For this reason, the Focus Team determined it would be best to use Eveg exclusively for CLN 2.0 as it would provide a consistent inventory of habitats across the various landscape units.

The discrepancies between fine-scale vegetation maps and Eveg are significant, and underscore the need for a consistent, fine-scale inventory of vegetation for the entire CLN study area using the biodiversity-centric *Manual of California Vegetation* classification system.

Figure 4.9 ■ Map Showing Extent of Fine-scale Vegetation Mapping in the Bay Area.



CHAPTER

5

Riparian Habitat & Fish

Headwaters of Saratoga Creek, Sanborn County Park. Photo by Teddy Miller / POST.

"Riparian corridors possess an unusually diverse array of species and environmental processes. This 'ecological' diversity is related to variable flood regimes, geomorphic channel processes, altitudinal climate shifts, and upland influences on the fluvial corridor. This dynamic environment results in a variety of life history strategies, and a diversity of biogeochemical cycles and rates, as organisms adapt to disturbance regimes over broad spatio-temporal scales."

- Naiman *et al.* 1993

Overview

Water is life — something that has become even more palpable during recent historic periods of drought. The Bay Area's Mediterranean climate brings an annual prolonged hot and dry season, during which vegetation and wildlife depend on a network of streams, ponds, lakes, and aquifers for life-giving moisture. Indeed, the presence of these wet zones in an otherwise fairly dry landscape is one of the reasons the Bay Area is so rich in biodiversity.

Climate change — which is bringing wide swings in precipitation, more summer heat, and increased drought — is upsetting the balance of water and affecting the Bay Area's hydrologic networks and biodiversity. Even more severe changes are anticipated. In the Bay Area, where as much as 95% of riparian habitat has already been lost (San Francisco Estuary Project 2007), protecting and restoring the remaining riparian zones is essential.

The charge for Bay Area conservation practitioners is to conserve hydrologic networks for biodiversity and landscape resilience. This will require broad understanding of riparian habitat function so that every opportunity is taken to enhance or restore the processes that support these functions. The Bay Area's vegetation and wildlife — and human populations — depend on the hydrologic processes that capture, store, and deliver water and sediment throughout the ecosystem.

Conserving and improving riparian and floodplain habitat yields myriad benefits for people as well as wildlife, even in urban areas. And as discussed in Chapter 2, because of the integral connection of upland riparian areas to bayland habitat, and the importance of this relationship in mitigating the effects of sea level rise, there are many opportunities for collaborative conservation efforts in this complicated sphere.

The CLN 2.0 riparian and fish conservation strategy builds on the framework designed by the CLN 1.0 Riparian and Fish Focus Team, which identified conservation targets for stream reaches, riparian vegetation, and fish. This second iteration of the Conservation Lands Network expands on this by adopting a functional definition of riparian — one that accounts for the space and time required for dynamic fluvial processes to occur. This revision includes new data designed to guide conservation toward important parts of the watershed for streams and fish: 1) stream valleys that approximate the space streams need to function, and 2) upper watershed zones that approximate the source headwaters of Bay Area streams.

Baylands and uplands: Interdependent systems

The baylands and uplands of the San Francisco Bay Area are often treated as separate worlds in conservation planning, funding, and policy. They are indeed two different biomes; the baylands are influenced by tidal processes, while the uplands are influenced by the region's Mediterranean weather patterns and terrestrial processes such as flooding from streams, fire, and vegetation succession. However, there are many physical and ecological interactions and dependencies between baylands and uplands that blur the distinction between the two.

For example, the streams that drain to the Bay supply needed sediment and nutrients to the marshes and mudflats that ring the Bay. Anadromous fish migrate through the estuary and upstream to their natal waters. The estuarine-terrestrial transition zone between bayland and upland habitats harbor animals that use each biome for different parts of their life history. Groundwater recharge from uplands maintains underground freshwater lenses and helps prevent saltwater intrusion into aquifers. Uplands provide high tide refuges for marsh species.

The connections between baylands and uplands should lead us to treat the two biomes as one interconnected system. Sea level rise and other anticipated effects of climate change add urgency to this shift in thinking. Sea level rise is an existential threat to bayland habitats. Without intervention, it is unclear whether baylands can accrete enough sediment to keep up with tidal inundation caused by sea level rise. Managers of upland watershed and riparian habitat must see themselves as a part of the solution for bayland inundation. See Figure 2.6 and the update of the Baylands Goals report (Baylands Goals Science Update 2015) for specific recommended actions for upland managers.

The baylands and uplands are connected hydrologically and ecologically, as at Coyote Hills Regional Park in Alameda County. Photo cc Charlie Day.

The Multiple Benefits of Stream Conservation

Improving ecosystem resilience

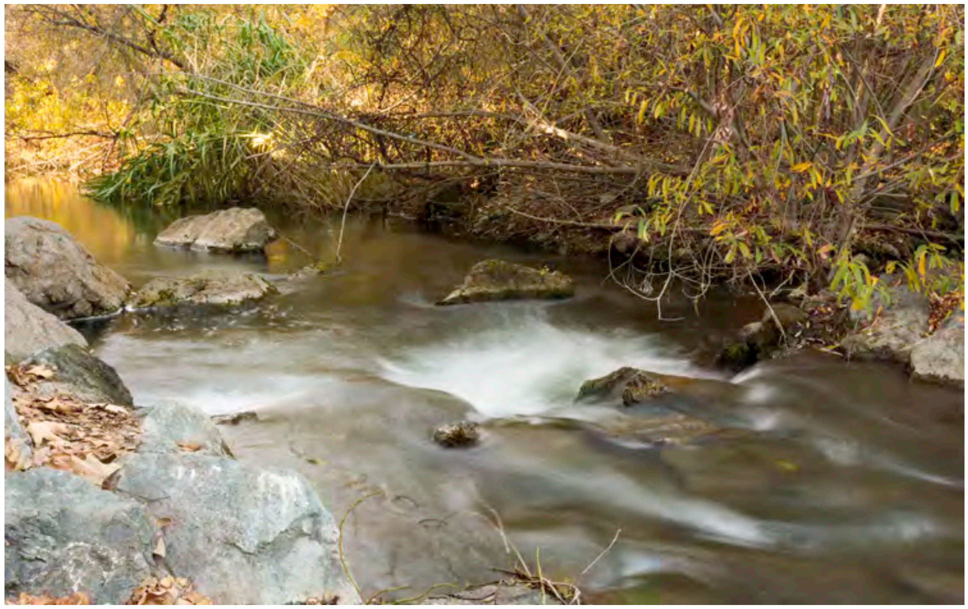
Riparian zones are inherently dynamic, and thus are better able to withstand and recover from extreme weather events than other terrestrial parts of the ecosystem — while continuing to provide habitat, store and release water, recharge groundwater, convey cool and moist air downhill, and attenuate storm energy (Naiman and Turner 2000; Seavy *et al.* 2009). The fact that riparian zones are suited to recover from disturbance and seasonal changes in flow and provide so many benefits to the surrounding landscape makes them keys to ecosystem resilience (Seavy *et al.* 2009). Ensuring that streams remain intact and functioning, and restoring function to degraded streams with process-based restoration projects, will help Bay Area landscapes adapt to climate change.

Pools and Drought Resilience

Drought was declared in California on December 20, 2011, and the state wasn't declared free of drought until March 14, 2019. This seven-year drought, considered the most intense in California in 500 years, took a toll on the Bay Area's anadromous fish. For example, the drought severely restricted and/or blocked smolt and adult passage for steelhead in South Bay streams like Stevens Creek, Guadalupe River, Coyote Creek, Uvas Creek, and Corralitos Creek (Smith pers. comm. 2019).

The drought also highlighted three important insights relevant to riparian conservation:

- In intermittent streams, persistent pools — discontinuous areas of standing water in stream channels connected only by subsurface flow — are key to species persistence through drought. Recent research in Coyote Creek (Santa Clara County) showed that naturally formed pools in intermittent reaches supported full assemblages of native fish, amphibians, and invertebrates during the drought, while the opposite was true for reaches with unnatural flow regimes, typically with augmented flows during the summer months (Bogan *et al.* 2019). These findings underscore the importance of maintaining natural flow regimes (including seasonal drying) in the Bay Area's creeks as well as cool groundwater inputs to persistent pools. For the latter, conservation efforts should focus on conserving adjacent stream valleys — including floodplains and terraces — that recharge riparian aquifers.
- Restoring passage for juvenile salmonids upstream to cooler, perennial headwaters will be a critical conservation strategy to support native fish populations facing drought and increased stream temperatures. Partial barriers that allow passage of adult fish both ways and juveniles downstream may block juveniles' upstream movement, which can be an important source of recolonization or adaptive seasonal movement.
- Short droughts are often tempered by species' longevity and ability to recolonize. Extended droughts can deplete year-to-year carryover in spring systems. For example, San Felipe Creek (a tributary in the Coyote Creek watershed) maintained extensive perennial habitat in the 1976-77 and 2007-2009 droughts because of carryover water discharge from the Calaveras Fault. However, the 2012-2017 drought resulted in drying of most of the usually perennial stream habitat (Rob Leidy pers. comm. 2019).



Periods of drought restrict steelhead passage in many creeks, including Santa Clara County's Coyote Creek. Photo by Derek Neumann, Santa Clara Valley Open Space Authority.

Sequestering atmospheric carbon

Woody vegetation and soils can sequester atmospheric carbon dioxide for decades, if not centuries; reforestation can play a significant role in achieving greenhouse gas reduction goals. A study of 42 healthy stream reaches in Marin and Sonoma counties (Lewis *et al.* 2015) demonstrated the significant capacity of intact riparian vegetation and soils to sequester atmospheric carbon dioxide. The study found an average of 382lbs of carbon in the soil and woody vegetation for every linear foot (578kg/m) of stream channel, including the channel, floodplain, and upper bank positions. This means that, on average, restoration of 1,000 feet of riparian habitat is equivalent to removing 135 cars from the road for a year (EPA 2019).

The fact that many Bay Area streams have been degraded and lack healthy riparian woodlands means there is great capacity for restoration and thus carbon sequestration. Riparian restoration should be a key activity of community climate adaptation plans.

Reducing public hazard risk

Natural resource and infrastructure managers at all levels of government are beginning to recognize that ecosystem resilience and public hazard mitigation depend on riparian system function (*e.g.*, Rijke *et al.* 2012; EPA 2014; California Assembly 2017). Among the planning strategies put forth to increase function and resilience, a top prescription is the protection and restoration of riparian zones, particularly mid-watershed (alluvial) reaches upstream of urban areas where storm energy attenuation and flood water storage capacity are highest and can have the greatest benefit to people (Seavy *et al.* 2009).

Improving Floodplain Habitat: Opportunities for Conservation, Restoration, and Stewardship

Floodplains are key features of all natural rivers and creeks in the Bay Area except in headwater reaches, where the channel is naturally confined by steep slopes. The large, alluvial rivers and streams of the Bay Area (*e.g.*, Russian River, Napa River, Alameda Creek, Coyote Creek, Pescadero Creek, and San Lorenzo Creek) have significant capacity to make and maintain floodplain habitat. But even their tributaries have gradients shallow enough for floodplains — and in most cases, these tributaries are the actual natal waters for salmonids. To ensure the inclusion of these important floodplains in CLN 2.0, the team mapped stream valleys (which include channels, floodplains, and terraces), a process described in “Riparian Habitat and Hydrologic Processes: Rethinking “Riparian” with Updates in 2.0” on page 92. This allowed the team to incorporate the natural/seminatural stream valleys that were not already in the Network as “Areas Essential to Conservation Goals,” adding 101,572 acres to the Network.

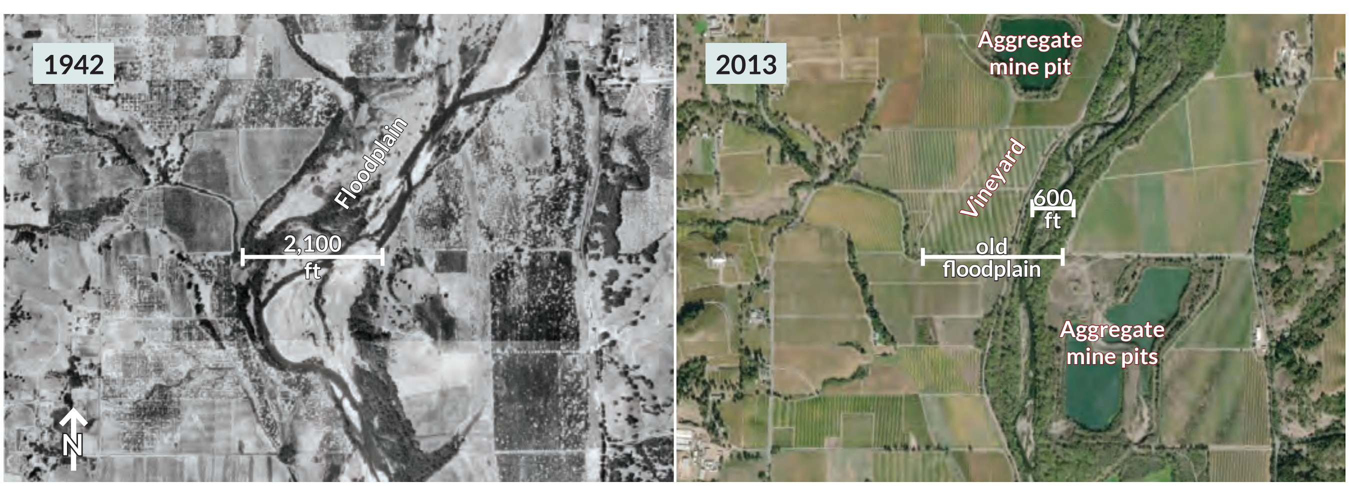
A significant amount of Bay Area floodplain habitat has been lost to channel armoring and straightening projects done to accommodate human land uses such as residential and commercial development, gravel mining, agriculture, and roads, or to convey stormwater more quickly through urban areas (Figure 5.1). The loss of Bay Area floodplain habitat has led to the low population numbers and endangered status of the region’s three main species of anadromous salmonids: coho, Chinook, and steelhead. Young salmon rear in the off-channel sloughs and secondary channels of floodplains where currents are slower and they can find protection from predators. When channel modification eliminates those floodplain features, smolt survival is reduced (Jeffres *et al.* 2008).

Floodplain vegetation is important for aquatic and terrestrial species alike. In healthy riparian systems, shrubs and woodlands (*e.g.*, sycamore, willow, white alder, red alder, Fremont cottonwood, Oregon ash, big leaf maple) create habitat of differing structures, or habitat mosaics that support riparian-obligate birds such as Belted Kingfisher and Wilson’s Warbler, and for amphibians such as Western Toad and Pacific Chorus Frog. Shade from tall woody vegetation is vital to maintaining cool stream temperatures for fish, while gaps in shade that allow in sunlight are essential to reptiles and amphibians that live in floodplain wetlands, such as Western Pond Turtle, California Red-legged Frog, and Foothill Yellow-legged Frog.

Focus Team conservation recommendations specifically for floodplains:

- Reestablish connectivity between channels and their floodplains through the creation of flood setbacks, which may require armoring and berm removal.
- Restore floodplain morphology and complexity, and manage reservoir releases to mirror natural flows, to benefit fish rearing in floodplain habitat.
- Promote habitat mosaics and native species assemblages on floodplains.

Figure 5.1 ■ **Example of Floodplain Loss.** Near Windsor in Sonoma County, the Russian River has lost floodplain to aggregate mining and agriculture. The photograph on the left, taken in 1942, shows a 2,100ft-wide undeveloped floodplain. It also shows scars from former channels, evidence of the river moving across the valley over time. The photo on the right, taken in 2013, shows channel migration 200ft to the east and floodplain loss to aggregate mining and agriculture.



"To accomplish anything these days, you almost have to be an expert in six different fields at once. Stream management and restoration are particularly this way."

— Ann Riley, Author of *Restoring Streams in Cities* (Riley 1998)

Urban Creeks and Biodiversity

Many of the Bay Area's creeks flow out of mountains and foothills onto urbanized plains or valleys, where they are confined to straightened channels that accommodate development and convey stormwater. Despite this significant modification and management, urban creeks can still provide significant habitat and ecosystem values.

For example, many of the Bay Area's anadromous fish runs must transit through downstream urban streams to reach upstream spawning and rearing habitat. These downstream reaches also support endemic warmwater fishes, making them essential to reaching regional fish conservation goals. Urban creeks act as movement corridors for terrestrial animals as they attempt to access other parts of their home ranges. Dredged sediment from urban flood control channels is needed for use in baylands restoration projects in locations where baylands are not able to accrete or import enough sediment in place. Perhaps equally important is the connection to nature urban residents can experience through urban creeks, including joining "friends of" groups to remove trash, manage invasive plants, and replant native vegetation.

Enhancement and restoration of urban creeks, even highly modified flood control channels, can include establishment of native vegetation cover and even mimicking natural channel morphology. Such restoration projects can provide unique public access opportunities as well as space for pedestrian and bike paths.

Improving urban creeks for biodiversity values is complex. Unlike rural creeks where stream management is borne by a handful of landowners, urban creeks involve multiple public agencies and layers of policy aimed at protecting urban populations and property from flooding and erosion. Agencies responsible for controlling flood risk manage urban creeks for maximum water conveyance, a goal that typically leads to removal of sediment and vegetation — and resulting degradation of riparian forests and delivery of sediment to baylands, where it is essential for sustaining marsh habitat. In addition, each urban creek is different with varying sediment loads, water regimes, channel shapes, and substrates.

With this in mind, the Fish and Riparian Focus Team strongly recommends the principles and tools developed for Flood Control 2.0, a joint project of the San Francisco Estuary Partnership, San Francisco Estuary Institute (SFEI), San Francisco Bay Conservation and Development Commission (BCDC), and San Francisco Bay Joint Venture. Flood Control 2.0 (www.sfei.org/projects/flood-control-20) includes data, tools, and initiatives that foster collaborations and help flood control agencies and natural resource organizations improve habitat function and other benefits in urban creeks and for the baylands to which they drain. One example is SediMatch, a dredge material-to-marsh matchmaking program. Flood Control 2.0 strategies are being implemented in Novato Creek and San Francisquito Creek, and the success of these projects shows great promise for the Bay Area's many other urban creeks.

The CLN 1.0 team added natural riparian vegetation within urban areas — post-Marxan — as a way to incorporate urban creeks into the network. However, the medium resolution of available vegetation data meant that many patches of riparian vegetation were omitted. To overcome this limitation, the CLN 2.0 team added more extensive stream valleys, along with vegetation data, to capture more of the urban creek space. These additions included undeveloped areas that may not be vegetated but that may have current or future ecological value. The CLN also targets Priority 1, 2, and 3 streams, which extend through urban areas and out to their mouths at the Bay or coast.

Urban Creek Restoration Success Stories

The Guadalupe River, a 500ft-wide creek channel flowing through San Jose, is an example of a large-scale, multi-benefit project that includes stream restoration for salmonids, flood control measures, and extensive public access.

Colgan Creek in Santa Rosa, a 100ft-wide engineered channel, is a smaller-scale multi-benefit project that creatively added stream meanders and space for riparian woodlands, and included an off-street biking and walking path.

Riparian Restoration Success Stories

Restoration for Native Fish in the Napa River

Stream restoration that emphasizes restoring riparian function rather than achieving percent canopy cover or other isolated components will better prepare creeks and streams for the effects of climate. Restoration work on the Napa River, which supports nearly the entire original native fish fauna, is an excellent example. At the time of CLN 1.0, Napa River restoration was underway in the Rutherford Reach, creating backwaters as refugia from high flows. These backwaters are now filled with native fish (Koehler pers. comm. 2011). Since then, restoration has extended south into the Oakville and Yountville reaches, and removal of several major barriers has allowed Chinook salmon and steelhead access to the upper watershed. Monitoring data from fish traps (Koehler and Blank 2018) show that despite ups and downs in recent years (attributable to the 2012-2015 drought and subsequent deluge in 2017), no native fish have disappeared.

Restoration along the Napa River. Photo by Jonathan Koehler.

Keeping Water in the Creek: A Landowner Innovation

Keeping water in riparian ecosystems is imperative, especially during the dry season. Diversions of surface water and shallow groundwater for agriculture and residential purposes during the dry season can de-water creeks, killing fish and other aquatic life. Some landowners have begun partnering with local Resource Conservation Districts and other conservation organizations to establish off-channel water storage tanks and ponds that fill during the wet season and can be drawn upon during the dry season. In Sonoma County's Salmon Creek Watershed, a local dairy operator partnered with the Gold Ridge Resource Conservation District to design and construct a 1.4 million-gallon storage pond that, in the summer, provided nearly 7,000 gallons/day of water that would otherwise have been siphoned out of the stream. This project not only benefited local streams but also created a drought-resilient dry season water supply for the landowner.

Collaboration Key to Riparian Conservation

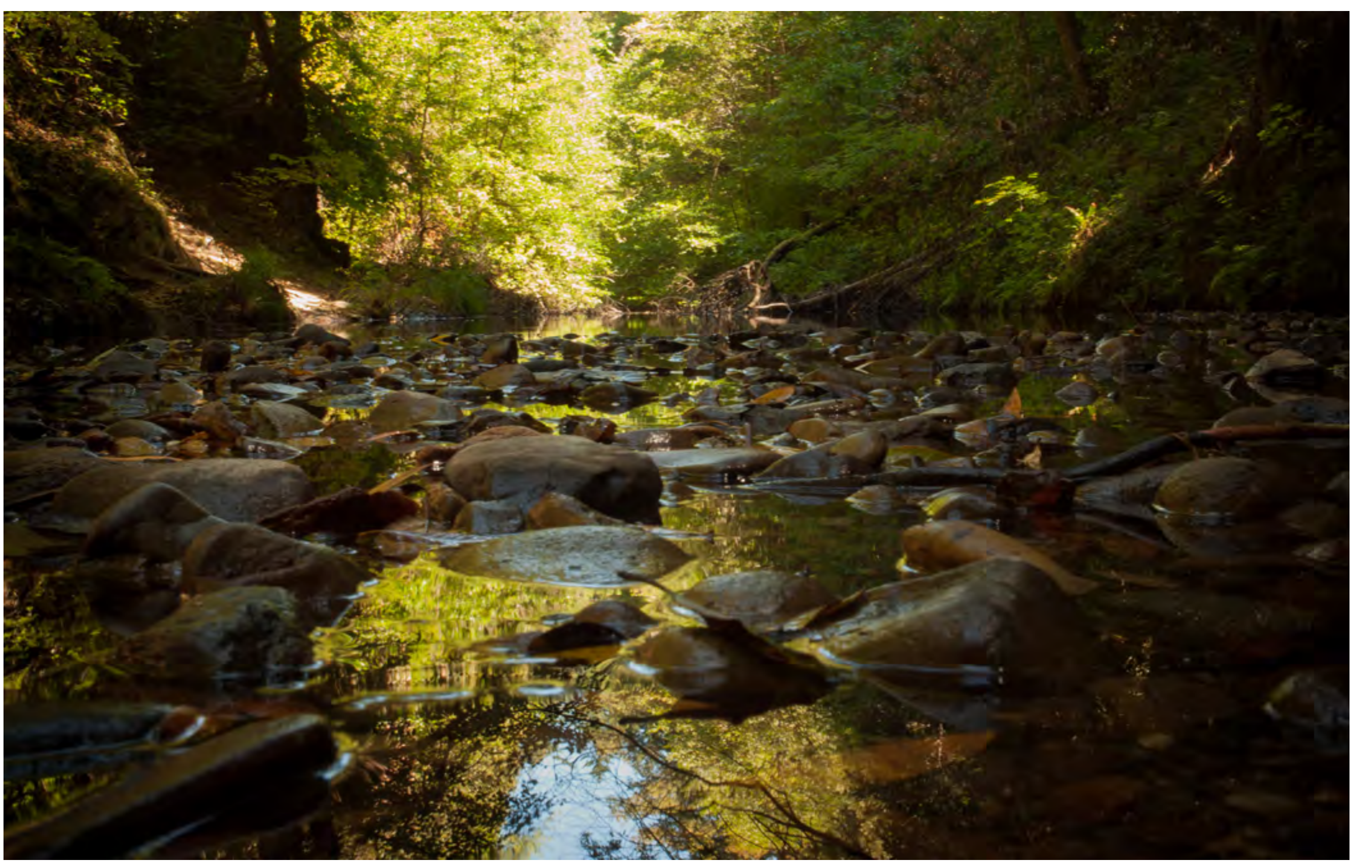
Stream conservation is particularly challenging because streams cross many ownership and jurisdiction boundaries. Successful conservation strategies are collaborative, engage private landowners, and include incentives and technical assistance. For example, the Sonoma County Conservation Venture Partnership is a collaboration — funded by a National Resource Conservation Service (NRCS) Resource Conservation Partnership Program grant — of conservation agencies, funders, residents, farmers in Sonoma County. The partnership aims to conserve working lands and natural areas in a way that supports agricultural systems that promote health and conservation of natural resources, and to strengthen the climate resilience of Sonoma County agricultural and natural systems. The Partnership is using conservation easements and enhanced on-farm practices that target insufficient water supplies, inadequate habitat for fish and wildlife, and soil and water quality degradation. Partners include the Sonoma County Agricultural Preservation and Open Space District, local and state NRCS offices, Sonoma Resource Conservation District, Gold Ridge Resource Conservation District, Sonoma Land Trust, Sonoma County Water Agency, and the Pepperwood Preserve.

Riparian and Fish Conservation Targets and Network Protection

The goal of CLN 2.0 is to conserve viable populations of full assemblages of native riparian biodiversity. Toward that goal, the Riparian and Fish Focus Team:

- Suggested, provided, and reviewed available distribution data on species and populations, including life history, ranges and occurrences, to update understanding of current distributions;
- Selected a list of native fish species as conservation targets (Fish Species Conservation Targets) and compiled their respective habitat requirements / descriptions;
- Selected and ranked a list of stream reaches that are essential to conserve for fish population persistence (Stream Conservation Targets);
- Selected a list of riparian habitats to include in the Marxan prioritization model;
- Reviewed new data depicting stream valleys and headwaters; and
- Recommended management and stewardship actions to ensure target fish species persistence.

One of the values of the CLN is the transfer of on-the-ground knowledge from focus team members into a central repository — the CLN databases. This is particularly important for streams and riparian zones, dynamic zones that can change from year to year. The Riparian and Fish Focus Team knowledge about the quality of in-stream habitat and distributions of fish and other aquatic species helped "true-up" the spatial data for the network update; perhaps more importantly, this input formed a collective understanding of how stream and riparian systems are faring after historic drought and wildfire.



Pescadero Creek, in San Mateo County's Pescadero Creek County Park. Photo cc Franco Folini.

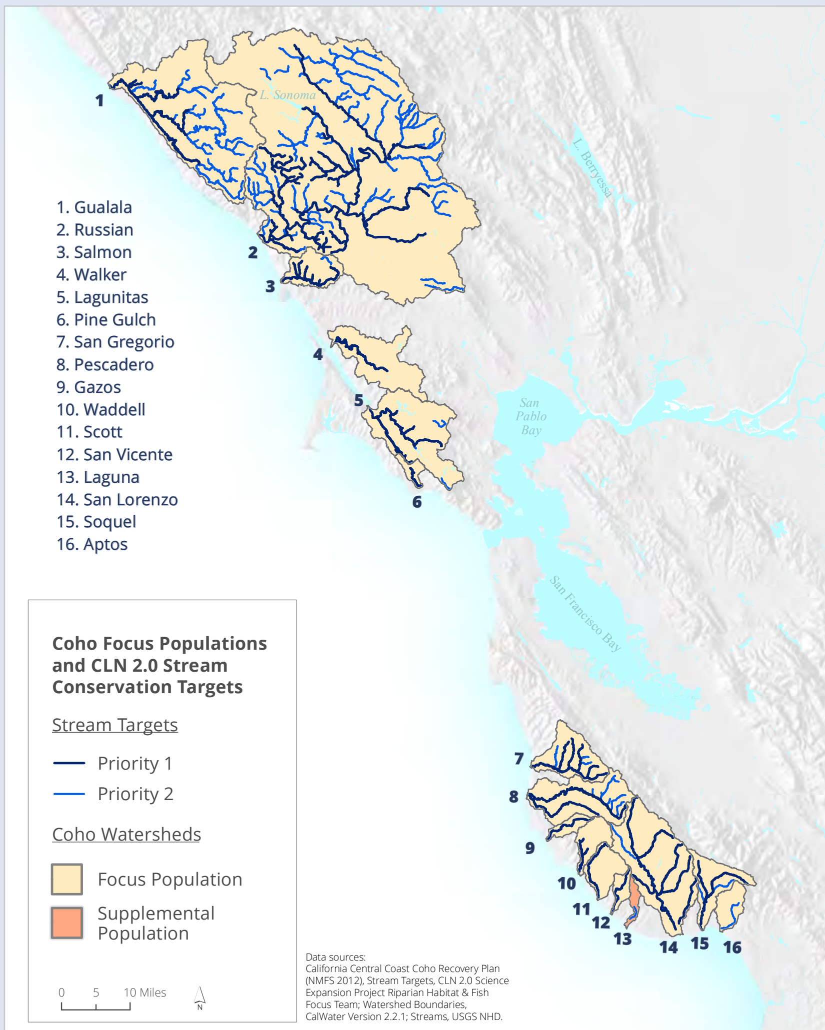
Coho salmon

The current status of Bay Area coho salmon is extremely troubling; the combination of drought and warm (poor upwelling) ocean conditions has driven the species to the brink of local extinction. The only surviving run south of the Golden Gate is in Scott Creek (Santa Cruz County), where a conservation hatchery operates. In Marin, historic runs in Redwood Creek are virtually extinct, and runs in Lagunitas Creek are the largest in the region. Both of these runs will benefit from restoration of marshes that serve as smolt rearing habitat before heading out to sea for two years. Small runs persist in the Russian River basin and are largely dependent on hatchery fish. Coho are still present in low numbers in the Gualala River system (NMFS 2012), but are in danger of extirpation.

The Coho Recovery Plan delineates two levels of priority for Planning Watersheds. **Focus Populations** are watershed-based delineations where coho are still extant or recently extirpated and that have high restoration potential in the short-term and need immediate actions. **Supplemental Populations** (also watershed-based) have high restoration potential, but efforts in these watersheds are dependent on supporting connectivity between Focus Populations. Supplemental Populations have some habitat potential, but are lower priority in the short-term.

The Bay Area contains 15 Central Coast Coho Focus Population watersheds and 1 Supplemental Population watershed (Figure 5.2). The Coho Recovery Plan contains a plethora of information and watershed specific assessments and actions, and should be consulted for any conservation project in a Coho Recovery Plan watershed.

Figure 5.2 ■ Map of Final Coho Recovery Plan Watersheds with CLN 2.0 Priority Streams.



Climate change is an existential threat to Bay Area coho. The southern watersheds and the inland parts of the Russian River are already near the temperature limit (average maximum August temperature 21.5° C). But recent assessment work by USGS has identified recharge and fog as key elements in hydrologic resilience to climate change (Torregrosa *et al.* 2019 in press). Recharge during the wet season produces cool spring water throughout the dry season. Fog reduces water temperatures by shading streams. Fog also reduces evapotranspiration from riparian vegetation, which combined with fog drip in upper watersheds can double late season streamflow (Sawaske and Freyberg 2014). Explicitly protecting and managing high recharge zones (dependent on bedrock geology) and high fog drip zones (windward upper slopes and ridgetops with large conifers) is a feasible strategy for maximizing hydrologic resilience for coho and steelhead.

Coho salmon in Lagunitas Creek in Marin County. Photo by Stuart Weiss.

Key Focus Team Determinations for Riparian Areas and Fish

- Bay Area mainstems (primary downstream segments of rivers) and tributaries still have some of the best assemblages of native fish and other aquatic vertebrates in the state.
- Even intermittent streams and those with low flow are worth protecting. Ephemeral and intermittent streams with natural flow regimes are extremely important and include refuge pools that are critical to the survival of native fauna during dry periods (even extreme dry periods). Current regulatory tools can result in undervaluing ephemeral and intermittent streams.
- Conserving space defined by habitat function that incorporates all the parts of the stream valley and associated headwaters will increase the probability of success for fish and other stream dwellers, especially Foothill Yellow-legged Frog and some populations of California Red-legged Frog.
- Riparian restoration should be process-based, an approach that re-establishes natural stream function (flooding, recruitment of large woody debris, etc.), which then promotes a mosaic of habitat structures. Mosaic habitats provide a balance between temperature and shading needs of aquatic and riparian species. For example, shade reduces water temperature while open areas are important for basking frogs and turtles. Open reaches have better aquatic insect production and visual feeding opportunities for steelhead (Smith pers. comm. 2019).
- Climate change poses great risks to fish through increased water temperatures and altered flow regimes (changes in the timing of rain and runoff), including earlier seasonal drying. In many managed streams, late summer flows are increased to transport stored reservoir water, and this can favor non-native aquatic organisms such as common carp, non-native species of sunfish, and Bullfrog.
- The listed salmonids each have approved Recovery Plans, which include detailed assessments and recommended conservation/restoration actions at the planning watershed scale.
- Limiting impervious surfaces and flow interception by paved and unpaved roads, especially in headwaters, has myriad positive effects throughout a watershed and remains a top conservation goal.

Recovery Plans for Salmonids

The anadromous salmonids of the Bay Area are an intense focus for conservation, and the subject of three official Recovery Plans:

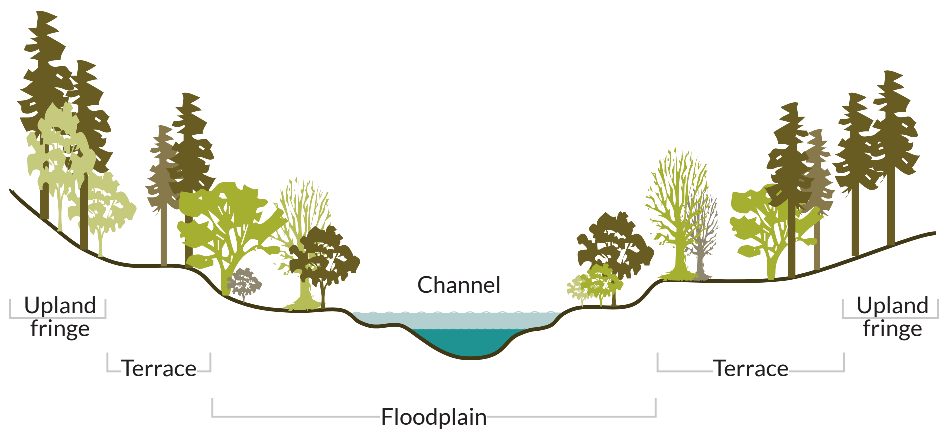
- Central California Coast Coho Salmon (NMFS 2012)
- South-Central California Coast Steelhead (NMFS 2013)
- Coastal Multispecies Final Recovery Plan: California Coastal Chinook Salmon, Northern California Steelhead, and Central California Coast Steelhead (NMFS 2016)

Riparian Habitat and Hydrologic Processes: Rethinking "Riparian" with Updates in 2.0

Modern strategies to conserve riparian areas call for a new way of thinking about these important areas. Central to this new thinking is conserving not simply a fixed-width buffer on either side of a stream, or a zone that covers existing riparian vegetation, but the physical space needed to allow fluvial and ecological processes to occur over their natural spatial and temporal scales. This functional approach leads us away from using riparian vegetation presence as the sole definition of riparian, and toward identifying variable-width corridors that follow stream valley morphology.

The CLN 2.0 team used the term "stream valley" to include all parts of the fluvial system: channel, floodplains, terraces, and the transitional upland fringe (see Figure 5.3). This is the stage for fluvial processes (*e.g.* flooding, natural bank erosion and failure, and aquifer recharge), as well as ecological functions (*e.g.* large wood recruitment, vegetation growth and succession, organic matter input, and shading) that are the drivers of the structural complexity, vegetation mosaics, and hydrological conditions that lead to healthy streams and riparian biodiversity.

Figure 5.3 ■ **Stream Valley Cross-section.** Functions of the floodplain include bank stability, shading, and organic matter inputs. Functions of the terrace and upland fringe include wood recruitment, sediment and nutrient retention, and habitat for riparian obligate species. Adapted from Eubanks 2004.



Considering Upland Vegetation Communities as Riparian

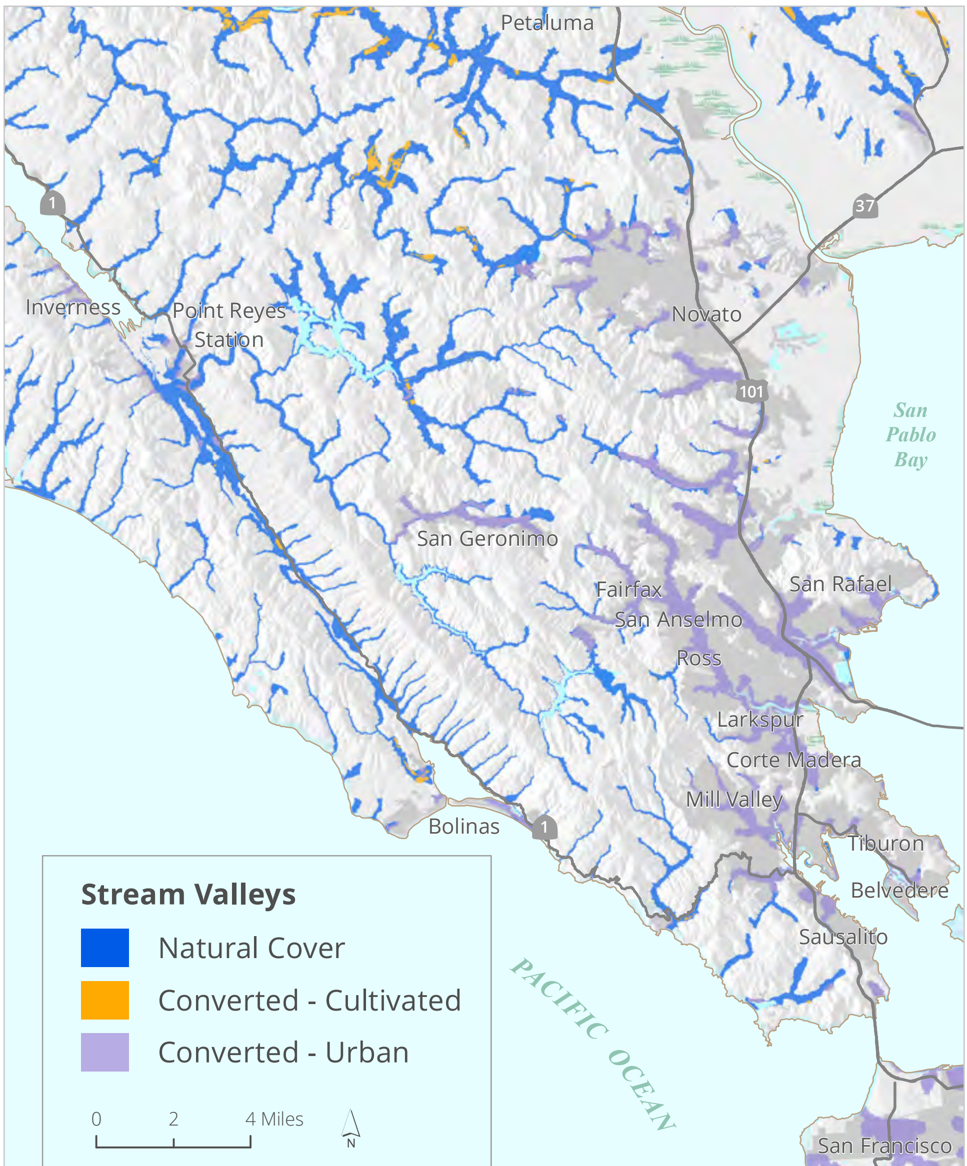
Stream valleys include many types of vegetation communities, including riparian obligate communities such as riparian mixed hardwoods and sycamore alluvial woodlands, valley bottom specialists such as valley oak woodlands, and even communities associated with uplands such as Douglas-fir forest. All vegetation communities within stream valleys serve some form of riparian ecological function, and are considered riparian in CLN 2.0.

Translating Concepts into Conservation Strategy: New Stream Valley Data

To support conservation of stream networks and riparian function, the CLN team produced and incorporated into CLN 2.0 new stream valley geographic data that characterize wide, variable-width corridors along streams. Using updated USGS terrain models based on recent high-resolution LIDAR imaging and analysis techniques developed by The Nature Conservancy (Smith *et al.* 2008), the CLN team mapped stream valleys (see Figure 5.4). This was an advancement called for in CLN 1.0 (see Riparian and Fish Data Gaps, "Develop a comprehensive map of riparian habitat in the San Francisco Bay Area," in CLN 1.0). To ensure that these important corridors were comprehensively covered, the stream valleys were added to the network after the Marxan analysis, along with riparian vegetation polygons in the CLN 2.0 vegetation map. Figure 5.5 shows the extent of these valleys in each county.

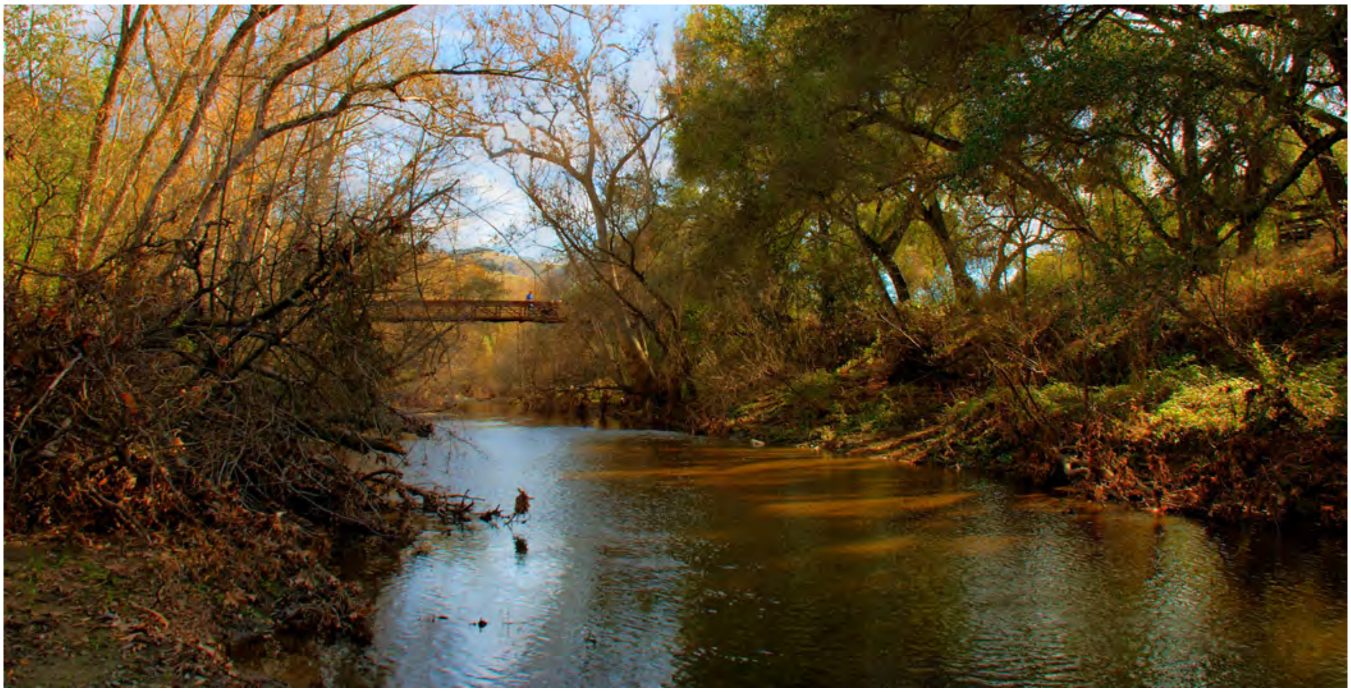
Because stream morphology is highly dependent upon local intrinsic factors such as geology and soil type, precipitation, and natural and artificial barriers to flow, it is difficult to perfectly map stream valleys. However, since stream valleys are highly controlled by local topography, they can be adequately approximated with high-resolution terrain models. The CLN 2.0 project team used new high-resolution terrain data for this purpose. These data show natural stream valleys where human impacts should be limited, cultivated stream valleys where habitat restoration should occur, and urbanized stream valleys where in-channel enhancements should be considered.

Figure 5.4 ■ Example of CLN 2.0 Stream Valley Mapping in Southern Marin County.



Data source: CLN 2.0 Science Expansion project.

The stream valley dataset is a significant addition to CLN 2.0. However, these data are limited in that they are based on existing drainage patterns. Many streams in the Bay Area emerge from mountains and foothills, and flow across fans of alluvial sediment deposits. A characteristic behavior of such streams is abrupt change of course after a log jam or other obstruction causes the creek to jump its banks. This is a natural process that results in abandonment of the former channel and establishment of a new channel. This process has been well-documented in the North Bay and South Bay through historical ecology work (*e.g.*, Grossinger *et al.* 2007, Grossinger 2012, Dawson and Sloop 2010). It is outside the scope of the CLN to model these kinds of long-term change.



Alameda Creek. Photo cc Don DeBold.

Figure 5.5 ■ Total Area of Stream Valleys (in acres), by County.

County	Natural/ Semi-natural	Converted - cultivated	Converted - urbanized	Total
Alameda	35,005	851	11,958	47,814
Contra Costa	30,861	280	23,778	54,918
Marin	34,127	2,338	11,862	48,327
Napa	51,444	13,832	2,593	67,870
San Francisco	*	*	*	
San Mateo	23,800	2,873	8,988	35,661
Santa Clara	63,973	2,989	11,380	78,343
Santa Cruz	26,126	3,634	11,980	41,740
Solano	21,708	3,002	10,277	34,987
Sonoma	98,902	26,171	4,393	129,465

* San Francisco was omitted from this analysis, as the model does not work well in highly modified landscapes.

New Headwater Source Area Data

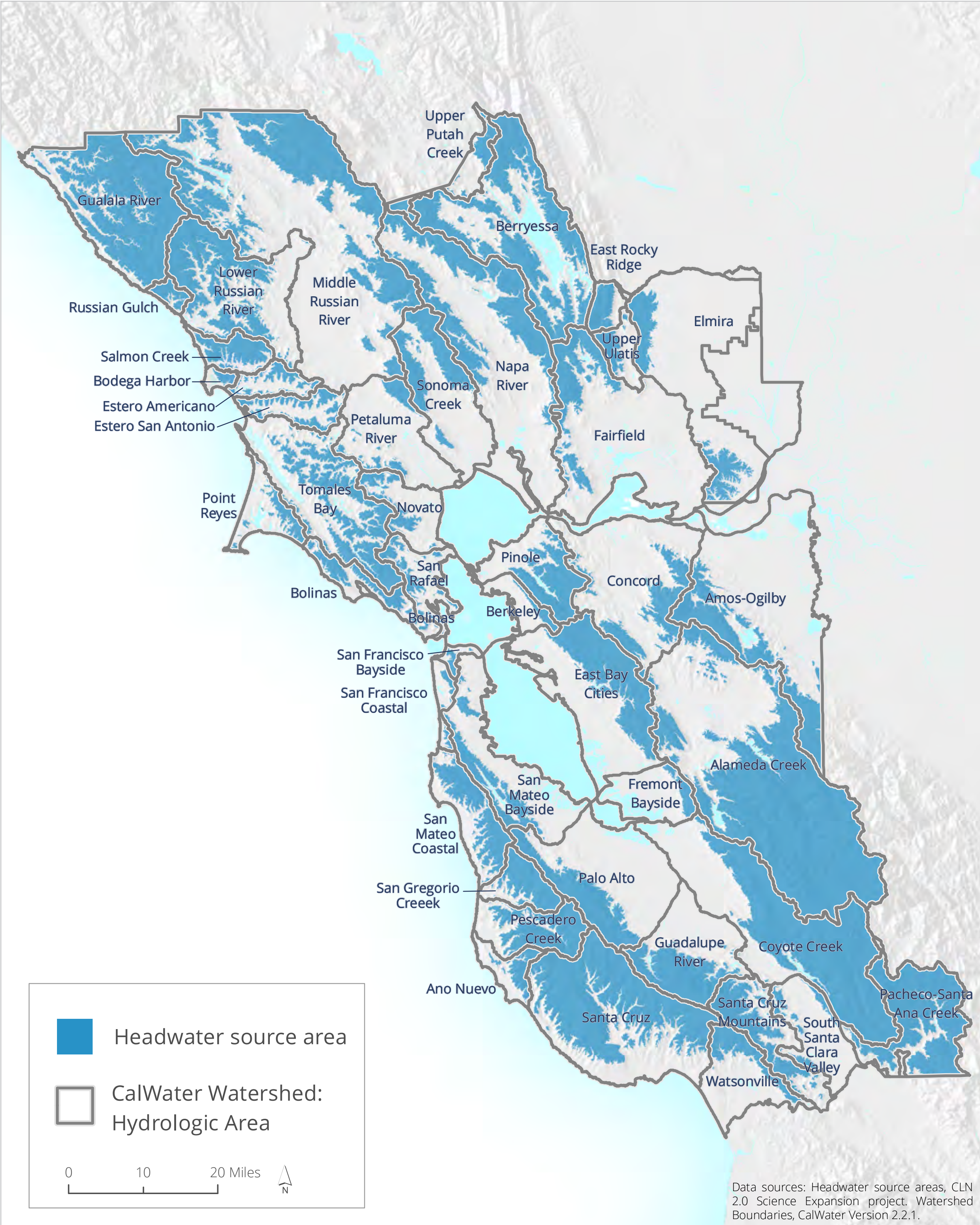
Headwaters, the upper part of a watershed, provide important benefits to the entire watershed. The many small tributaries in headwaters capture water and transfer sediment and organic matter to lower parts of the watershed. In forested coastal headwaters, fallen logs and other large woody debris are deposited into the stream and contribute to the creation of complex habitat for fish and other aquatic life in the lower sections.

Existing development in the headwaters of the Bay Area is patchy and tends to be rural residential and vineyard agriculture (primarily in Napa, Santa Cruz, and Sonoma counties). The cleared areas, hard surfaces, roads, and other impervious surfaces associated with these types of development increase runoff and the erosive power of streams, leading to an imbalance of sediment in lower reaches. The results are degraded stream reaches, where streambeds are eroded and lowered, and aggraded reaches, where the streambed is artificially raised from the collection of too much eroded sediment. These changes negatively impact fish. In degraded streams, the channel becomes disconnected from its floodplain and juvenile fish rearing habitat is lost. In aggraded streams, water becomes too shallow for adult fish and water temperatures become too high.

Climate change will exacerbate the effects of development on sediment balance. Extreme precipitation will interact with impervious surfaces and increase stream velocity and erosion in headwaters, negatively affecting habitat in downstream reaches (Pelletier *et al.* 2015). Conserving headwaters and minimizing impervious surfaces, including paved and unpaved roads, are key actions for climate resilience.

As a part of CLN 2.0, a new dataset was developed to represent headwater source areas (Figure 5.6). Because of the massive scale of these lands, the team did not incorporate these data into Marxan as explicit targets; they would have overwhelmed the network and diluted the other targets. The data were used to calculate how well the network represents headwaters; the Conservation Lands Network 2.0 includes 71% of the headwater source areas. The headwater data is an ancillary dataset on the CLN 2.0 Explorer, available to download at BayAreaLands.org.

Figure 5.6 ■ Map of Headwater Source Areas in the Bay Area.



Riparian and Fish Data Sources

Dataset	Source	Use(s) in CLN 2.0 Network Design
Stream valleys (polygon)	USGS 10m Digital Elevation Model	Added to network post-Marxan
Headwater contribution zones (polygon)	USGS 10m Digital Elevation Model; CalWater 2.2.1 watersheds	As a complementary dataset to the network
Stream conservation targets (lines)	Expert/focus team input; National Hydrography Dataset (NHD v2); California Aquatic Resource Inventory and Bay Area Aquatic Resource Inventory (SFEI)	As a complementary dataset to the network
Riparian vegetation (polygon)	Eveg vegetation map (USFS)	Added to Marxan with 90% conservation goal

Designing a Conservation Lands Network for Riparian Areas and Fish

To ensure that the network adequately protects riparian habitats and species, the CLN team identified three categories of conservation targets: fish species, riparian vegetation, and streams.

Fish Species Conservation Targets

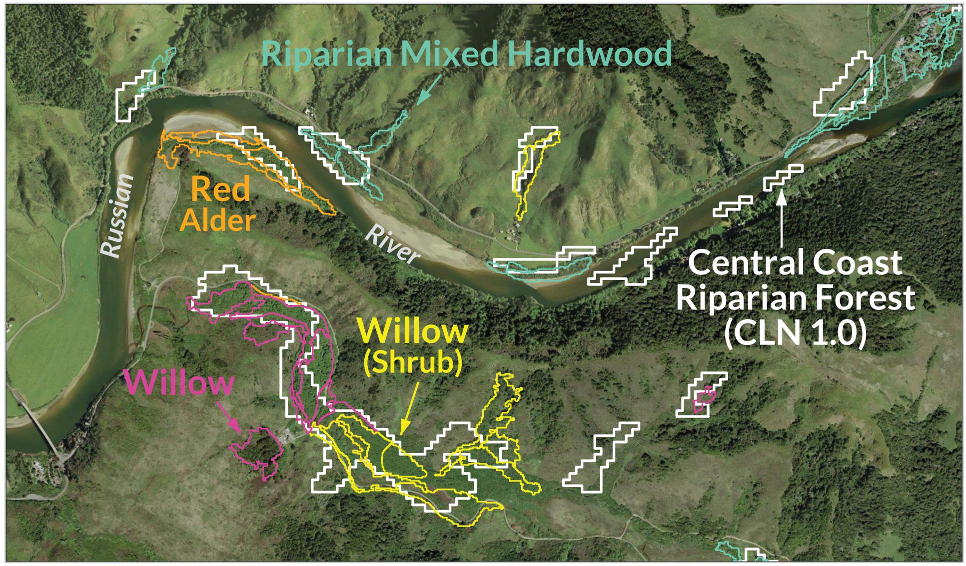
As in CLN 1.0, the Riparian and Fish Focus Team selected all native fish species found in San Francisco Bay Area and Santa Cruz County streams as conservation targets, with the goal of maintaining healthy assemblages of native fishes. Fish species conservation targets are listed in Figure 5.12.

Riparian Vegetation Targets

The vegetation map used to identify CLN 1.0 riparian vegetation conservation targets was a medium-resolution (30m) product with three classes of riparian vegetation: Central Coast Riparian Forest, Sycamore Alluvial Woodland, and Serpentine Riparian. Serpentine Riparian is composed of riparian classes with underlying serpentine geology.

CLN 2.0 used a finer-scale (5-10m) vegetation map with 13 classes of riparian habitat. All of these riparian classes were adopted as vegetation targets, and were assigned Rank 1 (90% acreage goal in each landscape unit) in the Marxan analysis. Figure 5.7 shows an example of this refined vegetation mapping. Figure 5.13 shows how CLN 2.0 riparian vegetation targets map to the CLN 1.0 targets.

Figure 5.7 ■ **Example of Differences in Riparian Vegetation Mapping, CLN 1.0 and CLN 2.0.** Central Coast Riparian Forest, a vegetation class from CLN 1.0 (shown in white), is split into several riparian vegetation classes new in CLN 2.0.



Stream Conservation Targets

The 387 CLN 1.0 stream conservation targets and classification into Priority 1, 2, and 3 streams were carried forward in CLN 2.0. Chapter 5 of the CLN 1.0 report details the criteria for priority ranking. The CLN 2.0 Riparian and Fish Focus Team thoroughly reviewed all stream reaches selected in CLN 1.0 and changed priority rank for 26 reaches, based on their knowledge of current conditions. As before, streams were ranked as Priority 1, 2, and 3 (see Figure 5.9 and Figure 5.14). A total of 23 reaches were upgraded, primarily due to focus team knowledge, while three reaches were downgraded as refinements of the original ranking. More information about stream conservation targets can be found in Appendix C at BayAreaLands.org.

As part of incorporating Santa Cruz County, the team added 25 new reaches (250 miles), including the San Lorenzo and Pajaro Rivers, to the stream targets list. The upgrades and downgrades contributed to total length differences between CLN 1.0 and CLN 2.0 (Figure 5.8), although these were minor (3 miles).

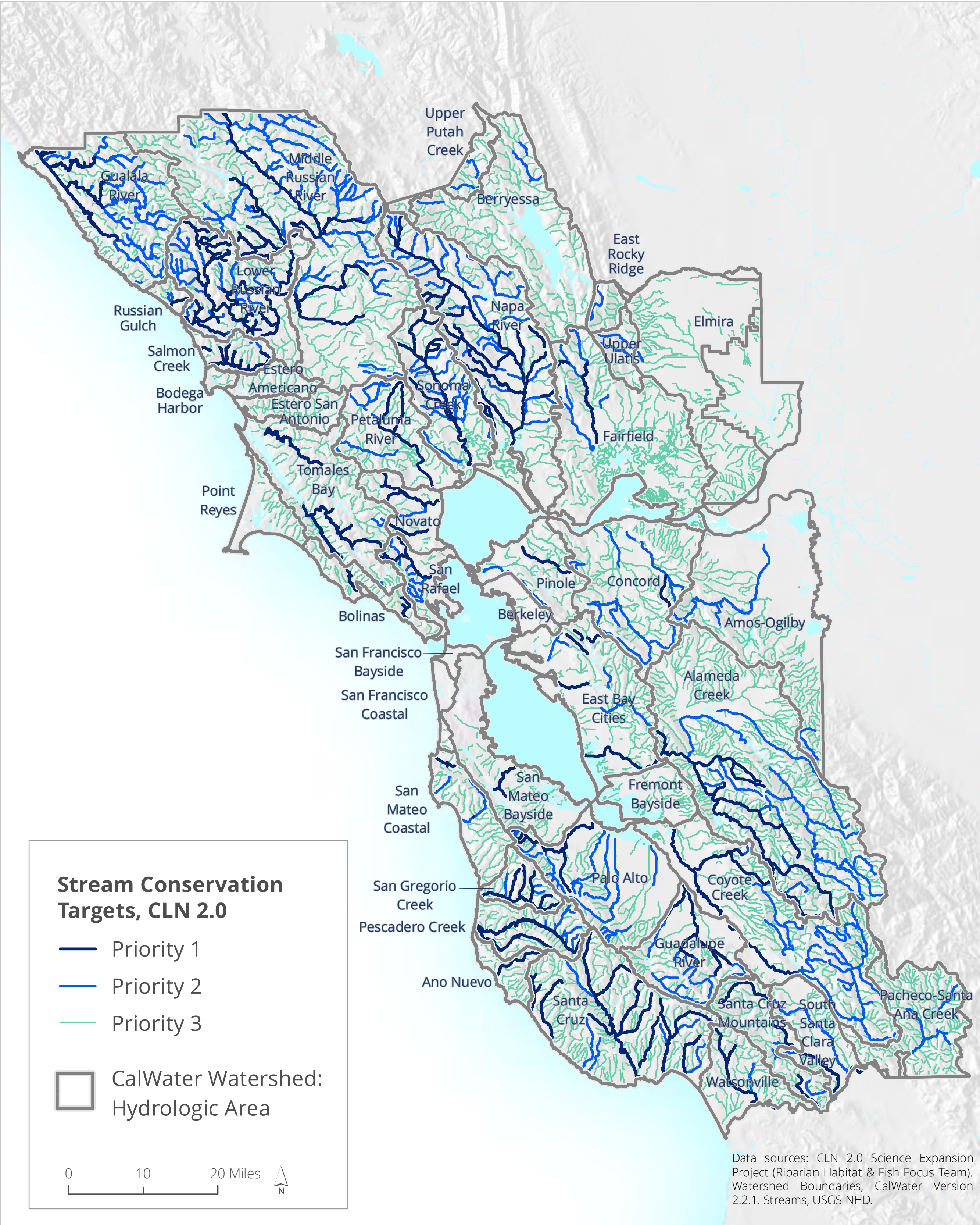
Figure 5.8 ■ **Differences in Stream Conservation Target Priority Ranking, CLN 1.0 and 2.0.** The changes are largely attributable to the addition of Santa Cruz County to the study area.

Stream Rank	General description	Total miles, CLN 1.0	Total miles, CLN 2.0	Change
Priority 1	Presence of coho salmon and inland steelhead (including adfluvial rainbow trout)	895	1,258	363
Priority 2	Presence of inland native fish and coastal steelhead streams	1,537	1,421	(116)

With the addition of Santa Cruz County, CLN 2.0 has a total of 409 Priority 1 and 2 stream conservation targets; this includes the 387 targets from CLN 1.0 minus one that was downgraded to Priority 3, and the addition of 23 new targets. Appendix C lists the targets and distinguishes coastal and estuary drainage; it also contains detailed information on species presence, stream conditions, and recommended priority conservation actions.

All Priority 1 and 2 streams, along with the data source and justification for the priority ranking, along with detailed lists of target fish species, are listed in Appendix C, available at BayAreaLands.org.

Figure 5.9 ■ **Map of Stream Conservation Targets in CLN 2.0.** All streams are included in the network and assigned a priority ranking of 1, 2, or 3. A high-resolution, zoomable version of this map is available at BayAreaLands.org.



Network design and riparian targets

As described in Chapter 3, the Marxan analysis creates a network using vegetation types (polygons) and species occurrences (points) and their associated acreage goals. The resulting network is made up of 250ac hexagons, ideal for accounting for wide-area habitats and small features (such as ponds or wetlands) nested within larger habitat types.

But Marxan is less suited to incorporating vast linear targets; this is further complicated by the fact that streams flow through converted lands that are not Marxan targets. For fish and riparian areas, riparian vegetation targets were identified within the CLN 2.0 vegetation map and included in the Marxan analysis. However, this was deemed inadequate to capture the habitat needs of fish due to the paucity of riparian vegetation records in the source vegetation map and the limitations of Marxan with respect to linear networks. Note that all converted lands are excised from the selected hexagons for final network configuration.

CLN 1.0 addressed the above issue through the Stream Conservation Targets, used to create a separate, linear overlay to the network. CLN 1.0 called for areas "as wide as possible" to be conserved on either side of the stream targets. This was a good way to provide strategic direction while avoiding the limitations of Marxan. However, important areas for riparian function were not fully incorporated into the network itself and, likely as a result of being delivered as a separate overlay, the streams targets have not always been considered in regional planning along with the network (*e.g.*, ABAG Priority Conservation Areas). CLN 2.0 addressed this deficiency by representing stream valleys in the delineation of new polygon features, described in the next section.

Pond, Diablo Foothills. Photo by Steven Joseph.

Figure 5.10 ■ Total Length of Priority 1 and 2 Streams, by County.

County	Stream length, in miles		
	Priority 1	Priority 2	Total
Alameda	69	103	171
Contra Costa	21	116	137
Marin	106	41	146
Napa	145	164	309
San Francisco	0	0	0
San Mateo	113	58	171
Santa Clara	191	370	561
Santa Cruz	148	40	188
Solano	10	48	58
Sonoma	397	485	882

Buckeye Creek in Buckeye Forest, Sonoma County. Photo courtesy Sonoma County Agricultural Preservation and Open Space District.

Threats to Riparian Areas and Fish and Recommended Conservation Actions

Conservation Lands Network 1.0 identified 16 threats and stressors for coho and stream habitat (CLN 1.0 report, pp. 88-90) and 8 recommended conservation actions. The focus team upheld those threats/stressors and recommendations, and offered the following refinements and calls for action.

The team identified the following factors critical to conservation of riparian areas and fish population persistence, here in alphabetical order:

- Climate change
- Habitat connectivity (reducing barriers to fish passage)
- Land use and development
- Predation
- Water quality and pollution

Climate change

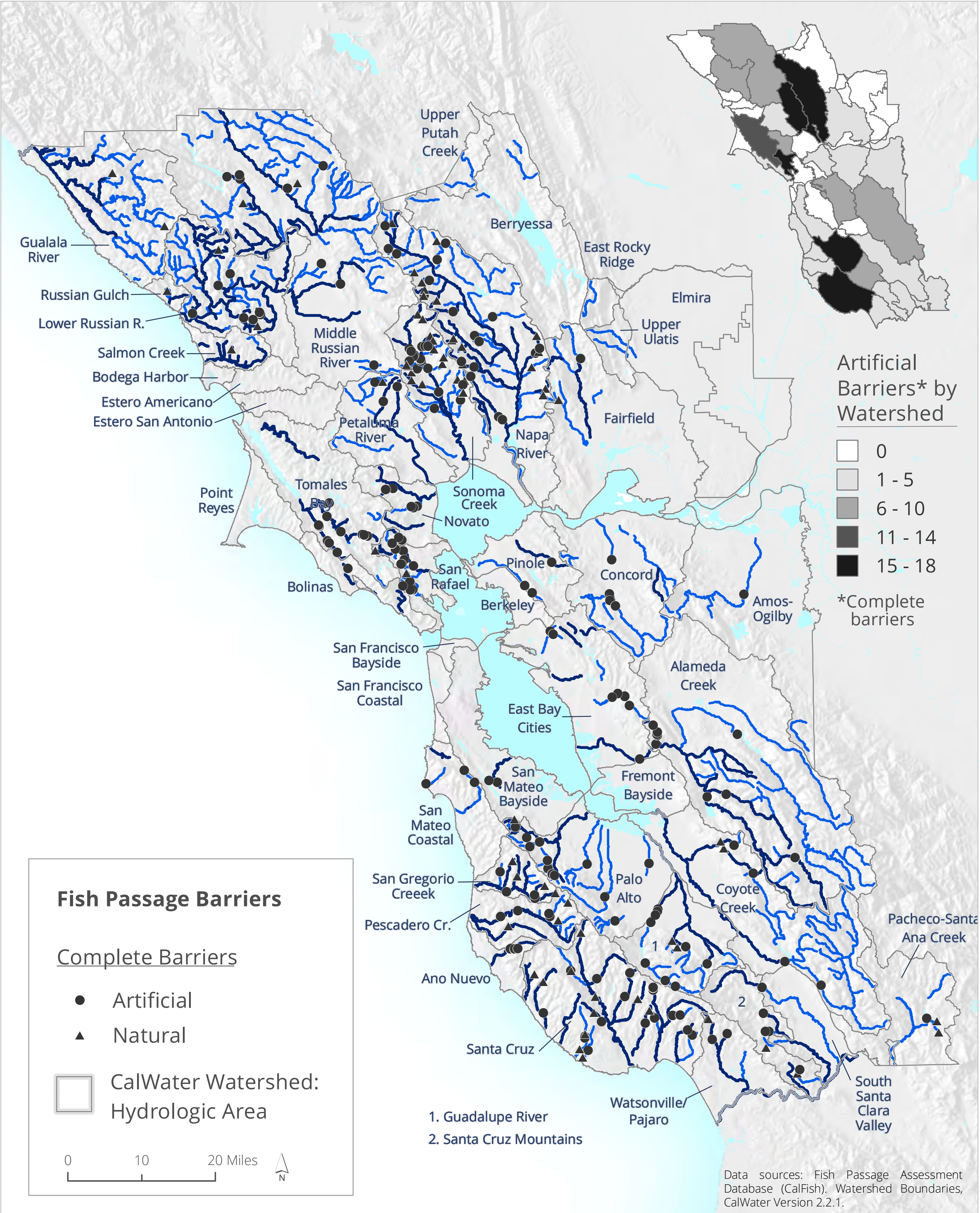
Threats	Conservation actions
Drought The recent drought impacted salmonids. For example, a study of steelhead in Coyote Creek (Santa Clara Valley) determined that the 4 years of drought affected smolt and/or adult passage resulting in no apparent steelhead production in 2015-2017 and the killing of smolts in drying reaches in 2014. Additionally, data show only limited localized reproduction in 2018. Drought may prove particularly challenging for species with a multi-year lifecycle such as coho, which have a three-year life cycle. Thus, severe population reductions recur every three years. Streams fed by deep groundwater or springs may be less susceptible.	■ For analyses, use recent drought as baseline to analyze runoff and recharge. ■ Consider aspect in restoration designs. Southwest facing slopes may be less resilient to climate change. Fund work on sites that may be more resilient long-term. ■ Consider the habitat needs of native warmwater fish. ■ Protect intermittent and ephemeral stream reaches that contain persistent pools (those that typically persist through the dry season) which support native fish, amphibians, and invertebrates.
Extreme flooding Streams and their associated floodplains, terraces, and upland transition zones are, by their nature, resilient to dynamic events (Seavy *et al.* 2009). Protecting waterways, restoring floodplains, and removing stream barriers, particularly upstream from and through populated areas, protect people from flood hazards (Palmer *et al.* 2008).	■ Protect, restore, and steward wide riparian/upland transition zones allowing for dynamic ecological and geomorphic processes (*e.g.*, flooding, sediment degradation/aggradation, large wood recruitment, vegetation succession, nutrient cycling) as a climate adaptation measure (Seavy *et al.* 2009).
Resilience to and preparation for sea level rise River and stream outlets to the San Francisco Bay and Pacific Ocean will see upstream migration of tidal habitat.	■ Identify, protect, and manage the future upland-estuarine transition zone.

Habitat connectivity

Threats	Conservation actions
Loss of connectivity along streams **Barriers to passage** **Loss of adjacent watersheds; fewer opportunities for interactions among fish populations** Streams connect uplands to the baylands by transporting sediment downstream and allowing movement of resident native fish and anadromous fish upstream and downstream. Loss of interacting anadromous runs in adjacent watersheds minimizes chances of natural re-establishment and augmentation of fish runs. Recolonization of Santa Cruz Mountain coho populations will require conservation hatcheries.	■ Ameliorate and address priority fish passage barriers (for both upstream and downstream migration for different life stages); tie this to flood risk reduction and nourishing sediment transport to the Bay to mitigate sea level rise (Figure 5.11). ■ Prioritize both above- and below-barrier populations of rainbow trout (*Oncorhynchus mykiss*); genetic research tells us above-barrier rainbow trout retain the ability to express anadromy in Bay Area (Leitwein *et al.* 2017). ■ Remove barriers to free upstream passage for juveniles to access cooler, perennial headwaters over time as a climate adaptation strategy for native fish populations during drought periods.

Rainbow trout in Llagas Creek, Rancho Cañada del Oro Open Space Preserve.
Photo by Cait Hutnik.

Figure 5.11 ■ Map of Fish Passage Barriers Along Priority 1 and 2 Streams.



Land use and development

Threats	Conservation actions
Dewatering of streams Groundwater pumping, direct diversion especially during the summer and fall when flows are low and dependent on shallow groundwater discharge into stream channels.	■ Find opportunities to install off-channel storage to reduce dewatering of creeks during the dry season. ■ Promote seasonal reservoir water releases to benefit native fish, especially rearing and smolting steelhead and, where appropriate, coho and Chinook salmon. ■ Promote reuse of graywater or use of recycled water for various activities to keep water in streams as much as possible. ■ Protect high recharge zones in watersheds.
Loss of habitat, generally **Modifications of stream channels** Riparian vegetation is removed for many reasons, such as construction of infrastructure. Riprap for bank stabilization replaces natural streambanks. Removal of large woody debris reduces in-stream complexity. Impervious surfaces near streams increases speed of runoff. Undersized culverts and bridges increase current velocity, with impacts far downstream.	■ Focus on CLN 2.0 Priority 1 and 2 Streams where ecological and hydrological processes still support healthy fish populations. ■ Consider, protect, and restore wide riparian/upland transition zones to allow dynamic ecological and geomorphic processes (*e.g.*, flooding, sediment degradation/aggradation, large wood recruitment, vegetation succession, nutrient cycling) to occur over their natural temporal scales and spatial scales of ecological/biological and geomorphic change (Naiman *et al.* 1993). ■ Protect and steward the different habitat functions throughout the watershed, *e.g.*, upstream, downstream, tidal, subtidal.
Loss of floodplain habitat Many Bay Area creeks and rivers now have a fraction of their original floodplains — a major limiting factor for coho and other salmonids in the region's watersheds. In most of the Bay Area, floodplains on the flatlands are developed. Lower Alameda Creek, for example, is completely channelized for flood control and restoration opportunities are few. The economic, regulatory, and political complexities of enhancing such habitats are daunting.	■ Restore and reconnect floodplain habitat wherever feasible. ■ Tie floodplain restoration to natural flow regimes and other fluvial processes (process-based restoration) in order to re-establish the drivers of habitat diversity. ■ Take advantage of wide areas within urban watersheds to spread and slow water, ameliorate flood risk, and benefit fish.
Urbanization and channelization of streams Concrete trapezoidal or box channels replace streams and provide little habitat. Undergrounding of urban creeks eliminates all functions except passage of water. Riparian vegetation is removed to maintain channel capacity for flood conveyance.	■ Restore and reconnect floodplains. ■ Daylight and restore streams through urban areas and also the riparian corridor. ■ Protect from development groundwater recharge zones and points of discharge (springs and seeps) that support fish-bearing streams. Heads of the alluvial fans are important for recharge.

Increased runoff and pollution from impervious surfaces such as roads and other urban areas affect stream water quality. Photo by Kathy Switky.

Predation

Threats	Conservation actions
Mammals The Bay Area's population of River Otter, which predate fish, is increasing.	- Research the impacts of River Otter population growth on other native species, including fish.

Water quality and pollution

Threats	Conservation actions
Pollution and contamination Agriculture results in nutrients and contaminants entering waterways. Plastic and trash from urban areas, roads, and publicly accessible stream banks and beaches end up in streams.	- Implement aggressive sediment and nonpoint source pollution control measures, enforced through the Clean Water Act. - Improve stewardship of streams and riparian areas on public and private land.
Impervious surfaces Impervious surfaces increase runoff rates and stream erosive power, which result in artificially high sediment loads in waterways. Roads are sources of pollutants such as oil from engines and copper from disc brakes.	- Create an inventory of impervious surfaces in watersheds in the Bay Area; identify "at risk" watersheds that approach a percent threshold (*e.g.*, 12%, EPA 2011) to help raise awareness of the importance of keeping watershed lands permeable. - Further educate the public and landowners about the impacts of impervious surfaces. - Encourage use of porous pavement materials or water retention/recharge features in new construction.

Data Gaps

- Work with California Department of Fish and Wildlife to improve data quality in the Passage Assessment Database in order to distinguish between severe and relatively insignificant "partial barriers" in a watershed. For example, if some adult fish are occasionally blocked, the stream is regularly seeded despite the barrier, and thus the barrier may not be population-limiting. Understanding the different levels of threats of these barriers will focus attention to the barriers that most limit recruitment.
- Research the impacts of River Otter population growth on fish and other native species.

River Otter at Richmond Marina. Photo cc Scott Campbell.

Steelhead

Steelhead are more widely distributed than coho, but are a shadow of their former distribution and abundance. Historically, the Bay Area's larger rivers each supported thousands of fish, and those large populations supported runs in nearly every accessible creek in a robust metapopulation. Because spawning steelhead may wander from their natal creeks, recolonization and reinforcement of small runs was historically routine. Steelhead are resilient and resourceful fish, true survivors, and potentially take advantage of any opportunity. At present, every extant run, even a few fish in a surprisingly small creek, is important.

The Coastal Multispecies Recovery Plan (NMFS 2016) contains detailed information for the California coastal Chinook, northern California steelhead, and central California coast steelhead populations on a watershed level, and should be a guiding document for any stream or watershed restoration. The Plan provides detailed recovery scenarios by watershed that map intrinsic potential (a geomorphic measure of habitat suitability for spawning), identify key stream reaches, account for barriers, and designate connectivity reaches that allow returning fish to transit through urban and other unsuitable areas.

Many Bay Area streams are incised, and provide poor fish habitat. Riparian restoration that creates complex structure, especially high water refugia and deep pools, is being implemented widely. Consideration of the entire stream valley is essential for success. The establishment of beaver may be a key in some streams to coho and steelhead recovery, as beaver dams create complexity, reverse channel incision, and retain surface and subsurface waters (Lanman *et al.* 2013).

Ongoing fish passage projects — removing small dams, fixing culverts, and reshaping man-made waterfalls — are increasing access to spawning habitat. Since 2010, many barriers have been removed or modified. In Sonoma Valley, an abrupt man-made waterfall on Stuart Creek was replaced with a series of step pools. A diversion dam on San Francisquito Creek, one of the Anchor Watersheds discussed in CLN 1.0, was similarly replaced with step pools. Removal of some larger dams is being considered, prominently among them Searsville Dam on the Stanford University campus (Stanford University 2015). These complex projects take years to plan, dealing with issues including sediment removal/stabilization, downstream flood protection, short-term negative impacts versus long-term restoration of fluvial geomorphic processes.

Bay Area creeks also support resident populations of rainbow trout that are not anadromous, some of which are the result of hatchery releases. These fish remain relatively small compared with anadromous individuals. Some resident populations are trapped behind dams, and in some cases become adfluvial where they run down to the lake to feed and grow and run up the creek to spawn. In some creeks, these fish may be the best sample of ancestral steelhead and an extremely important genetic resource (Leitwin *et al.* 2017). Streams that support adfluvial steelhead were changed to Priority 1 based on this factor.

Chinook salmon

Chinook salmon are present in a number of Bay Area streams. In the Napa River, they were once blocked at Zinfandel Lane just below St. Helena, but in 2011 that barrier was removed, opening up 58 miles of spawning habitat for salmon and steelhead (Napa County Resource Conservation District 2019). Chinook salmon can be found in the Guadalupe River in downtown San Jose. These fish may be hatchery strays, but their presence is still important. The Russian River is designated as "Essential" in the Recovery Plan, with a goal of 9,300 spawners, and the Gualala River is designated as "Supporting" with a goal of 1,052-2,105 spawners.

Warmwater California endemic fish

Just as important as the salmonids to the region's biodiversity, warmwater fish are true California endemics that deserve conservation focus. These fish — hardhead, hitch, Sacramento sucker, Sacramento pikeminnow, Sacramento blackfish, tule perch, and others — occupy the warmer, slow-moving lower reaches of streams, often in urban areas, where channelization, polluted urban runoff, trash, non-native fish, and lack of riparian cover create challenging conditions. Blackfish, in particular, can survive in low oxygen waters inhospitable to most other fish.

Legal Status

CE	California Endangered
CT	California Threatened
FE	Federal Endangered
FT	Federal Threatened

Figure 5.12 ■ **Fish Species Conservation Targets.** Species in bold are endemic to the Sacramento-San Joaquin Province and known from streams of the San Francisco Estuary (Leidy 2008).

Native Anadromous Fish	Native Resident Fish	Native Resident Fish in Estuary and Ocean *
Chinook salmon (FT)	**California roach**	arrow goby
chum salmon	coast range sculpin	Bay goby
coho salmon (FE, CE)	**Hardhead**	**Delta smelt (FE,CE)**
green sturgeon	**Hitch**	jack smelt
Pacific lamprey	Pacific brook lamprey [1]	longfin smelt
pink salmon	prickly sculpin	longjaw mudsucker
rainbow trout / steelhead (FT, CT)	rainbow trout / steelhead	northern anchovy
river lamprey	riffle sculpin	Pacific herring
	Sacramento blackfish	Pacific staghorn sculpin
	Sacramento perch	shiner perch
	Sacramento pikeminnow	speckled sandab
	Sacramento sucker	**splittail** [4]
	speckled dace [2]	starry flounder
	thicktail chub [3]	tidewater goby (FE)
	three-spine stickleback	three-spine stickleback
	tule perch	white sturgeon

* *Typical range is in the San Francisco Bay Estuary; the Conservation Lands Network focuses on the health and integrity of watersheds entering the Bay and ocean.*

[1] *Listed in CLN 1.0 as western brook lamprey. Changed to Pacific brook lamprey in CLN 2.0 as the species' taxonomic status is currently under revision (see Bogan* et al. *2019).*

[2] *In CLN 1.0, speckled dace was listed in both Native Resident Fish and Native Resident Fish in Estuary and Ocean categories. It was removed from the latter category in CLN 2.0 to correct an error; the only speckled dace population in the CLN 2.0 study area is in coastal San Lorenzo River in Santa Cruz County.*

[3] *Extirpated species. The last thicktail chub sighting was in the 1950s; however, the fish could possibly show up in any part of its historical habitat.*

[4] *Splittail is an estuarine and freshwater fish. In essence, it is an anadromous fish that migrates to freshwater to reproduce. Splittail is similar to Delta smelt, but with potentially much more extensive upstream migration for spawning.*

Figure 5.13 ■ **Riparian Vegetation Conservation Targets in CLN 2.0 and CLN 1.0.**

Riparian Vegetation Target, CLN 2.0	Equivalent Riparian Vegetation Target, CLN 1.0
California Sycamore	Sycamore Alluvial Woodland; Central Coast Riparian Forest
Fremont Cottonwood	Sycamore Alluvial Woodland
High Water Line/Gravel/Sand Bar	not included in CLN 1.0
Red Alder	Central Coast Riparian Forest
Riparian Mixed Hardwood	Central Coast Riparian Forest
Riparian Mixed Shrub	Central Coast Riparian Forest
River/Stream/Canal	not included in CLN 1.0
Serpentine Riparian	Serpentine Riparian
Tule – Cattail	not included in CLN 1.0
White Alder	Central Coast Riparian Forest
Willow	Central Coast Riparian Forest
Willow – Alder	Central Coast Riparian Forest
Willow (shrub)	Central Coast Riparian Forest

Figure 5.14 ■ Classification of Priority Streams in the Conservation Lands Network.

Priority 1 Streams	Priority 1 streams and watersheds have existing steelhead populations, available rearing habitat, and current or historic coho populations that must be conserved and/or restored as soon as possible for fish conservation to be successful.

1. Essential Streams for steelhead draining to the San Francisco Estuary as identified in Becker *et al.* 2007.
2. Coho Core Area and most Phase 1 Expansion Area streams from the Public Draft Recovery Plan for the Evolutionarily Significant Unit of Central California Coast Coho Salmon. Both Dependent and Independent coho streams were given a Priority 1.
3. Historic coho streams listed in the CalFish Coho Distribution data (CalFish 2012).
4. Streams draining to the Bay with high diversity assemblages of warm-water native fish (Leidy 2008).
5. The best coastal steelhead streams not covered by coho salmon (CalFish Winter Steelhead Distribution and Riparian and Fish Focus Team expert opinion).
6. The healthiest steelhead streams in the Pajaro River basin (Santa Clara Valley Habitat Plan; expert opinion of Riparian and Fish Focus Team).
7. Streams with adfluvial fish, where fish grow large in a reservoir and run upstream to spawn. Reservoirs in watersheds with adfluvial fish populations are listed below. (Note: Adfluvial fish may be present in watersheds of smaller reservoirs not listed below; those were not included as Priority 1 stream reaches.)
   Calaveras Reservoir
   San Antonio Reservoir
   Lake Del Valle
   Anderson Reservoir
   Coyote Reservoir
   Lake Sonoma
   Lake Hennessey
   Chesbro Reservoir
   Lake Chabot
8. San Pablo Reservoir
9. Stevens Creek Reservoir
10. Uvas Reservoir

Priority 2 Streams	Priority 2 streams and watersheds should receive substantial protection and restoration for long-term fish conservation. Priority 2 streams have smaller steelhead and land-locked rainbow trout populations and /or other healthy assemblages of native fish. They may also be isolated stream segments with high conservation value. For example, Upper Stevens Creek in the Santa Cruz Mountains North Landscape Unit supports resident rainbow trout, California roach and Sacramento sucker; Coyote Creek above Coyote Reservoir supports rainbow trout and five other native fishes. In coastal areas, all identified winter steelhead streams were included as Priority 2. These are the majority of streams with any connection to the ocean.

1. Streams draining to the San Francisco Estuary with steelhead runs that are less healthy than those marked Priority 1 (Becker *et al.* 2007).
2. Streams draining to the San Francisco Estuary with assemblages of native fish other than steelhead (Leidy 2008).
3. Most Phase II Expansion Areas from the Recovery Plan for the Evolutionarily Significant Unit of the Central California Coast Coho Salmon were designated as Priority 2 streams (NMFS 2012).
4. Streams in the Pajaro River basin with less-healthy steelhead runs (Riparian and Fish Focus Team expert opinion and Santa Clara County Habitat Conservation Plan).
5. Coastal streams with steelhead streams draining into coho streams, including the Russian River basin (CalFish Winter Steelhead Distribution).

Priority 3 Streams	Because of the critical role played by all riparian areas in providing hydrologic integrity, wildlife habitat, linkages, and buffering against climate change, all remaining streams are classified as Priority 3.

All other streams.

CHAPTER

6 Mammals

Tule elk at Tomales Point. Photo by Stuart Weiss.

Overview

Mammalian diversity in the Bay Area reflects the region's climate and vegetation diversity, as well as the intersection of the southern range limit of mammals typical of wet Pacific Northwest coniferous forests and the northern and western range limits of species typical of the arid Central Valley. From the charismatic mountain lion and tule elk to the seldom-seen western spotted skunk, long-tailed weasel, and many others, each species plays a critical ecological role in the food chain.

More so than any other taxa, most mammals require large blocks of intact habitat and effective connectivity within and between them to prevent genetic and demographic isolation. In the Bay Area, local organizations have stepped up to this challenge and are partnering to acquire and steward key linkage parcels, advocating for wildlife-friendly policies, reducing barriers to road crossings, and conducting research to understand how mammal species are responding to human activity and conservation interventions. Recommended actions to support mammal populations are featured in this chapter; for more details, see Chapter 6 of the CLN 1.0 report

Despite the many important conservation actions enacted to conserve core habitats and linkages, mammals living in the Bay Area are challenged by the realities of living in an increasingly shrinking, fragmented, and disturbed landscape alongside an ever-expanding population of eight million people. Sheer losses of habitat squeeze species' ranges. Increased drought and fire brought on by climate change is changing species' ranges and requiring adaptations that are not yet fully understood. Highways and houses isolate mountain ranges, and animals seeking food, territory, and mates are challenged by impassable barriers, poison, and disease. Even passive recreation has been shown to affect mammal behavior.

The Conservation Lands Network can play a role in lessening these likely pressures on mammals. The mapped Network itself is a vision for a conserved "backbone" of natural land — perhaps the most important result for all species in the region. The recommended actions in this chapter are designed to address a full range of impacts to Bay Area mammals through on-the-ground conservation, stewardship, and policy. The calls to action are straightforward and achievable.

Mountain lion (puma) is an apex predator with a large home range and generalized habitat preferences focused on mule deer, its primary prey. Most landscape units include individual mountain lion, but no single landscape unit can support a viable local population in isolation. For these reasons, mountain lion continues to be a focal species for connectivity planning.

Recent genetic studies (Gustafson *et al.* 2019) show that the North Central Coast subpopulation (Santa Cruz Mountains and East Bay) is at high risk of inbreeding and genetic drift. Maintaining and enhancing connectivity, by adding crossing infrastructure and maintaining and improving culverts south across Pacheco Pass (Highway 152) and Chittenden Gap (Highway 129) to the Central Coast subpopulation is a high priority. Connectivity among the landscape units within the North Central Coast population area is essential to maintaining mountain lion across the south and east Bay.

In contrast, north Bay subpopulations are part of a much larger north coast population that is currently well-connected to the rest of California; here, maintaining connectivity among the landscape units remains a priority. Only small amounts of successful immigration (one individual per generation) are required to genetically refresh isolated local populations (Gustafson *et al.* 2017). As they disperse to find their own territories, juvenile male mountain lions are forced into suburbs and have even been sighted in urban areas like downtown Berkeley, Palo Alto, Los Gatos, and Santa Rosa. While these forays into the built environment can lead to tragic endings for the individuals, it is a positive sign that available habitat is saturated (Wilmers pers. comm. 2018).

Collared Mountain Lion, Sierra Azul Open Space Preserve, Santa Clara County.
Wildlife camera photo by Ken Hickman.

The Santa Cruz Puma Project has documented the intimate details of mountain lion life history using GPS collars and accelerometers to track individuals and their behavior, and there are myriad uses of such information in acquisition and stewardship. For example, recreation planners designing a trail system at San Vicente Redwoods were able to design around key mating areas, and the Highway 17 linkage project considered documentation of mammals' negative responses to human presence.

Habitat Connectivity: A Mammal Requirement

Populations of large predators with extensive home ranges require large and connected habitat mosaics. Because of the importance of connectivity between landscapes, the mammals team assessed specific needs for habitat connectivity within and between landscape units using a combination of regional linkage designs for various mammal species and habitat connectivity; Figure 6.1 shows connectivity in a sample area, comparing maps of both Critical Linkages and Omniscape.

Habitat Connectivity

Landscape or habitat connectivity is a measure of the ability of organisms to move among separated patches of suitable habitat.

Structural connectivity is a measure based on the physical arrangements of habitat patches, disturbance, and other landscape elements presumed to be important for organisms to move through the landscape.

Functional connectivity is the ease (or difficulty) with which individuals can access other members of their population, or the rate of gene exchange.

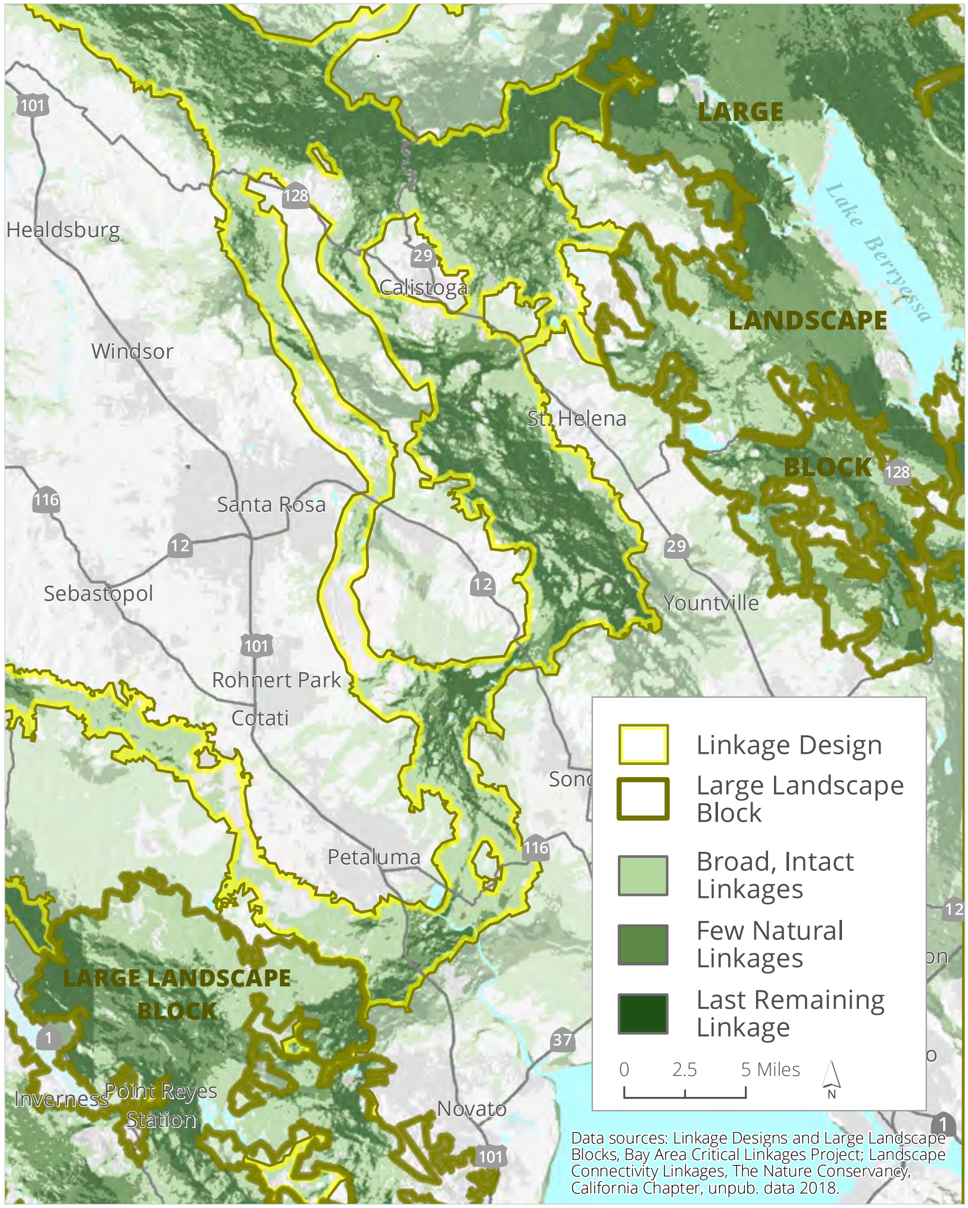
Where habitat is physically connected and continuous, with no obvious barriers to movement, this structural connectivity does not always correlate to functional connectivity for animal or plant populations. A good example is American badger, which depends on friable (loose and crumbly) soil types for burrowing. Corridors of protected land that lack friable soils may not be suitable for badger dispersal over long distances. The lack of friable soils, therefore, constitutes a functional barrier within structurally connected habitat. Badger also rely on burrowing mammals such as ground squirrel; where grasslands are present but burrowing mammals are not (or are in low numbers), the functional connectivity has also been curtailed.

Modified from Meiklejohn et al. *2009 and Hilty* et al. *2019*

Some large and medium-sized mammals have absolute needs for broad-scale connectivity. Carnivores in particular are driven by their intrinsically low population densities that lead to low numbers within local populations. The perils of low population size include loss of genetic diversity through inbreeding and genetic drift, demographic stochasticity (random variation in births and deaths), difficulty finding mates, and inability to persist through epidemics and extreme environmental events. While connectivity is relevant to most species, it is of critical importance for mammals. From a genetic perspective, the effective population size (the number that determines rates of inbreeding and genetic drift) is far lower than the census population size — as low as 10% because of breeding status, sex ratios, variable reproductive output among breeding individuals, and other demographic factors (Frankham *et al.* 2002). However, studies show that these losses can be counteracted by low levels of immigration, even as low as one successful breeding individual per generation, as shown by the positive, but transient, genetic impact of a single successful immigrant puma in the Santa Ana Mountains in southern California (Gustafson *et al.* 2017).

Fortunately, conservation and recreation organizations in the Bay Area have collectively preserved large swaths of natural habitat that are physically connected. Thousands of parcels changed hands through land transactions over the past six decades, resulting in today's network of conserved and connected lands.

Figure 6.1 ■ **Sample Map Showing Habitat Connectivity.** Here, connectivity needs in the Mayacamas and Blue Ridge/Berryessa regions are shown in both Bay Area Critical Linkages (Linkage Designs and Large Landscape Blocks) and Omniscape (Broad, Intact Linkages; Few Natural Linkages; and Last Remaining Linkage).



Bay Area scientists, agencies, and conservation organizations have led — and are leading — an impressive number of studies of habitat connectivity, listed in Figure 6.2. At a regional level, there are regional linkage designs from Bay Area Critical Linkages and Omniscape; in addition, a number of specific studies have been done at a smaller scale. Each of these studies adds important data regarding population viability, dispersal of individuals, and barriers to functional connectivity.

These studies demonstrate the practices required to successfully understand local and ecoregional connectivity challenges, and to design and implement projects to mitigate barriers to movement. In a recent paper, Keeley and others (Keeley *et al.* 2018) present a valuable overview of connectivity study best practices geared toward conservation practitioners (Figure 6.3.)

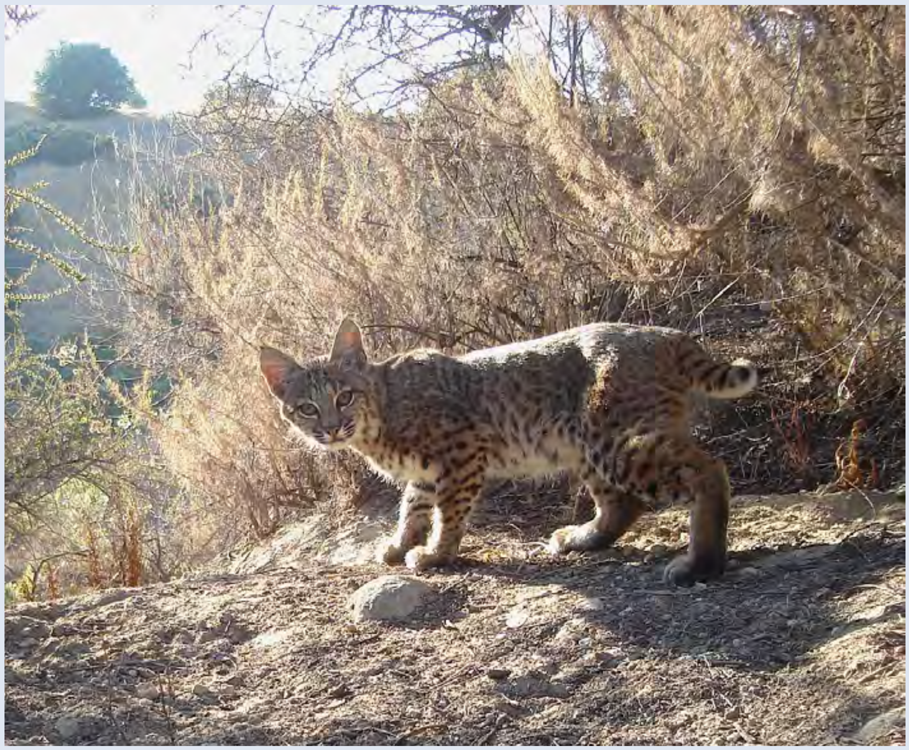
Figure 6.2 ■ **Bay Area Habitat Linkage Studies.**

Focus area	Connectivity and linkage studies
Southern Santa Cruz Mountains – Gabilan Range – Pajaro Valley	**Southern Santa Cruz Mountains Wildlife Connectivity Study**, conducted by Pathways for Wildlife for POST and Caltrans. 2018-present. **The Nature Conservancy's Pajaro Wildlife Connectivity Study**, conducted by Pathways for Wildlife for TNC. 2012-2013. **Central Coast Connectivity Project**, conducted by Pathways for Wildlife for the Big Sur Land Trust. 2009-2011 and 2013-2014.
SR-152 Diablo Range	**Wildlife Permeability and Hazards across SR-152 Pacheco Pass**, conducted by Pathways for Wildlife for the Santa Clara Valley Habitat Agency, with funding support from DFW. 2018-present.
Coyote Valley Landscape	**Coyote Valley Bobcat and Gray Fox Connectivity Study**, conducted by UCSC Chris Wilmers Lab and Pathways for Wildlife for POST and the Santa Clara Valley Open Space Authority, with funding support from DFW. 2017-2018. **Coyote Valley Landscape: Linkage Assessment Study**, conducted by Pathways for Wildlife for the Santa Clara Valley Open Space Authority, with funding support from DFW. 2015-2016. **Coyote Valley Landscape Linkage**, conducted by the Santa Clara Valley Open Space Authority and the Conservation Biology Institute. 2017.
Sonoma Valley	**Sonoma Valley Wildlife Corridor Project: Management and Monitoring Strategy**, conducted by Sonoma Land Trust. 2014.
Highway 17	**Highway 17 Wildlife Connectivity Project – Lexington Study Area**, conducted by Pathways for Wildlife for Midpeninsula Regional Open Space District and POST. 2013-2016. Highway 17 Wildlife Connectivity Project – Laurel Curve Study Area, conducted by Pathways for Wildlife for the Land Trust of Santa Cruz. 2013-present.
American Badger and Burrowing Owl	**American Badger and Burrowing Owl Habitat Suitability Assessment**, conducted by Pathways for Wildlife and San Francisco Bay Bird Observatory for Midpeninsula Regional Open Space District. 2019-present.
Mayacamas to Blue Ridge Berryessa	**Building Landscape Connectivity for Climate Adaptation: Mayacamas to Berryessa Connectivity Network (M2B)**, Pepperwood Preserve and UC Berkeley, a multi-county connectivity roadmap. 2018.

Long-tailed weasel at Tomales Point, Marin County. Photo by Bob Gunderson.

Bobcat is doing well across the region, because these cats are highly mobile and can exist at much higher population densities than mountain lion. They are regularly photographed by wildlife cameras, and observed directly more often than most other predatory mammals. Recent tracking studies in Coyote Valley have revealed bobcat activities across a highly modified agricultural and rural landscape, including regular use of culverts, underpasses, cultivated fields, and orchards.

Unfortunately, vehicle mortality of collared animals has also been observed across the region (Diamond and Snyder 2018; California Roadkill Observation System). Linkage projects (Figure 6.2) have observed bobcat in far southern Santa Clara County that may have suffered mortality from mange related to rodenticides (Diamond pers. comm. 2018). In 2019, the California Ecosystems Protection Act (AB 1788) proposes to more tightly regulate rodenticides, especially second-generation anticoagulants that pass up the food chain.



Bobcat in Fremont Older Open Space Preserve, Santa Clara County. Wildlife camera photo by Ken Hickman.

Gray foxes in Mayacamas Mountains. Wildlife camera photo by Tony Nelson.


Bobcat and kitten in Santa Cruz Mountains. Wildlife camera photo by Yiwei Wang.

Figure 6.3 ■ **Habitat Connectivity Recommendations and Best Practices.** These are generally relevant to governments, public agencies, and conservation organizations; detailed recommendations necessarily need to be project-specific because the socio-ecological context affects the whole process of connectivity implementation. From Keeley *et al.* 2018.

Habitat connectivity recommendation	Justification
Create clear regulations and policies for public agencies.	This is important for spurring government agencies to address connectivity conservation.
Create voluntary incentive programs for private landowners.	Private landowners likely respond better to incentive programs than to regulations.
Offer incentives to diversify agricultural lands and cityscape.	This would increase general landscape permeability.
Use zoning with incentives to promote land conservation.	Especially in landscapes where development is sprawling, zoning can keep key areas open for wildlife, averting the need to purchase land for connectivity conservation in the future.
Create connectivity-specific funding sources.	This would enable connectivity projects that may otherwise fall through the cracks, *e.g.*, because conservation legislation focuses on endangered species, which may not be present in all corridors. It would also mainstream connectivity conservation, which is necessary for rapid, landscape-wide implementation.
Use the level of threat of land-use conversion to development and intensive agriculture as a basis for identifying the most critical locations for corridors.	Focus connectivity conservation in high-risk areas.
Avoid planning at parcel scale in private lands without landowner engagement.	Landowners will often feel targeted by what are perceived as new regulations or restrictions on rights.
Land acquisition should be phased to complete a minimum viable linkage.	If linkage implementation involves multiple private properties this strategy ensures a continuous corridor that can be widened with time to allow for redundancy and possibly greater functionality into the future.
Set clearly-defined spatial priorities and implementation timelines where possible and appropriate.	This ensures that connectivity goals are being met.
Run state/country-wide and regional public campaigns.	Public outreach galvanizes support and participation.
Wildlife agencies should coordinate and facilitate the collection of solid biological baseline data.	These data are vital for justifying corridor projects to stakeholders and the public, as well as for determining the best location for a corridor in priority connectivity areas.
Offer training for conservation practitioners on how to interpret and use connectivity data.	This ensures that science is used to maximum benefit.
Focus connectivity programs within regions with similar ecological and social attributes.	Implementing connectivity in ecologically and socially similar regions may be more successful than spanning diverse areas.

Mammal Conservation Targets and Network Protection

The goal of CLN 2.0 is to conserve viable populations of all remaining mammal species in the Bay Area. A protected, contiguous network of natural land within each landscape unit can ensure the local habitat connectivity required by mammals. In addition, the CLN team paid special attention to pinch-points and tenuous corridors between and within landscape units.

Toward that goal, the Mammals Focus Team:

- Suggested, provided, and reviewed available distribution data on species and populations, including ranges and occurrences, to update our understanding of current distributions;
- Selected a list of mammal species conservation targets and their respective habitat requirements / descriptions; and
- Recommended management and stewardship actions to promote target species conservation and persistence in Bay Area given current understanding of their distributions and abundance.

As with CLN 1.0, the Mammals team relied heavily on the California Wildlife Habitat Relationships (CWHR) range maps and habitat suitability system, as well as the California Natural Diversity Database (CNDDB), both of which have been updated by the California Department of Fish and Wildlife in recent years. The team also reviewed a wealth of new data, particularly distribution information from now widespread wildlife cameras, which have vastly increased our knowledge of mammal distributions and, in some sites, relative abundance. Collaring studies have revealed details of mountain lion and bobcat movements and behaviors, and genetic studies peer into population processes like inbreeding and dispersal. The team also considered data from citizen science projects such as iNaturalist and Otter Spotters, along with records from the California Roadkill Observation System.

Bobcat at Ed R. Levin County Park, Santa Clara County. Photo by Bob Gunderson.

River otter is still largely absent from the Santa Cruz Mountains, but has reoccupied many streams in the Bay Area, including several urban streams. Citizen "Otter Spotters" with the River Otter Ecology Project have effectively documented the spreading distribution (Figure 6.4). The celebrated return of a top predator to the region's streams has downsides: the species' voracious appetite may impede restoration of salmon and steelhead. Riparian goals, including the full protection of the stream valley bottoms, protect habitat and the processes that maintain healthy fish and otter populations.

River Otter in Santa Rosa's Nagasawa Park, Sonoma County. More research is needed to understand the impact of Otter population growth on native fish an other species. Photo cc Don McCullough.

Figure 6.4 ■ Map of River Otter Occurrences in the Bay Area. Source: www.riverotterecology.org.

Key Focus Team Determinations for Mammals

- Habitat connectivity — particularly functional connectivity — is crucial in the Bay Area's fragmented landscape. New subregional partnerships of scientists and organizations would contribute to the understanding of how wide-ranging mammal populations use local habitat to access other individuals for genetic exchange, and what barriers may exist.
- Large, connected blocks of habitat (*e.g.*, CLN landscape units, "Large Landscape Blocks" in the Bay Area Critical Linkages study) are increasingly important in light of climate change, providing potential for refugia and migration across latitudinal and elevational gradients.
- Grazing is important for native mammal species, particularly ground squirrel, which both serve as prey and create burrows upon which many other species depend. In grasslands left ungrazed (or unburned), non-native grasses can make habitat less suitable for ground squirrel and badger.

Badger breeds and feeds in grasslands and open habitats but can disperse widely across almost all vegetation types. The Mammals Focus Team confirmed badger presence in nearly every non-urban landscape unit, except the East Bay Hills. However, local populations are sparse and small, and like mountain lion, this species requires connectivity between landscape units. They frequently cross roads, and their belligerence toward oncoming traffic often results in roadkill. Badger is thus a focal species for landscape linkage studies such as those in Coyote Valley and along Highway 152.

Badger, Purisima Creek Redwoods Open Space Preserve in Woodside. Wildlife camera photo by Ken Hickman.

Research and land acquisition continues to benefit this species. The Midpeninsula Regional Open Space District is funding a study of badger populations and genetics in the Santa Cruz Mountains, where a highly isolated subpopulation persists in the grasslands among the coastal scrub and forests. In 2012, badger precipitated the acquisition of the 11-acre Paula Lane Nature Preserve in rural Petaluma, at the edge of the extensive population in Marin and western Sonoma County. Funded in part by the Sonoma County Agricultural Preservation and Open Space District, the small preserve is an example of finding room for wildlife within the rural residential matrix that fringe many urban areas in the Bay Area. The preserve also provides a chance for visitors to learn about and observe badger.

One mid- and long-term threat to badger is succession of grasslands to shrublands and forests, reducing available prime habitat. Maintaining healthy populations of prey — primarily ground squirrel and gopher — within extant grasslands is a management priority.

Kangaroo rats are habitat specialists that occupy desert, grassland, scrub, and chaparral where friable, sandy soils allow for burrowing. **California kangaroo rat** extends across the arid reaches of the North Bay. **Berkeley** and **Tulare kangaroo rat** are still extant in scattered populations in the East Bay in the Diablo Range, including on Mount Diablo and in the Ohlone Wilderness east to Patterson Pass. But recent research to understand their ranges suggests that the region's eight recognized subspecies of **Heermann's kangaroo rat**, which is widespread in the San Joaquin Valley and foothills and includes subspecies *berkeleyensis* and *tularensis*, may be too genetically and morphologically similar to be separable as subspecies (Benedict *et al.* 2018). **Santa Cruz kangaroo rat** is an upland chaparral dweller that appears to be barely hanging on in a few fragmented populations in the Santa Cruz Mountains.

While kangaroo rat populations commonly exhibit large fluctuations in abundance, when fragmented and isolated they become highly susceptible to extinction from external pressures, including habitat conversion, poor fire management (too severe/frequent or not at all), localized disease outbreak, domestic/feral cat predation, and illegal recreational activity that can collapse burrows, all of which can threaten population viability and species survival.

Santa Cruz Kangaroo Rat in Henry Cowell Redwoods State Park, Santa Cruz County. Wildlife camera photo by Ken Hickman.

Mammal Data Sources

Dataset	Source	Use(s) in CLN 2.0 Network Design
Range maps for vertebrate species (polygon)	California Wildlife Habitat Relationships (CDFW)	Create species list Mask suitability layers Determine habitat suitability and life history information
Various species occurrences (polygons converted to points)	California Natural Diversity Database (CNDDB) (CDFW)	Create species list (29 mammal species represented in CNDDB) Assess coverage by draft network
Various species occurrences (point)	Museum of Vertebrate Zoology (MVZ) (UC Berkeley)	Create species list (48 mammal species represented in MVZ) Assess coverage by draft network
Sandhills habitat in Santa Cruz County (polygons)	Jodi McGraw Consulting	In Marxan analysis (present in two landscape units with a 90% conservation goal) to ensure coverage for Santa Cruz kangaroo rat (*Dipodomys venustus venustus*), a habitat specialist, as well as the more widely distributed black-tailed hare (*Lepus californicus*), pocket mouse (*Chaetodipus californicus*), and Merriam chipmunk (*Eutamias merriami*).
Various species occurrences (points)	iNaturalist, 'Research Grade' (California Academy of Sciences)	Visual inspection of agreement between known species occurrences and published range maps by CDFW. Range maps clipped to the Bay Area are included in the CLN 2.0 database.

Designing a Conservation Lands Network for Mammals

The Mammals Focus Team retained the 48 native mammal taxa chosen as conservation targets in CLN 1.0; together, these cover a range of life history and ecological roles. These species are listed in Figure 6.5. Also included, as before, are five non-native species that represent specific management concerns. The focus team helped the project team document known species abundance and distributions, noting where data gaps exist.

The team determined that the habitat needs of the vast majority of smaller mammals will be protected by the vegetation goal of protecting 50% of the common vegetation types (Rank 3) and more for rare types (Ranks 1 and 2). The large acreages of common vegetation types in the CLN will ensure sufficient habitat to support viable local populations of these species.

The team also considered special life history requirements and management issues — such as disease, vegetation succession, and interactions with livestock grazing — and how these are impacting population viability of various mammal species, and adapted the network as needed to reflect these considerations. Special habitats such as cliffs and caves are critical for some species; where these are identified on maps, the Mammals Focus Team added them to the list of fine-filter targets.

Non-native mammals remain of conservation concern. Feral and domestic cats prey on native birds and small mammals. Eastern red fox preys on federally endangered Ridgway's rail, California least tern, and threatened Western snowy plover in the baylands. Control of feral animals is highly contentious with some parts of the public. Wild pig can rototill acres at a time, digging for roots and bulbs, leaving a wake of erosion, muddy water, and weed invasions. At the same time, they can aerate the soil and till under non-native grasses while leaving native bunch grasses. More work is needed to understand their role as potential ecosystem engineers. Some native mammals, such as raccoon and opossum, may have excessive impacts on native birds when their numbers are inflated by access to human food.

Wild pigs and damage at Jenner, Sonoma County. Photos by Stuart Weiss.

Threats to Mammals and Recommended Conservation Actions

The focus team identified five key influences on Bay Area mammals, specific threats, and recommended conservation actions (in addition to the recommendations of the CLN 1.0 report). The influences, here in alphabetical order, are:

- Chemicals and pollutants
- Climate change
- Habitat connectivity
- Land use
- Pests and disease

Chemicals and pollutants

Threats	Conservation actions
Chemical use, including rodenticides, herbicides, and fungicides Rodenticides reduce prey base and can cause direct mortality of predators, especially smaller rodent-eating mesopredators such as weasel and skunk. Rodenticides are responsible for sharp increases in recent observed deaths in bobcat and coyote in the Southern Santa Cruz Mountains-Gabilan Linkage, particularly by suppressing the animals' immune systems, making them susceptible to secondary diseases such as mange. Rodenticides, herbicides, and fungicides can leach into riparian zones and waterways. Reduction in ground squirrel populations, caused by rodenticides, have repercussions for numerous other species, including predators and species that live in old burrows (*e.g.*, badger, burrowing owl, and amphibians).	■ Educate and change perceptions on agricultural and wildlife compatibility; promote wildlife-compatible agricultural practices. ■ Support policies that restrict use of highly destructive chemicals, such as AB 1788, which would ban anticoagulant rodenticides statewide. ■ Decrease chemical use, especially in areas identified as sensitive areas. ■ Educate agriculturalists and homeowners on associated effects of rodenticides, pesticides, and herbicides. ■ Identify and promote alternatives to chemical use.

Climate change

Threats	Conservation actions
Increased drought and fire The aridification of the landscape causes mesic-adapted species to retreat, and arid-adapted wildlife species to expand. Drought can stress water resources upon which wildlife depend. Climate-stressed landscapes may be more susceptible to new and expanding disease, resulting in changes in vegetation that can affect wildlife habitat. Catastrophic fire kills mammals directly, and induces changes in vegetation that can affect wildlife habitat.	■ Acquire and protect connected lands. ■ Provide habitat connectivity across climatic gradients (elevation and coastal-inland) to allow for adaptation to a changing climate. ■ Develop, steward and maintain corridors and wildlife crossings to allow mammals to move between protected habitats. ■ Develop and implement fire management plans. ■ Where drought is expected to have a significant impact, ensure and maintain hydrologic connectivity. ■ Implement water conservation practices. ■ Restore habitats to promote water storage and groundwater recharge. ■ Utilize best management practices to prevent drawdown of springs and seeps.

Habitat connectivity

Threats	Conservation actions
Genetic inbreeding Puma have experienced genetic inbreeding in the Bay Area. Bobcat have large home ranges and need large, intact habitat blocks. Many other mesocarnivore populations in small landscape units are at risk.	■ Conserve and steward lands that connect large blocks of intact habitat (corridors) through otherwise converted lands, or lands that have been impacted by human development and activity. ■ Identify and manage points of constricted wildlife movement (pinch-points), including maintaining culverts and developing wildlife crossings. ■ Conserve and steward highly permeable lands, or lands with high habitat connectivity. ■ As appropriate, translocate individuals or populations of native plants and animals (facilitated dispersal).
Roadways/ railways bisecting populations/habitat Roads and rail can limit home range size, reduce movement of mammals, and serve as barriers to gene flow (Ernest *et al.* 2014, Vickers *et al.* 2015). Developing areas see an increasing incidence of roadkill (Fahrig and Rytwinski 2009). Large highways (*e.g.*, Highway 101) with culverts and bridges where animals can cross are less significant barriers than smaller, high-traffic roads with adjacent open space and barriers to crossing (*e.g.*, Highway 12, Monterey Road, Edgewood Road). Road mortality is considered a contributing factor to badger decline in the Bay Area and elsewhere (Quinn 2008, Weir *et al.* 2004).	■ Create and maintain wildlife-friendly overcrossings and undercrossings on new and existing roads and railways. ■ Modify current crossings to be more attractive to wildlife (*e.g.*, adding visual screens, selecting appropriate surface materials, and improving sight lines). ■ Consider existing barriers and critical linkages when siting new projects. ■ Keep vegetation clear along crossing structures, through managed grazing or mowing. ■ Consider focusing land acquisition and stewardship in areas with existing linkages. ■ Remove wildlife exclusionary fencing, or replace with inclusion fencing.

Land use

Threats	Conservation actions
Human interactions and conflicts Human/wildlife interactions are highest where development and/or recreation is near habitat. For example, many carnivores avoid heavily used trails (Reed and Merenlender 2008). Mountain lion alters hunting and feeding behaviors and diet with human-induced stress (Smith *et al.* 2015). Stress and changed behaviors could lead to reduced breeding and impact population stability. Large predators such as mountain lion avoid populated areas (*e.g.*, the Oakland hills), which can cause populations of deer and other prey to expand (Burdett *et al.* 2010). Domestic animals may attract predators and lead to more negative human/wildlife interactions. There is evidence of some recreation use pushing wildlife to more nocturnal behavior, potentially increasing competition for resources (Larson *et al.* 2016, Townsend *et al.* 2017). Domestic dogs may suppress activity of coyote, bobcat, and other mesopredators in protected lands (Reed and Merenlender 2011).	■ Preserve and connect large, contiguous blocks of land. ■ Develop and protect corridors and wildlife crossings. ■ Promote urban infill and limit expansion of urban limit lines adjacent to core habitat. ■ Support and implement public policy and general plans that limit growth outside of urban limit lines. ■ Install wildlife-proof trash cans in populated areas to discourage interaction. ■ Site recreational activities in consideration of species habitat needs. ■ Support park policies that balance on and off-leash opportunities for dogs with consideration for important wildlife sites.
Agricultural uses Too much residual dry matter (plant material on the surface at the end of the dry season) may limit habitat for some species, like badger. Grazing must be well-managed; too little residual dry matter can increase erosion and sedimentation rates with downstream impacts to aquatic species. Fences in vineyards restrict animal movement (Hilty and Merenlender 2004). Clean field edges on row crops eliminate vegetative cover needed by mammals.	■ Educate and change perceptions on agricultural and wildlife compatibility; promote wildlife-compatible agricultural practices. ■ Implement grazing regimes that effectively manage residual dry matter and invasive plants to benefit wildlife. ■ Maintain residual dry matter at levels that are beneficial to burrowing mammals. ■ Provide wildlife movement corridors between habitat patches in cultivated areas.

Threats	Conservation actions
Land conversion Land conversion can decrease the ability of land to support wildlife. Agricultural lands can provide valuable habitat for some species, but not all. Lack of vegetation management can result in natural succession that converts grasslands to shrublands. These habitats are less valuable for some species, such as badger.	■ Prevent conversion of CLN Essential habitat. ■ Preserve and connect large, contiguous blocks of land. ■ Implement public policy and general plans that limit growth outside of urban limit lines. ■ Steward and manage existing protected lands for wildlife habitat quality.
Wind farms Wind farms are known to be fatal to birds, but they also can kill bats. Wind farms have also implemented rodent poisoning campaigns to reduce prey for raptors and thus reduce bird strikes.	■ Site new wind farms with consideration of protected areas and habitat for bats to reduce turbine/wildlife interactions.

Pests and disease

Threats	Conservation actions
Non-native animals Wild pig predates native animals and negatively impact native plant species, including acorns and other mammal food sources (Loggins *et al.* 2002, Jolley *et al.* 2010, Ballari and Barrios-García 2014). Native western gray squirrel is being outcompeted by non-native eastern gray squirrel in fragmented landscapes in parts of the Bay Area (Jessen *et al.* 2018). Non-native wildlife can hybridize with native species, reducing the integrity of the native genetic stock.	■ To control the abundance and spread of non-native animals, allow hunting or other active non-native species management techniques in areas where non-native animals are impacting native populations. ■ Provide quality habitat conditions that favor native species.
Disease Diseases that are transmitted from domestic animals, including feline leukemia, parvovirus, and distemper, can affect native wildlife, such as western spotted skunk and gray fox (Quinn *et al.* 2012, Hickman pers. comm. 2018). Populations weakened by unhealthy habitats (such as eating trash) or that exceed the carrying capacity of the landscape are at greater risk of disease. Disease can be spread and increased with wildlife/human interactions, *e.g.*, species congregating at dumpsters.	■ Reduce opportunities for disease to spread by encouraging the public to not feed feral cats. ■ Install wildlife-proof trash cans in populated areas near core habitat and in recreation areas. ■ Control populations oversized relative to the area's carrying capacity. ■ Plan and manage development and recreation in ways that reduce human/wildlife interaction. ■ Maintain intact open spaces to minimize the wildland/urban edge. ■ Implement Best Management Practices for managing disease (*e.g.*, Wobeser 2002).

Western spotted skunk has disappeared from most of the Bay Area. Pandemic diseases (parvovirus and canine distemper virus) devastated spotted skunks and other mesopredators in the Santa Cruz Mountains in the 1970s (Hickman pers. comm. 2018).

Today, this species is limited to areas remote from human settlement because of its susceptibility to diseases that are transmitted from domestic animals, such as feline leukemia, canine distemper, parvovirus, and rabies as well as competition and disease transmission from striped skunk, which has adapted well to human-modified environments.

Of the remaining populations, those in northern Sonoma and Napa Counties are well-connected outside that region. Another population extends from Point Reyes into the Marin Coast Range. Thanks to the use of wildlife cameras in the Santa Cruz Mountains, individuals were detected off China Grade Road in 2011 and near Gazos Creek in 2012 (Wang pers. comm. 2018).

Western spotted skunk at Audubon Canyon Ranch in Marin County. Wildlife camera photo by Christian Naventi.

Gray fox at Quarry County Park, San Mateo County. Wildlife camera photo by Ken Hickman.

Data Gaps

- Conduct a regional habitat connectivity and health assessment of target mammal species population health (*e.g.*, One Tam Health Report, www.onetam.org/peak-health).
- Coordinate use of wildlife cameras using the Wildlife Picture Index (O'Brien *et al.* 2010) to assess for most target mammal species:
  - Presence/absence
  - A metric of abundance (*e.g.*, occupancy rates)
  - Estimate of population stability
- Develop useful measures to understand the CLN framework's effectiveness as a tool for mammal conservation.
- Continue to form subregional partnerships to learn how wide-ranging mammal populations use local habitat to access other individuals for genetic exchange, and what barriers may exist.
- Test the assumption that the CLN contains sufficient diversity in topography, microclimate, etc. to maintain mammal populations in the face of climate change.

Beaver was eradicated from most of California by the time of the Gold Rush, but the California Department of Fish and Wildlife reintroduced the species to the Bay Area from the 1920s through the 1950s. Beaver is now slowly spreading in Bay Area streams, first gaining notoriety in 2007 when it took up residence in Alhambra Creek in downtown Martinez. The mammal is now established in upper Los Gatos Creek, downtown San Jose (Bergamin 2013), Napa River, Sonoma Creek, Russian River, and various tributaries thereof. Their dams profoundly shape stream morphology, helping to create wetlands, retain water in the landscape, and nurture fish populations including steelhead and coho salmon. While the return of beaver may thin riparian forests and inconvenience some property owners, their potential to transform degraded streams and wetlands is immense, and they may be a key to restoring coho salmon in coastal watersheds.

Beaver dam on the Napa River. Photo by Jonathan Koehler.

Figure 6.5 ■ **CLN 2.0 Mammal Species Conservation Targets.** For a detailed list of all mammal conservation targets with information about each species' habitat and management issues, see Appendix C.

Common Name	Scientific Name	Legal Status
Category 1: Endemic / At Risk or Species of Concern		
Pallid bat	*Antrozous pallidus*	CA SSC, BLM S, USFS S
Point Reyes mountain beaver	*Aplodontia rufa phaea*	CA SSC
Townsend's big-eared bat	*Corynorhinus townsendii*	CA SSC, BLM S, USFS S
Berkeley kangaroo rat (*moved from CLN 1.0 Category 4)*	*Dipodomys heermanni berkeleyensis*	FE, CE, CA FP
Point Reyes jumping mouse	*Zapus trinotatus orarius*	CA SSC
Category 2: Not Endemic / Species of Concern / Globally Rare (not necessarily listed as a CA Species of Special Concern)		
Sonoma tree vole (alt. red tree vole)	*Arborimus pomo*	CA SSC
Ringtail	*Bassariscus astitus*	CA FP
Western red bat	*Lasiurus blossevillii*	USFS S, CA SSC
Fringed myotis	*Myotis thysanodes*	BLM S, proposed CA SSC but denied
Long-legged myotis	*Myotis volans*	proposed CA SSC but denied
San Francisco dusky-footed woodrat	*Neotoma fuscipes annectens*	CA SSC
Sonoma chipmunk	*Neotamias sonomae*	–
Western gray squirrel	*Sciurus griseus*	–
American badger	*Taxidea taxus*	CA SSC
San Joaquin kit fox	*Vulpes macrotis mutica*	FE, CE
Category 3: Locally Rare / Unique		
Pronghorn	*Antilocarpa americana*	–
Tule elk	*Cervus elaphus nannodes*	–
Western red-backed vole	*Clethrionomnys californicus*	–
California kangaroo rat	*Dipodomys californicus*	–
Tulare kangaroo rat	*Dipodomys heermanni tularensis*	–
Santa Cruz kangaroo rat (*moved from CLN 1.0 Category 4)*	*Dipodomys venustus venustus*	CA SCC candidate
North American porcupine	*Erethizon dorsatum*	–
Merriam chipmunk	*Neotamias merriami*	–
River otter	*Lontra canadensis*	CA SSC, BLM S
Long-tailed weasel	*Mustela frenata*	–
American mink	*Mustela vison*	–
San Joaquin pocket mouse	*Perognathus inornatus inornatus*	BLM S
Brush mouse	*Peromyscus boylii*	–
Shrew mole	*Neurotrichus gibbsii*	–
Marsh shrew	*Sorex bendirii*	–
Fog shrew	*Sorex sonomae*	–
Western spotted skunk	*Spilogale gracilis*	–
Black bear	*Ursus americana*	–

Legal Status

BLM S	BLM Sensitive
CA FP	California Fully Protected
CA SSC	California Species of Special Concern
CE	California Endangered
FE	Federal Endangered
FT	Federal Threatened
USFS S	US Forest Service

Common Name	Scientific Name	Legal Status
Category 4: Regionally Extinct		
Fisher	*Martes pennanti*	BLM S, USFS S
Grizzly bear	*Ursus horribilis*	FT (in current range)
Category 5: Predator/Widespread but Inherently Low Population		
Bobcat	*Lynx rufus*	CA FP
Mountain lion	*Puma concolor*	CA FP
Category 6: Prey Species/Game Animal		
Tule elk	*Cervus elaphus nannodes*	—
Mule deer	*Odocoileus hemionus*	—
Wild pig	*Sus scrofa*	—
Category 7: Widespread / Native / Management Concern / Keystone Species		
Coyote	*Canis latrans*	—
Hoary bat	*Lasiurus cinereus*	CA SSC
Silver-haired bat	*Lasionycteris noctivagans*	—
California myotis	*Myotis californicus*	—
Long-eared myotis	*Myotis evotis*	—
Gray fox	*Urocyon cinereoargenteus*	—
Category 8 : Non-Native Species of Management Concern		
Axis deer	*Axis axis*	—
Fallow deer	*Dama dama*	—
Feral cat	*Felis catus*	—
Wild pig	*Sus scrofa*	—
Red fox	*Vulpes vulpes*	—
Domestic dog	*Canis familiaris*	—

CHAPTER

7 Birds

Loggerhead Shrike in Coyote Valley. Photo by Steve Rottenborn.

Overview

The Bay Area's upland habitats support a staggering 300+ bird species, of which more than 100 are resident year-round. Indeed, the region's richness rivals that of some countries. As with other Bay Area taxa, the region's diversity of habitats translates to the rich diversity of bird species. Birds of the Bay Area range from the 4" Bushtit flitting among branches to the soaring Golden Eagle — with its 7' wingspan — eyeing ground squirrels hundreds of feet below.

The region also provides temporary food and shelter for hundreds of species that stopover in the Bay Area along the Pacific Flyway; indeed, the Bay Area is of international importance to migratory waterfowl and shorebirds. The San Francisco Bay is one of only 106 sites globally recognized for their importance to shorebirds by the Western Hemisphere Shorebird Reserve Network. The intergovernmental Convention on Wetlands (the Ramsar Convention) has designated the Laguna de Santa Rosa a Ramsar Wetland of International Importance.

Birds utilize all habitat types, and are generally well-monitored, making them good indicators of broader environmental change — whether they are benefiting from conservation successes or responding to threats (Pitkin and Wood 2011).

Birds are the most visible and popular wild animals in most people's lives. Keeping landscapes musical with singing birds and providing for the thrill of Osprey, Swainson's Hawk, and other raptors soaring overhead are key aspects of the overarching goal of conserving healthy and diverse bird populations. Birding — whether by serious "twitchers" seeking rarities or by casual observers enjoying backyard birds — engages people with nature and nourishes a conservation mindset. For decades, bird enthusiasts have driven political and conservation advocacy.

Besides aesthetic and existence values, birds are key players in ecosystems, consuming and dispersing seeds and fruits, and preying on innumerable insects, small mammals, amphibians, reptiles, and fish. Migratory birds connect us with distant lands from Patagonia to the Arctic. The keys to bird conservation in CLN include protecting and stewarding large contiguous landscapes with diverse vegetation structure and composition, blanket preservation for riparian zones, heightened attention to rangeland stewardship, enforcement of laws like the Migratory Bird Treaty Act, and coordinated strategic actions across multiple habitat types and jurisdictions.

The CLN 1.0 report included an extensive discussion of bird conservation, which will not be repeated here. This chapter provides a summary of current issues raised by the CLN 2.0 Birds Focus Team, with the goal of inspiring the conservation of a resilient and connected network of bird habitats, as well as specific expert-recommended actions necessary to ensure that the Bay Area's unique bird fauna persists into the future.

Burrowing Owl at Arrowhead Marsh, Alameda County. Photo by Bob Gunderson.

Bird Conservation Targets and Network Protection

The goal of CLN 2.0 is to conserve viable populations of all bird species in the Bay Area through the design and implementation of a resilient and connected network of conserved and stewarded network of habitat, and through the promotion of other key actions that will benefit birds.

Toward that goal, the Birds Focus Team:

- Suggested, provided, and reviewed available distribution data on species and populations, including ranges and occurrences, to update the collective understanding of current distributions;
- Selected a list of bird species conservation targets and their respective habitat requirements / descriptions;
- Decided which species warranted direct targeting in Marxan; and
- Recommended management and stewardship actions to ensure target species viability.

As with CLN 1.0, the Birds team relied heavily on breeding bird atlases that have been completed for Bay area counties, as well as on the California Wildlife Habitat Relationships (CWHR) range maps and habitat suitability system and the California Natural Diversity Database (CNDDB), both of which have been updated by the California Department of Fish and Wildlife in recent years. The team also considered data from citizen science projects such as iNaturalist and eBird.

The State of the Birds: San Francisco Bay (Pitkin and Wood 2011) report provides an excellent summary of data on the status of bird populations in the San Francisco Bay Area. Although focused on the estuary, the report includes trends, threats, and actions for upland bird habitats. These are incorporated into the population threats and recommended conservation actions in this chapter. The report includes three noteworthy trends from monitoring over the past 42 years:

- Riparian birds have increased, likely in response to stream restoration.
- Oak woodland and coniferous redwood forest birds appear stable.
- Coastal scrub-chaparral and grassland birds are declining likely due to continued loss and degradation of habitat.

Key Focus Team Determinations for Birds

- Protecting and managing large, intact blocks of connected habitat and riparian zones is the single most impactful collective action for birds.
- Species at particular risk are grassland birds (habitat loss and inappropriate management) and insectivorous birds (sharp declines in insects, climate change, pesticide use).
- Coordinated strategic action is needed for upland birds in the region. The chances of success will be increased by creating forums to prioritize and coordinate action.
- Well-managed agricultural lands — both rangeland and cultivated land — can be very beneficial to some bird species.

Bird Data Sources

Dataset	Source	Use in CLN 2.0 Network Design
Range maps for vertebrate species (polygon)	California Wildlife Habitat Relationships (CWHR), CDFW	Create species list Mask suitability layers Determine habitat suitability and life history information
Various species occurrences (polygons converted to points)	California Natural Diversity Database (CNDDB), CDFW	Create species list (49 bird species represented in CNDDB) Assessment of coverage by draft network
Northern Spotted Owl positive observations and activity centers (point)	Point Blue Conservation Science	In Marxan analysis (present in 9 landscape units with 90% conservation goal)
Various species occurrences (point)	eBird (Cornell Lab of Ornithology), via Global Biodiversity Information Facility (GBIF)	Create species list (347 bird species represented in eBird) Assessment of coverage by draft network
Colonial bird rookery sites (point)	San Francisco Bay Bird Observatory	In Marxan analysis (present in 2 Landscape Units with 90% conservation goal) to ensure coverage for colonial bird nesting sites
Various species occurrences (point)	iNaturalist (California Academy of Sciences) via GBIF eBird, via GBIF California Avian Database (Point Blue Conservation Science)	Assessment of coverage by draft network
Important Bird Areas (polygon)	California Audubon	Assessment of coverage by draft network

Western Snowy Plover is typically associated with beaches, as well as barren areas in the baylands (which are outside the CLN study area) from the south Bay up to Napa and Solano Counties. The South Bay is believed to support more than 90% of the breeding population in the Bay Area (Wang pers. comm. 2019). A big threat to beach dwellers is disturbance by humans and dogs, and many state and NPS beaches are protecting nesting sites (California DPR 2019). Gulls and other predatory birds can be problematic as well. The USFWS published a Recovery Plan for the species in 2007 (USFWS 2007).

Western Snowy Plover chick and egg. Photo cc Alexis Frangis / California Department of Parks and Recreation.

Western Bluebird. Photo by Bob Gunderson.

Designing a Conservation Lands Network for Birds

The Birds Focus team met three times between March 2018 and December 2018 and provided updates to the bird species conservation targets and notes on conservation status and habitat. The team also listed the current top causes of stress to Bay Area bird populations. For each stressor, the team provided examples, and, most importantly, a list of conservation actions needed to mitigate the stressor in order to ensure bird population viability.

As in CLN 1.0, bird species conservation targets were selected to represent the Bay Area's major bird habitat types. The CLN identifies 12 bird habitat types including wide-area habitats such as oak woodland and grassland, but also smaller habitats embedded in the landscape, such as rock outcrops, rookery trees, and wetlands.

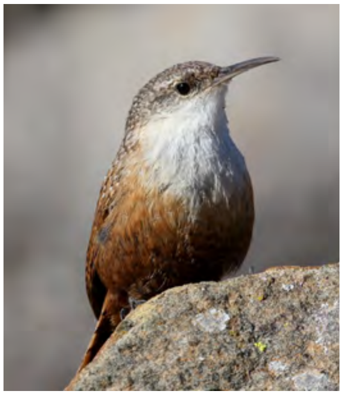
- Coastal Scrub-Chaparral
- Coastal Strand
- Coniferous Forest
- Coniferous Forest / Oak Woodland
- Grassland
- Oak Woodland
- Old-Growth Redwood
- Riparian
- Rock Outcrops
- Rookeries
- Wetlands / Lakes / Open Water
- Streams/Reservoir Edges

The CLN 2.0 vegetation map well-represented broad habitat types and some smaller habitat features, such as rocky outcrops. Other embedded habitats were accounted for using ancillary data for ponds, known rookery sites, and stream valleys (described in Chapter 5). When included in Marxan, these data help create a network that is sensitive to the habitat needs of birds, and if conserved and stewarded will be the foundation for ensuring that the Bay Area will support high bird diversity in a rapidly changing environment.

The Birds Focus Team retained all but one of the 85 native bird species chosen as conservation targets in CLN 1.0. Bullock's Oriole was removed because it is a habitat generalist in the Bay Area, making it unsuitable as a conservation target.

Two species that were not considered in CLN 1.0 but were added by the Focus Team to CLN 2.0 as targets for rookery habitat were Black-crowned Night Heron and Snowy Egret. The Focus Team added the San Francisco Common Yellowthroat subspecies as a Wetlands / Lakes / Open Water conservation target. The Focus Team also changed Double-crested Cormorant from a Wetlands / Lakes / Open Water conservation target to a Rookeries target. The CLN 2.0 team used spatial data on rookeries from the San Francisco Bay Bird Observatory to explicitly target rookery habitat in Marxan.

The Focus Team determined that the 87 CLN 2.0 bird species conservation targets (shown in Figure 7.1) cover a full range of ecological bird niches found in the Bay Area and that the habitat needs of the vast majority of bird species would be covered by the CLN 2.0 habitat goals.



Canyon Wren at Coyote Lake, Santa Clara County. Photo by Steve Rottenborn.

Threats to Birds and Recommended Conservation Actions

Conserving and stewarding a network of habitat will not be enough for many Bay Area bird species. The list of impacts affecting bird population viability goes beyond direct habitat loss, degradation, and fragmentation by development. Impacts to birds are complicated and cumulative. The Birds Focus Team identified several of these threats. They include, among others:

- Climate change, which is responsible for aridification of the landscape, vegetation stand replacement by severe wildfire, phenological mismatches with prey species, and stressors related to shifts in species' ranges;
- Introduced disease such as West Nile virus, 'subsidized predators' such as house and feral cats, and human-facilitated expansion of native predators such as crows and ravens; and
- Detrimental land management practices such as heavily grazed riparian zones with reduced understory, undergrazing for several species such as Mountain Plover and Horned Lark, and reduction in prey species from the use of pesticide, insecticide, and rodenticide use.

The Focus Team identified five key influences to Bay Area birds (shown here in alphabetical order), specific threats, and a number of recommended conservation actions:

- Climate change
- Habitat degradation
- Land management
- Land use, habitat loss, and fragmentation
- Pests and disease

Golden Eagle. Photo by Beth Hamel.

Climate change

Threats	Conservation actions

Drought, aridification, and changes in seasonality
Aridification of landscape is causing a retreat of mesic-adapted species and expansion of arid-adapted species according to vegetation changes (Stralburg *et al.* 2009).
Changing seasonality for migrants and residents is a reflection of both local and distant climate change (OEHHA 2018).
Severe fire can cause vegetation stand replacement and loss of mature trees favored by many species.
Tree die-offs affect nesting birds (Whitham 2017). For example, drought is affecting Gray Pine nesting habitat for Golden Eagle.
Dead trees also provide cavities for many species.
Climate change is shifting species distributions and driving species range expansion. In 2019, Elegant Tern was recorded nesting inside the San Francisco Bay for the first time. The range of Say's Phoebe is expanding on a large scale. Both are believed to be linked to changes in climate (Leong pers. comm. 2019).
	■ Plant restoration areas with transitional species that can adapt to changing landscape.
	■ Conserve large areas with high topographic and elevational diversity to allow populations of less mobile species to shift with climate change (*e.g.*, Loarie *et al.* 2009).
	■ Because landscape resilience depends on natural processes, conserve space where natural ecological processes can occur, such as flooding and fire, without posing risks to people.
	■ Implement restoration elements that address future needs based on expected climate changes, for example:
	  ■ Plant species that flower for more months out of the year.
	  ■ Match plants with expected future water availability.
	■ A good reference is the *Climate-Smart Restoration Toolkit* from Point Blue Conservation Science (Point Blue 2019).

Extreme weather events from climate change Climate change will impact species through extreme events. The recent drought is an example: a recent study showed that the combination of no rain and very high temperatures stressed vegetation communities and caused a state change in a riparian area, with all the cottonwoods dying during the drought (Whitham 2017). There will be a change in both the intensity and the frequency of these events.	■ Allowing more fires or prescribing fires could be a great management tool that would benefit a suite of species of varying taxa including Bell's Sparrow and Black-chinned Sparrow. ■ Protect large contiguous blocks of habitat. ■ Restore natural infrastructure (*e.g.*, flood bypasses, floodplain-channel connectivity) that have dual benefits of wildlife habitat and hazard risk reduction. ■ Accept and embrace certain change that will occur regardless of our actions.
Sea level rise Sea level rise will affect birds that live on the edges of the Bay. Habitat may migrate up the upland transition zone with sea level rise.	■ Build marshes to accommodate sea level rise. In the upland-bayland transition zone, design for high tide refugia for bayland species. Similarly, protect from development areas that will be future transition zones as seas rise and current transition becomes marsh. ■ For tidal marsh restoration: match dredge sediment supply to tidal marsh needs, as in the SediMatch program. Sediment trapped in reservoirs is a potential source.

Habitat degradation

Threats	Conservation actions
Impacts to habitat quality and forage availability Loss of habitat abundance, diversity, or richness at the macro and micro scale affects many species either through direct loss of nesting habitat or via impacts on the larger food web. Birds have different vegetative structural needs throughout their life cycle.	■ Protect and steward a connected network of large, intact habitat blocks with the full range of habitats in the ecoregion to meet diverse habitat requirements. ■ Restore and manage forests, woodlands, and shrubs to promote the development of habitat structural complexity (including understory in forests and woodlands) and natural vegetation succession in order to meet a variety of bird life cycle needs. ■ Retain downed wood and snags that provide cavities for cavity-nesting birds such as Western Bluebird, Western Screech Owl, Purple Martin, and Acorn Woodpecker. ■ Retain large diameter hollow conifer trees (live and dead) for Vaux's Swift (range is in Sonoma, Marin, San Mateo, Santa Clara, and Santa Cruz counties). ■ Create artificial burrows for Burrowing Owl where there are sufficient food sources. ■ Maintain complex forest structure for species like Band-tailed Pigeon, Black-throated Gray Warbler, Brown Creeper, Olive-sided Flycatcher, and Western Tanager. ■ Build, install, and maintain nest boxes for cavity-nesting birds where natural cavities are rare.
Habitat succession due to lack of fire and other controls Habitat succession or transition can occur naturally or because historic processes have been altered, such as through the suppression of fire or reduction of grazing by native ungulates, particularly elk. It is not only grasslands that face succession. Coastal scrubland can convert to tree habitats from lack of disturbance and grazing. Similarly, oak woodlands can convert to confer forests. Succession of oak woodland to coniferous forest could affect species like Acorn Woodpecker and Ash-throated Flycatcher. Several local bird species (*e.g.*, Bell's Sparrow and Black-chinned Sparrow) depend on open shrubby communities that tend to be maintained by natural fire regimes. Fire suppression can lead to altered, communities with denser shrubs and lower numbers of these species. Fire heterogeneity is actually good for diversity — woodpeckers take advantage of dead standing trees, and woodpecker cavities in some burned areas provide nesting sites for Purple Martin.	■ Implement land management techniques that mimic historic controls on succession and reduce fire fuels, such as grazing, and controlled burns. ■ Facilitate permitting and implementation of prescribed burning. Allowing more fires or prescribing fires could be a great management tool that would benefit a suite of species of varying taxa including Bell's Sparrow and Black-chinned Sparrow. ■ Restore habitats to mimic early successional processes. ■ Grazing as needed to maintain habitat (grassland, coastal scrub) for California Horned Lark, Burrowing Owl, Grasshopper Sparrow, Loggerhead Shrike, Mountain Plover, and Western Meadowlark. ■ Support and participate in local vegetation management plans. Local and subregional vegetation management collaborations present real opportunities for achieving biodiversity goals.

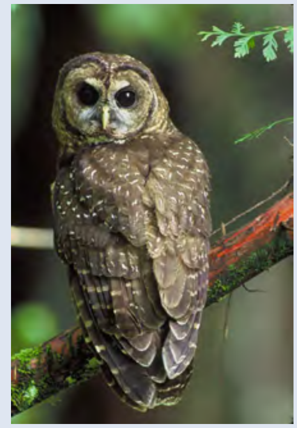
Burrowing Owl has garnered increased attention in the last decade. Breeding habitat in the flatlands and low elevations has largely been paved over, but the Bay Area attracts thousands of overwintering owls from across the West. Overwintering birds are far more widespread than breeding birds. For example in Santa Clara County, the breeding owl population has collapsed by 90% over the past two decades. Breeding birds are only found along the Bayshore, but overwintering birds are commonly encountered in upland grasslands as on Coyote Ridge. Burrowing Owl is covered by the three regional HCPs. The Santa Clara Valley Habitat Plan is funding efforts to reintroduce rescue birds into suitable habitats in Coyote Valley as well as along the Bayshore.

Burrowing Owl in Antioch, Contra Costa County. Photo cc Cheryl Reynolds.

Land management

Threats	Conservation actions
Grazing practices Grazing is important to create appropriate grassland vegetation structure for many species in the Bay Area, including species such as California Horned Lark, Grasshopper Sparrow, Loggerhead Shrike, Mountain Plover, and Western Meadowlark. For Burrowing Owl, reduction of thatch via grazing benefits ground squirrels whose burrows the owls use for habitat. While livestock grazing is beneficial for many species, particularly for maintaining grassland habitats, it can be detrimental for Northern Harrier. Northern Harrier is a ground nester and a ground rooster that forms small to large communal winter roosts in tall grasslands for cover. Harriers primarily hunt by ear and tall grass provides an advantage to the harrier such that the prey does not see it coming. Overgrazing of riparian vegetation impacts riparian birds such as Allen's Hummingbird, Black-headed Grosbeak, Cassin's Vireo, Swainson's Thrush, and others. Overgrazing degrades riparian vegetation and interrupts natural processes of vegetation succession, which in turn changes habitat structure and species composition.	■ In areas where Northern Harrier may nest, or where maintaining high thatch levels is important for mammalian prey (*e.g.*, voles), maintain some areas that are ungrazed or lightly/infrequently grazed during the nonbreeding season. Monitor for benefits to Harrier population levels. ■ Harriers nest in more mesic grasslands that can be tall/dense, so grazing in shorter or sparser grasslands (*e.g.*, serpentine) would not adversely affect their nesting. ■ Maintain grazing regimes as a management tool to mimic native browsing. ■ Limit or carefully manage grazing in riparian and wetland zones so as not to destroy or remove understory vegetation, which is important to many species for nesting and foraging. Discourage grazing of riparian vegetation during breeding season. Consult rangeland management professionals (*e.g.*, Certified Rangeland Managers) to employ grazing while reducing soil compaction and non-native plants.
Pesticide/Insecticide Use All insect-eating birds are potentially affected by loss of insects. Correlations between Purple Martin population declines and recent increases in the use of neonicotinoid pesticides suggest that elimination of aquatic-emergent flying insects may be associated with the rapid decline of the breeding populations in Sacramento (Airola and Kopp 2009).	■ Implement policies that limit the sale and application of pesticides and insecticides. ■ Educate pesticide/insecticide applicators about the impacts to birds and other species and best practices. ■ Continue research to understand effects.
Rodenticides Rodenticides kill Ground Squirrel, which is important for creating and maintaining burrows used by Burrowing Owl. Ground Squirrel is also important prey for species like Ferruginous Hawk, Golden Eagle, and Northern Spotted Owl.	■ Implement policies that limit the sale and application of rodenticides, particularly those that may result in secondary poisoning of predators and scavengers.
Reservoir water management, including boating and recreation Fluctuating water levels can destroy nests for species like Clark's Grebe and Western Grebe.	■ Floating nest platforms can mitigate fluctuating water levels. ■ Understand bird use in reservoirs and set limits on water level fluctuation and boating use during the nesting season.
Collisions due to night lighting and glass construction Collision with glass is a primary killer of birds in the urban landscape. Birds are attracted to night lighting of buildings constructed with glass and collide headlong into the buildings.	■ Adopt bird-safe design ordinances and guidelines as has been done in Oakland and San Francisco. ■ Limit night time construction and night lighting on new structures through regulatory permitting process. ■ Collect more local data on the problem (frequency of bird collisions, factors affecting collision frequency such as juxtaposition of glass and high-quality bird habitat) and refine bird-safe design guidelines as necessary.

Northern Spotted Owl has a stronghold in the North Bay; indeed, these are among the healthiest populations of the owl. It occupies mixed hardwoods and second growth forests, in addition to old-growth conifers (Evens 2017). The population on Mount Tamalpais is rated in "Good" condition — most territories are occupied and surviving fledglings have been observed nearly every year (One Tam 2019). **Barred Owl**, which threatens Spotted Owl in the Pacific Northwest, has appeared in small numbers in the North Bay, and is being closely monitored by National Park Service biologists.



Northern Spotted Owl.
Photo cc USFWS, Pacific Southwest Region 5.

Land use, habitat loss, and fragmentation

Threats	Conservation actions
Development and human settlement Sprawl-style urban development, which has disproportionately impacted low-lying grasslands and rangelands, impacts 12 bird species conservation targets, including Burrowing Owl, Swainson's Hawk, and White-tailed Kite. Potential rookeries are also reduced through tree loss, including the purposeful removal of trees to get rid of nesting birds that are perceived as nuisances due to smell. Rural residential ranchette-style development impacts bird species as well. The number of bird species declines with degree of habitat fragmentation (Hansen *et al.* 2005). Tricolored Blackbird nests in grain and silage fields, creating management issues for farmers.	■ Support policy that encourages urban infill while still retaining a patchwork of urban parks and greenspace (with connectivity where feasible). ■ Use CLN 2.0 framework with Priority Conservation Areas (MTC/ABAG program), local HCP/NCCPs, and other efforts that have analyzed (1) how to maintain connectivity, (2) where conservation action is most feasible within the built environment, and (3) where development does the least damage and impact and makes the most sense due to proximity to other development, transit, etc. ■ Protect large contiguous blocks of native habitat, including rangelands, from fragmentation by rural residential development everywhere, but particularly in Sonoma and Santa Cruz counties where rural residential already makes up more than 7% and 13% of the total land area, respectively. ■ Support stewardship of both private and public lands that results in preservation and restoration of native habitat (*e.g.*, support legislation that bolsters budgets for regional parks and open space districts, support Resource Conservation District budgets). ■ Consider the habitat needs of migratory birds in Bay Area conservation projects. Work with private landowners whose farms and ranches support resident and migratory birds. ■ Increase habitat quantity and quality in urban areas by increased use of native tree and shrub species in landscaping, *e.g.*, Re-Oaking Silicon Valley. ■ Protect and restore riparian habitat corridors and maintain stands of trees in the agricultural matrix to benefit Swainson's Hawk and others.
Wind farms Although they are renewable sources of energy, wind farms threaten species such as Burrowing Owl, Prairie Falcon, and Golden Eagle. While older windmill/turbine designs that were devastating to hawks and eagles are being decommissioned (*e.g.*, the lattice-tower windmills in the Altamont Pass) and new camera technology is being deployed, new designs result in mortality of different and smaller species that are harder to document (H.T. Harvey & Assoc. 2018).	■ Continue to study the effects of wind farms to understand the full range of impacts and support ways to eliminate bird mortality. ■ Modify turbines to reduce effects. And use least damaging turbines in new construction. ■ Site new wind farms in locations outside of flyway and migration paths.

Threats	Conservation actions
Landfills and commercial/industrial development Landfills and other places with food remains attract corvids (crows and ravens) and gulls that predate other birds, including eggs and nestlings.	■ Control birds' access to food in landfills by quickly covering waste and actively discouraging feeding through techniques such as noise cannons, drones, and visual deterrents.
Loss of habitat connectivity As with all animals, birds require access to preferred habitats. The health of bird species populations is improved when these habitats are within their respective dispersal distances. Even though birds can fly through/over developed land, connectivity can be important. Certain species (*e.g.*, Wrentit, California Quail) have short dispersal distances and require habitat patches to be close in proximity (Penrod *et al.* 2013).	■ Implement the Bay Area Critical Linkages strategy (Penrod *et al.* 2013), which includes several focal bird species, and other linkage strategies (*e.g.*, Merenlender *et al.* 2010) that promote protection of key pathways to intact habitat cores so that birds can readily disperse and adapt to a changing climate (Keeley *et al.* 2018). ■ Retain and enhance remnant patches of natural habitat in cultivated and urbanized area — these can assist in movement and access to forage and/or roosting habitat. ■ Protect and/or restore riparian areas for their connectivity value. However, even if riparian habitat is degraded (*e.g.*, denuded or abuts urbanization), waterways provide corridors of movement for birds. ■ Where feasible, in order to provide continuous habitat for birds and other wildlife in urban areas, uncover (or "daylight") urban creeks that have been covered to accommodate development.
Human recreation The number of birds and the number of bird species decreases with increases in trail use (Botsch *et al.* 2018)	■ Minimize disturbance during breeding seasons. ■ Site desired breeding locations (when enhancing habitat) and trails (when planning for recreation) far enough apart that disturbance is not an issue. ■ Consider temporary trail closures for sites with known sensitive species and/ or those with very high diversity.

Golden Eagle is widespread but have inherently low population density generally. However, the Diablo Range and Mt. Hamilton Range supports one of the densest known populations of this bird. It can be observed soaring over many open habitats in search of ground squirrels, rabbits, and other prey. Oak woodlands are the preferred nesting and rearing habitats, and cliffs are often used as actual nest sites. Wind farms are an important source of mortality, but recent redesigns of turbines have reduced, but not eliminated, mortality (Kolar and Wiens 2017). Rodenticides have been used to reduce ground squirrel around wind farms and make them less attractive to raptors, but rodenticide use can poison Golden Eagle and other predators that feed on carcasses.

Golden Eagle. Photo by Beth Hamel.

Wilson's Warbler in San Jose. Photo by Steve Rottenborn.

Pests and disease

Threats	Conservation actions
Disease West Nile virus greatly impacted Yellow-billed Magpie, whose numbers are in decline — particularly in Coyote Valley. Band-tailed Pigeon is sensitive to disease outbreaks, which also affects raptors, for which Band-tailed Pigeon is an important prey species. Sudden oak death is affecting trees that oak woodland species depend on, such as Acorn Woodpecker and Ash-throated Flycatcher. Disease can be exacerbated by climate change. Warmer weather pathogens are spreading to new populations. Mosquitoes and ticks can be carriers.	■ Protect large, intact blocks of habitat. Abundant and diverse habitats also spread out populations on the landscape — diseases may be likely to spread or be as detrimental in less dense, more dispersed populations. ■ Implement best management practices that help control the spread of disease, such as nursery practices that reduce the spread of soil pathogens that can affect habitat.
Non-native birds and native nuisance/predator species Nest predation by corvids (crows and ravens) and gulls is a major conservation issue (probably more so than non-native mammal predation). Corvid and gull diets are "subsidized" by human food waste in public areas and landfills. As a result, their ranges are expanding and are even moving from uplands into baylands and predating on shore birds, including corvid predation of endangered Snowy Plover (Liebezeit *et al.* 2002, SFBBO 2018).	■ Manage landfills and other public spaces to avoid feeding gulls and corvids (see 'Landfills and Commercial/Industrial Developments' above). ■ Reduce food waste availability (*e.g.*, open garbage cans, outdoor pet food dishes, etc.) where people congregate in order to curtail the mechanisms of human-facilitation (human-subsidization) of native nuisance predator species.
Non-native mammals Off-leash dogs are a significant conservation concern for birds as they can disturb nesting areas and flush ground-nesting birds, which can lead to nest abandonment. Pet dogs and cats and feral cat colonies (actually a bigger problem than pets) predate songbirds and ground-nesting birds. Many areas support feral cat colonies. Cat feces spread Toxoplasma, a parasitic disease that affects people. Cats contract the disease by eating infected wildlife, including birds.	■ Support and implement on-leash policies in sensitive wildlife areas or during the breeding season. ■ Manage off-leash dogs to protect birds and create more off-leash dog parks near communities to meet the growing demand by the Bay Area's urban population. ■ Control feral wildlife. ■ Discourage the feeding of feral cats in order to reduce predation of native birds. ■ Create nesting islands for wading birds that reduce access of mammalian predators to nesting birds.
Invasive plants Certain invasive plants in grasslands can reduce habitat suitability considerably for a variety of ground-nesting birds.	■ Work with land managers to improve invasive plant management using a variety of methods.

Data Gaps

- Monitor, measure, and adapt accordingly (*e.g.*, use and contribute to the Avian Knowledge Network).
- Investigate causes of observed range shifts (*e.g.*, Swainson's Hawk expanding from Solano County to Marin County; Cassin's Vireo moving into Solano County; and Least Tern nesting in Solano County).
- Develop a climate change vulnerability assessment for the Bay Area region's flora and fauna.
- Develop abundance targets and associated habitat acreage targets for a representative subset of bird species.
- Test the assumption that the CLN contains sufficient diversity in topography, microclimate, etc. to maintain bird populations in the face of climate change.
- Identify species that will require continuing, species-specific intervention ("conservation-reliant species") and develop Bay Area-wide recommendations for actions and enabling conditions to take the actions (*e.g.*, Scott *et al.* 2010, Goble *et al.* 2012).
- Update the *State of the Birds* report (Pitkin and Woods 2011).
- Complete Breeding Bird Atlas (BBA) projects for all counties in the San Francisco Bay Area, including spatial records. Note: Recent BBAs have been conducted in Marin, Napa, Solano, Sonoma, and Santa Clara counties, and a BBA project is underway in Santa Cruz County.
- Quantitatively link the benefits of bird conservation to other societal benefits.
- Monitor for nest material sourcing in order to determine whether restoration plantings benefit native species.

Marbled Murrelet forages in the ocean and nest in tall trees, and is hanging on as a population of a few hundred birds in old-growth conifer stands in southern San Mateo and northern Santa Cruz Counties: Memorial County Park, Portola Redwoods State Park, Butano State Park, and Big Basin Redwoods State Park (NPS 2019). A major challenge for Marbled Murrelet is predation by jays and crows, which forage at campsites and picnic areas and then prey on murrelet nests high in the canopy. Park initiatives such as "Crumb Clean" attempt to ameliorate this threat. The bird is also sensitive to ocean conditions, and stressed by warm water during El Niño events. There is a 1997 USFWS Recovery Plan.

Marbled Murrelet. Photo Hamer Environmental L.P. / US Fish and Wildlife Service.

Figure 7.1 ■ **CLN 2.0 Bird Species Conservation Targets.** Species marked with an asterisk (*) were added since CLN 1.0. For a detailed list of all bird conservation targets with information about each species' habitat and management issues, see Appendix C.

Common Name	Scientific Name	Legal Status Bold indicates changes in legal status since 2010
Coastal Scrub-Chaparral		
Black-chinned Sparrow	*Spizella atrogularis*	—
California Thrasher	*Toxostoma redivivum*	—
Greater Roadrunner	*Geococcyx californianus*	—
Mountain Quail	*Oreortyx pictus*	—
Nuttall's White-crowned Sparrow	*Zonotrichia leucophrys nuttalli*	—
Rufous-crowned Sparrow	*Aimophila ruficeps*	CA SSC
Bell's Sparrow	*Artemisiospiza belli*	—
Wrentit	*Chamaea fasciata*	—
Coastal Strand		
Western Snowy Plover	*Charadrius nivosus*	FT, CA SSC
Coniferous Forest		
Golden-crowned Kinglet	*Regulus satrapa*	—
Northern Saw-whet Owl	*Aegolius acadicus*	—
Pileated Woodpecker	*Dryocopus pileatus*	—
Purple Martin	*Progne subis*	**CA SSC**
Pygmy Nuthatch	*Sitta pygmaea*	—
Red-breasted Nuthatch	*Sitta canadensis*	—
Sharp-shinned Hawk	*Accipiter striatus*	—
Vaux's Swift	*Chaetura vauxi*	CA SSC
Coniferous Forest / Oak Woodland		
Band-tailed Pigeon	*Patagioenas fasciata*	—
Black-throated Gray Warbler	*Dendroica nigrescens*	—
Brown Creeper	*Certhia americana*	—
Northern Spotted Owl	*Strix occidentalis caurina*	FT, CA SSC
Olive-sided Flycatcher	*Contopus cooperi*	CA SSC
Western Tanager	*Piranga ludoviciana*	—
Grassland		
Burrowing Owl	*Athene cunicularia*	CA SSC
California Horned Lark	*Eremophila alpestris actia*	—
Ferruginous Hawk	*Buteo regalis*	—
Grasshopper Sparrow	*Ammodramus savannarum*	CA SSC
Loggerhead Shrike	*Lanius ludovicianus*	CA SSC
Mountain Plover	*Charadrius montanus*	CA SSC
Northern Harrier	*Circus cyaneus*	CA SSC
Prairie Falcon	*Falco mexicanus*	—
Savannah Sparrow	*Passerculus sandwichensis*	—
Swainson's Hawk	*Buteo swainsoni*	CT
Western Meadowlark	*Sturnella neglecta*	—
White-tailed Kite	*Elanus leucurus*	CA FP

Legal Status

BAGEPA	Bald and Golden Eagle Protection Act
BLM S	BLM Sensitive
CA C	California Candidate
CA FP	California Fully Protected
CA SSC	California Species of Special Concern
CE	California Endangered
FC	Federal Candidate
FE	Federal Endangered
FSC	Federal Species of Concern
FT	Federal Threatened
CT	California Threatened
USFS S	US Forest Service Sensitive

Common Name	Scientific Name	**Legal Status** Bold indicates changes in legal status since 2010
Oak Woodland		
Acorn Woodpecker	*Melanerpes formicivorus*	–
Ash-throated Flycatcher	*Myiarchus cinerascens*	–
Blue-gray Gnatcatcher	*Polioptila caerulea*	–
Cooper's Hawk	*Accipiter cooperii*	–
Golden Eagle	*Aquila chrysaetos*	**CA FP, BAGEPA**
Lark Sparrow	*Chondestes grammacus*	–
Lawrence's Goldfinch	*Carduelis lawrencei*	–
Lazuli Bunting	*Passerina amoena*	–
Lewis's Woodpecker	*Melanerpes lewis*	–
Nuttall's Woodpecker	*Picoides nuttalli*	–
Oak Titmouse	*Baeolophus inornatus*	–
Western Bluebird	*Sialia mexicana*	–
Western Screech-Owl	*Megascops kennicottii*	–
California Scrub-Jay	*Aphelocoma californica*	–
Yellow-billed Magpie	*Pica nuttalli*	–
Old-growth Redwood Forest		
Marbled Murrelet	*Brachyramphus marmoratus*	FT, CE
Riparian		
Allen's Hummingbird	*Selasphorus sasin*	–
American Dipper	*Cinclus mexicanus*	–
Bank Swallow	*Riparia riparia*	CT
Belted Kingfisher	*Megaceryle alcyon*	–
Black-headed Grosbeak	*Pheucticus melanocephalus*	–
Blue Grosbeak	*Passerina caerulea*	–
Cassin's Vireo	*Vireo cassinii*	–
MacGillivray's Warbler	*Geothlypis tolmiei*	–
Northern Pygmy-Owl	*Glaucidium gnoma*	–
Song Sparrow	*Melospiza melodia*	CA SSC
Swainson's Thrush	*Catharus ustulatus*	–
Warbling Vireo	*Vireo gilvus*	–
Wilson's Warbler	*Wilsonia pusilla*	–
Yellow Warbler	*Setophaga petechia*	CA SSC
Yellow-breasted Chat	*Icteria virens*	CA SSC
Rock Outcrops		
Canyon Wren	*Catherpes mexicanus*	–
Peregrine Falcon	*Falco peregrinus*	federally delisted in 1999, **CA FP**
Rock Wren	*Salpinctes obsoletus*	–
White-throated Swift	*Aeronautes saxatilis*	–

Common Name	Scientific Name	**Legal Status** Bold indicates changes in legal status since 2010
Rookeries/Colonies		
Black-crowned Night Heron *	*Nycticorax nycticorax*	—
Double-crested Cormorant	*Phalacrocorax auritus*	—
Great Blue Heron	*Ardea herodias*	—
Great Egret	*Ardea alba*	—
Snowy Egret *	*Egretta thula*	—
Wetlands / Lakes / Open Water		
Bald Eagle	*Haliaeetus leucocephalus*	federally delisted in 2007, CE, **CA FP**, BAGEPA
Cackling (Aleutian Canada) Goose	*Branta hutchinsii leucopareia*	federally delisted in 2001
Clark's Grebe	*Aechmophorus clarkii*	—
Common Yellowthroat	*Geothlypis trichas*	—
Osprey	*Pandion haliaetus*	—
San Francisco Common Yellowthroat *	*Geothlypis trichas sinuosa*	**CA SSC**
Tree Swallow	*Tachycineta bicolor*	—
Tricolored Blackbird	*Agelaius tricolor*	CT
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	CA SSC
Western Grebe	*Aechmophorus occidentalis*	—
Streams/Reservoir Edges		
Common Merganser	*Mergus merganser*	—
Wood Duck	*Aix sponsa*	—

CHAPTER

8 Amphibians & Reptiles

San Francisco Garter Snake. Photo Swaim Biological.

Overview

The reptiles and amphibians of the Bay Area, like other biota, reflect the climatic and physiographic diversity of the region. Desert species such as Western Spadefoot Toad, Glossy Snake, Coachwhip, and Western Whiptail live in the arid fringes of the Central Valley in eastern Alameda, Contra Costa, and Santa Clara Counties. Some Pacific Northwest species such as Northwestern Salamander and Red-bellied Newt reach their southern range limits in coastal Sonoma County, with the exception of an isolated population of Red-bellied Newt in San Mateo County. California Giant Salamander is virtually endemic to the moist forests of Santa Cruz, San Mateo, Marin, Sonoma, and Napa Counties. Alameda Striped Racer (also known as Alameda Whipsnake) is endemic to the East Bay, and San Francisco Garter Snake is known only from the San Francisco Peninsula (Stebbins 2003).

These animals have suffered from intense human development, yet still persist and even thrive when their habitats are protected and appropriately managed. Red-legged Frog, Tiger Salamander, and Western Pond Turtle were once abundant in valley bottom wetlands and vernal pool complexes that long ago disappeared under the plow and the pavement. Now these species are largely relegated to networks of small natural wetlands, ranch ponds, and some streams in undeveloped uplands. Many amphibian species are now utterly dependent on cattle ranching, which provides ponds required for breeding, controls annual grasses, and prevents succession of grassland into scrub.

California Giant Salamander is a Bay Area endemic, distributed in heavily forested coastal streams from the Santa Cruz Mountains north into the Sonoma Coast Range and extending inland to the Mayacamas and Vaca West/Blue Ridge Berryessa Landscape Units. The species is locally abundant (though cryptic and nocturnal), and its habitat needs are well covered by the riparian and coniferous forest goals. Recent large acquisitions that include habitat for this species include Buckeye Forest (Sonoma County), San Vicente Redwoods (Santa Cruz County), and smaller projects include redwood, Douglas-fir, and hardwood forests and embedded streams.

California Giant Salamander. Photo cc Natalie McNear.

Amphibian and Reptile Conservation Targets and Network Protection

The goal of the Conservation Lands Network (CLN) is to conserve and steward enough habitat for these amphibians and reptiles to remain viable within each landscape unit, in the course of exhibiting typical boom-bust cycles. The vegetation goals are particularly effective in conserving terrestrial reptiles which, like small mammals, can have high local population densities. For aquatic species, the CLN includes all undeveloped riparian zones, as well as stream corridors through urban and agricultural landscapes. The network also specifically targets wetlands and ponds. Many taxa are on state and federal lists as Endangered, Threatened, or Special Concern, and substantial portions of their ranges are covered under the regional HCP/NCCPs, which add protections for these species.

Toward that goal, the Amphibian and Reptile Focus Team:

- Suggested, provided, and reviewed available distribution data on species and populations, including ranges and occurrences, to update understanding of current distributions;
- Selected a list of amphibians and reptiles as conservation targets and compiled their respective habitat requirements / descriptions; and
- Recommended management and stewardship actions to ensure target species persistence.

As with CLN 1.0, the Focus Team considered a wide range of species, starting with the state and federally listed species but casting a wide net to capture many ecological roles and specialized habitats. The Focus Team retained the original list of 14 amphibians and 22 reptiles from CLN 1.0. The team added two amphibian species (Santa Cruz Black Salamander and Santa Cruz Long-toed Salamander), and removed two reptile species (Coast horned lizard and Nightsnake, which is represented on the target list by the subspecies present in the study area).

The team then consulted the California Natural Diversity Database (CNDDB), Recovery Plans, and Five-Year Reviews to document known distributions, habitat relationships, and data gaps, contributed expert knowledge, and assessed the adequacy of the vegetation, riparian, and other goals to provide sufficient habitat for targets. In cases where data were available in CNDDB and species have limited distributions and specific habitat requirements, Marxan was configured to specifically capture habitat for these species. Importantly, the stewardship requirements of these species were explicitly considered.

Key Focus Team Determinations for Amphibians and Reptiles

- As described in the CLN 1.0 report, the vegetation goals — 50% of the common vegetation types (Rank 3) and more for rare types (Ranks 1 and 2) — meet the habitat needs of the vast majority of terrestrial reptiles and several salamander species.
- For pond dwellers and breeders, explicit targeting of thousands of ponds in Marxan (50% in large and 75% in small landscape units), as shown in Figure 8.1, produced pond networks that could support viable metapopulations, assuming effective pond stewardship.
- Ranching provides stock ponds, and well-managed grazing maintains vernal pools. Short grass facilitates movement, and favors burrowing mammals that provide upland habitat.
- The riparian goals provide for functional stream valleys that provide habitat for stream dwellers, especially Foothill Yellow-legged Frog and some populations of California Red-legged Frog.
- Riparian restoration and management should maintain some open areas for basking frogs and turtles.
- Reintroduction has proven effective at several sites and should be further considered to repopulate empty habitats.
- Climate change poses great risks to these taxa that depend on the ambient environment to regulate body temperature and moisture. Increased aridity and extreme rainfall produce higher risks in an already variable environment.
- The regional climate gradients, topoclimatic variability, and hydrologic diversity that are captured within contiguous conservation lands provide substantial buffers against climate change. The presence of arid-adapted southern and desert species at the fringe of the Central Valley provides the nuclei for expansion with increasing aridity.
- Listed taxa are increasingly covered by regional and local HCPs and NCCPs, which help secure lands and provide long-term stewardship.

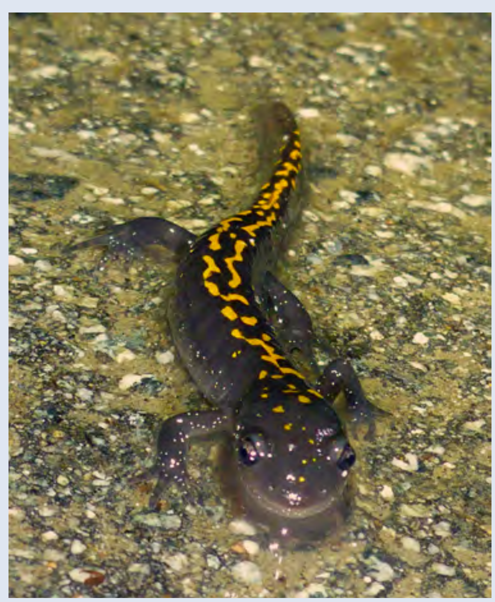
Western Pond Turtle at Felt Lake, Stanford. Photo by Stanford Conservation Program.

California Tiger Salamander. Photo by Stanford Conservation Program.

Amphibian and Reptile Data Sources

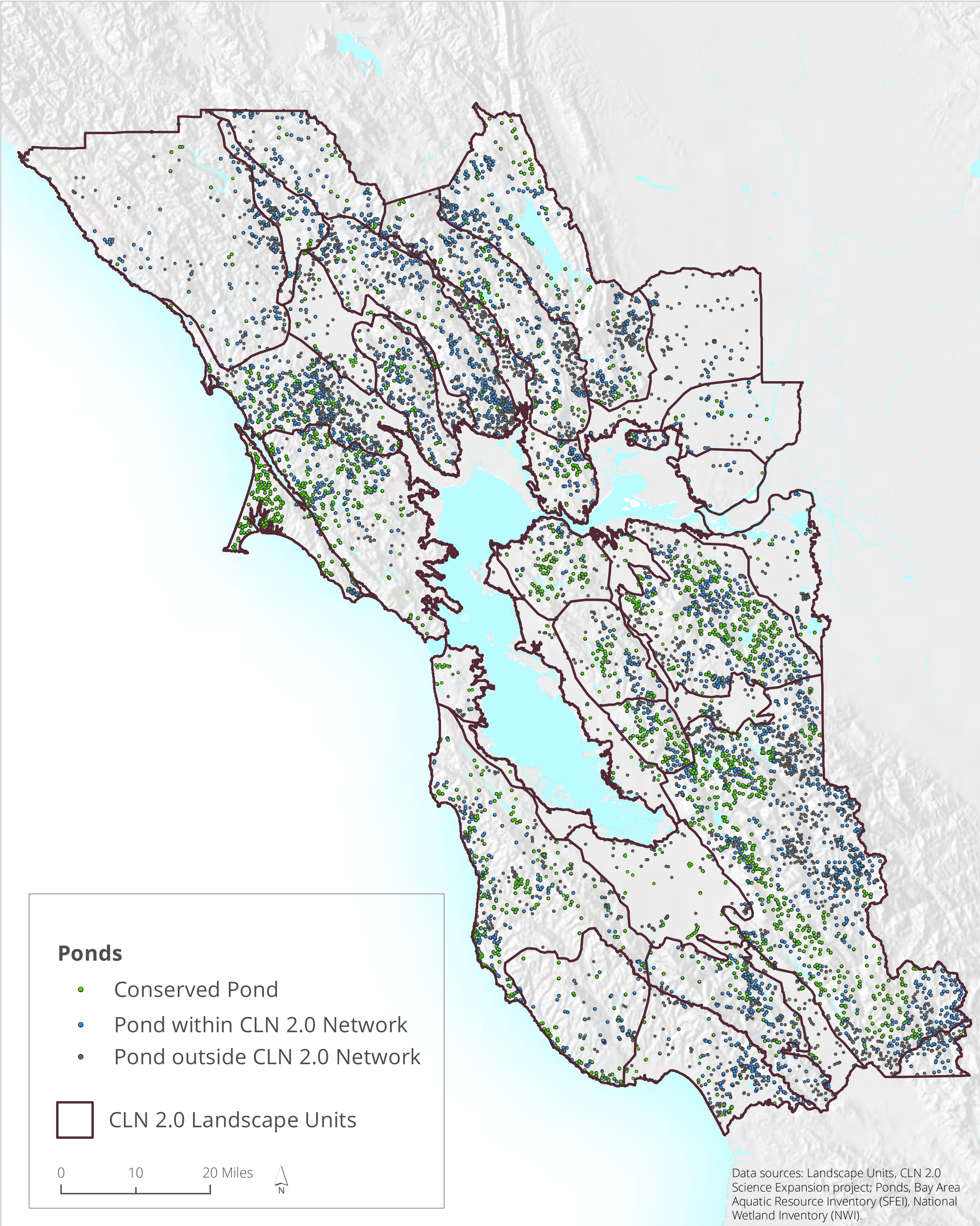
Dataset	Source	Use in CLN 2.0 Network Design
Range maps for vertebrate species (polygon)	California Wildlife Habitat Relationships (CDFW)	Create species list Mask suitability layers Habitat suitability and life history information
Various species occurrences (polygons converted to points)	California Natural Diversity Database (CNDDB) (CDFW)	Create species list Assess coverage by draft network
Various species occurrences (point)	Museum of Vertebrate Zoology (UC Berkeley)	Create species list Assess coverage by draft network
Pond occurrences (polygons converted to points)	California Aquatic Resource Inventory and Bay Area Aquatic Resource Inventory (SFEI)	Marxan with 50% conservation goal In smaller landscape units, Marxan with 75% conservation goal
Alameda Striped Racer (Alameda whipsnake) occurrences (points)	California Natural Diversity Database, Swaim Biological, Inc.	In Marxan analysis (present in three landscape units with 75% conservation goal)
Various species occurrences (points)	iNaturalist (California Academy of Sciences)	Assess coverage by draft network
Vernal pool occurrences (points) in Napa County	California Department of Fish and Wildlife Vernal Pool Assessment	In Marxan analysis (present in 5 landscape units with 75% conservation goal)
Vernal pool occurrences (polygons)	California Department of Fish and Wildlife Vernal Pool Assessment	In Marxan analysis (in 18 landscape units with 75% conservation goal)

Santa Cruz Long-toed Salamander is narrowly distributed in seasonal ponds and adjacent upland areas in southern Santa Cruz County and northern Monterey County, divided into six metapopulations consisting of pond networks and adjacent upland habitats. High levels of habitat fragmentation by roads, residential development, and cultivated agriculture threaten the integrity of these metapopulations, as does agricultural runoff with pesticides. Mosquito Fish and Crayfish in breeding ponds can cause high predation rates. Wildlife tunnels proved ineffective in the Valencia-Seascape population, which is covered by a small HCP. Many ponds have been acquired across the metapopulations, and the taxon is targeted for captive rearing and release in coming years.



Santa Cruz Long-toed Salamander. Photo cc Robin Agarawal.

Figure 8.1 ■ Distribution of Ponds Within the CLN 2.0 Network.



Foothill Yellow-legged Frog. Photo cc USDA.

Foothill Yellow-legged Frog is a stream dweller that requires calm backwaters and eddy habitat. It occupies many watersheds in the Sonoma Coast Range, Northern and Southern Mayacamas, Vaca Mountains West, and Blue Ridge-Berryessa (see Figure 8.2). Two small populations remain in the Marin Coast Range in Big Carson and Little Carson Creeks, but are in danger of becoming shaded out (One Tam 2019). The species is reported to occur in a number of watersheds in the Santa Cruz Mountains: Pescadero (questionable), Capitola, Monte Toyon, Sveadal, and Llagas.

The frog is more widely distributed in the Mount Hamilton Landscape Unit, but occurs in only one watershed in Mount Diablo Range Landscape Unit. Maintaining open areas along streams is important to provide basking sites for this and other stream dwellers. Alterations of streamflow by dams, including dam releases for anadromous fish, can decrease habitat suitability. The species is covered by the Santa Clara Valley and East Contra Costa HCP/NCCPs, and is under review for both state and federal listing (Center for Biological Diversity 2016). Confirmation of occurrence records and comprehensive surveys are needed.

Gap Analysis: Network Protection for Stream Dwellers

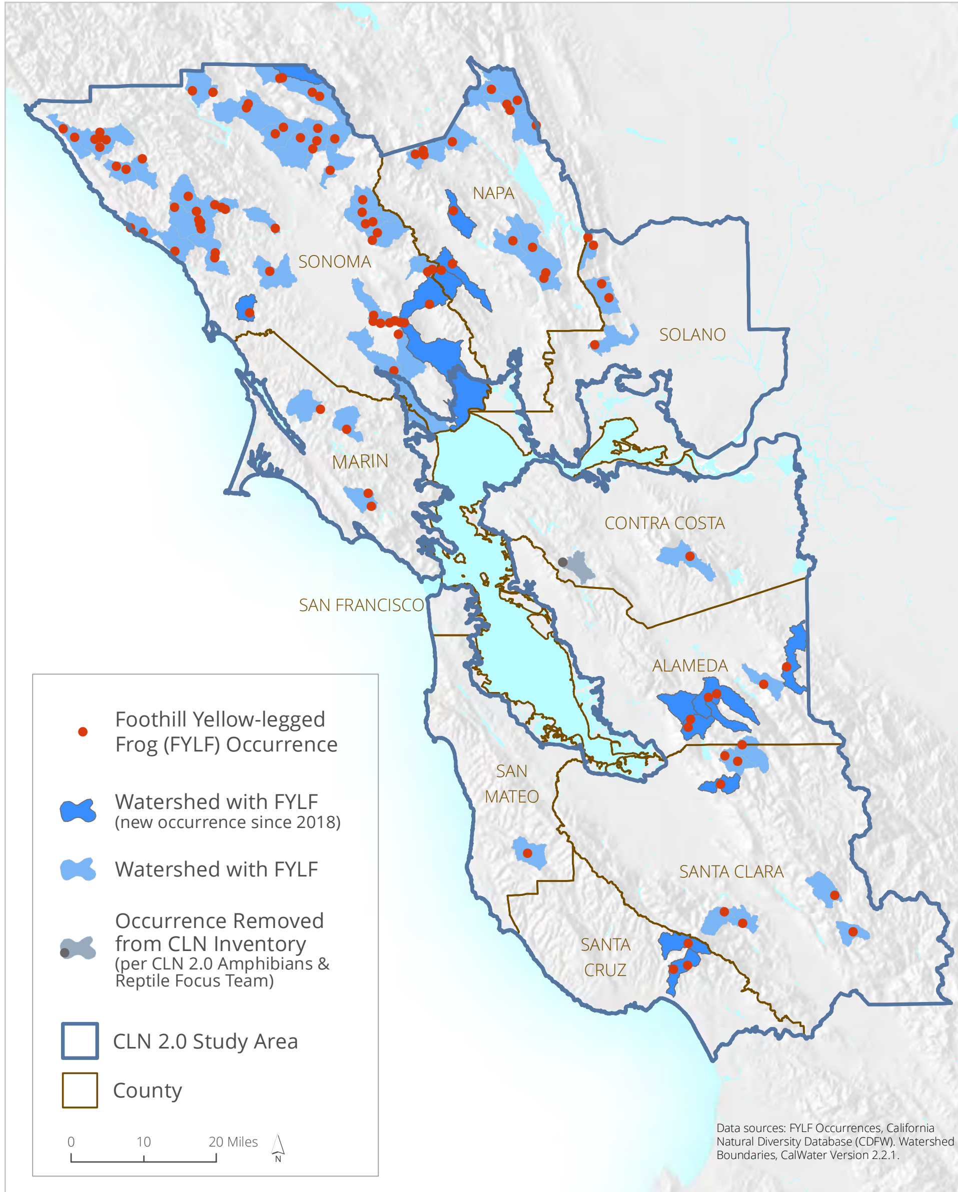
In CLN 1.0, the Riparian/Fish Focus Team used CalWater 2.2.1 Hydrologic Areas and Planning Watersheds to review network coverage for fish, riparian, and stream conservation targets by the Conservation Lands Network, and found it generally adequate. The team also recommended that CLN 2.0 consider adding fine-filter targets for specific watersheds.

The CLN 2.0 focus team felt that the addition of functional stream valleys to the network would better target habitat for stream dwellers. To test this assumption, the team conducted a gap analysis for Foothill Yellow-legged Frog, a California Species of Special Concern currently under petition for Threatened status at both federal and state levels.

This species was chosen in part because of the number of new occurrence records added to the California Natural Diversity Database (CNDDB) between 2010 and 2018. In a review of these 23 new occurrence records, as well as historical occurrences, the team flagged several as suspect, and recommended that they be confirmed with comprehensive field surveys.

Planning Watersheds, which represent not only the stream valleys that are current and future suitable habitat but also the contributing watershed lands, were overlaid with the CLN 2.0 coarse-filter network and point occurrences of Foothill Yellow-legged Frog (Figure 8.2). The team found that the network adequately covered these watersheds, and thus habitat for the frog and other stream dwellers in those specific watersheds. In addition, the analysis showed that the network covered 97 of the 107 CNDDB occurrences of Foothill Yellow-legged Frog, meeting the 90% goal for this species.

Figure 8.2 ■ Gap Analysis Map Showing Network Protection for Planning Watersheds and Foothill Yellow-legged Frog CNDDB Occurrences. Note the new occurrences and expansion into Santa Cruz County.



San Francisco Garter Snake at Mindego Lake near La Honda. Photo by Stuart Weiss.

San Francisco Garter Snake inhabits wetlands and ponds in San Mateo County and northern Santa Cruz County (Waddell Creek). One of the most well-studied populations is isolated but thrives near the San Francisco International Airport (Reeder *et al.* 2015). The snake's striking red stripe made it a magnet for collectors ("the most beautiful snake in the United States" (Stebbins and McGinnis 2012), and it received early protection under the Endangered Species Act, in 1967. Despite the fact that one of the species' favorite prey items is California Red-legged Frog, both are doing well in this area.

In 2009, Peninsula Open Space Trust and Midpeninsula Regional Open Space District (Midpen) protected a large core population near La Honda at Mindego Lake, where the USGS has studied and monitored the population (Kim *et al.* 2018). Mindego Lake dried out completely in 2014, which obviated the need to deliberately drain it to eliminate fish and bullfrogs. Re-population of empty habitats in other Midpen preserves will eventually use Mindego Lake as a source population.

Cattle at Sierra Vista Open Space Preserve. Photo by Lark Burkhardt.

Designing a Conservation Lands Network for Amphibians and Reptiles

The Amphibians and Reptiles Focus Team determined that the conservation target species (see Figure 8.3) cover a range of life history and ecological roles. As before, the focus team helped the project team document known species abundance and distributions, noting where species names have changed and where data gaps exist.

The team determined that the habitat needs of the vast majority of terrestrial reptiles and amphibians will be protected by the vegetation goal of protecting 50% of the common vegetation types (Rank 3) and more for rare types (Ranks 1 and 2). The large acreages of common vegetation types in the CLN will ensure sufficient habitat to support viable local populations of these species.

The aquatic species required additional considerations. The pond dwellers require networks of ponds, most often ranch ponds, within landscape units. As in CLN 1.0, ponds became fine-filter targets to ensure that the number of ponds conserved was sufficient for robust metapopulations, and that the inherent variability in habitat suitability among ponds would be captured by the network. Also, a great emphasis on pond management is necessary. For stream dwellers, the inclusion of all stream valleys in the network covered them in general, but considerations of adjacent upland habitats and the watersheds feeding the streams were also deemed important.

The team also considered special life history requirements and management issues, such as disease, vegetation succession, and interactions with livestock grazing, and how these are affecting — for better or worse — various amphibian and reptile species.

Once restored, former ranch stock ponds such as this one at Rancho Cañada del Oro Open Space Preserve in Santa Clara County may provide breeding habitat for amphibians including California Tiger Salamander and California Red-legged Frog. Photo by Steven Joseph.

Threats to Amphibians and Reptiles and Recommended Conservation Actions

The focus team identified five key influences on populations of Bay Area amphibians and reptiles (here in alphabetical order), specific threats, and recommended conservation actions:

- Chemicals and pollutants
- Climate change
- Habitat connectivity
- Land use and management
- Pests and disease

Chemicals and pollutants

Threats	Conservation actions
Pesticides and herbicides Use of the herbicide atrazine, and its subsequent contamination of surface and groundwater, has been shown to disrupt hormones and reproduction in amphibians (Hayes 2004). Banned in Europe, atrazine is still commonly used in the US. Illegal backcountry cannabis grows can harm streams. Pesticides in Llagas Creek impacted the isolated Foothill Yellow-legged Frog population (Congdon pers. comm. 2007). Public agencies already invest significant resources detecting and controlling such grows. Pesticide drift from adjacent row crops and orchards and runoff from urban areas poisons invertebrates.	■ Support statewide and national bans on atrazine. ■ Increase education regarding the harmful effects of pesticides. ■ Promote alternatives to pesticides, including integrated pest management. ■ Increase regulation and monitoring for commercial enterprises, and continue to shut down illegal cannabis farms.
Rodenticides Rodenticides reduce populations of Ground Squirrel and thus number of its burrows. These burrows are used by a variety of amphibian and reptile (as well as invertebrate) species as aestivation sites and hibernacula (Stebbins and McGinnis 2012).	■ Increase education regarding the harmful effects of rodenticides. ■ Promote alternatives to rodenticides. ■ Support policies that restrict use of highly destructive chemicals, such as AB 1788, which would ban anticoagulant rodenticides statewide.
Water quality and stream sedimentation Amphibians are highly sensitive to water quality, and thus serve as indicators for water quality and ecosystem health. Increased sedimentation, turbidity, and contamination of waterways can be particularly impactful to amphibian species such as Foothill Yellow-legged Frog. On the other hand, murky water in ponds and vernal pools provides cover for tadpoles and salamander larvae.	■ Plan and budget for dredging sediment-filled ponds about every eight years or as needed. Permitting should be streamlined for dredging that benefits native species. ■ Install vegetated buffers to protect waterways from pollution. ■ Use best management practices in areas prone to erosion, such as exposed soils near construction activities. ■ Educate on the importance of good water quality for species and provide recommendations for what individuals can do to protect water quality (*e.g.* "Flows to the Bay" stencils).

Climate change

Threats	Conservation actions
Drought Increased evaporative demand reduces pond habitat for dependent species such as California Red-legged Frog and California Tiger Salamander. Extreme drought can help eliminate Bullfrog and fish (for example, at Mindego Lake). Groundwater pumping during drought exacerbates issues of pond drying.	■ Build more ponds at a variety of sizes and depths/hydroperiod to buffer climate variation. ■ Manage habitat for hydrological diversity over space and time. ■ Ensure that ponds have drain pipes to allow periodic draining to control non-native amphibians and reptiles that require year-round water.
Irregular and extreme weather Extreme precipitation affects streamflow, which in turn affects breeding success and population stability, which pose challenges for species such as Foothill Yellow-legged Frog.	■ Manage discharges from reservoirs in consideration of effects on wildlife.
Fire Intense, uncontrolled wildfire can kill many wildlife species, including amphibians and reptiles. Ash loading after fires, in combination with subsequent rain events, can asphyxiate amphibians.	■ Use managed fires as a management tool to reduce fuel loads and residual dry matter. Regular controlled burning allows for smaller areas of low-intensity fires, which may be easier for wildlife to escape. ■ Manual removal of vegetation and fuels can also serve to reduce the risk of extreme fire events. ■ Retain some amount of downed trees and debris material post fire for habitat complexity on both land and aquatic habitats.

Habitat connectivity

Threats	Conservation actions
Habitat fragmentation Large contiguous areas of terrestrial habitat are especially important to support metapopulations of reptiles. All parts of the stream valley are needed for aquatic habitat integrity and heterogeneity. Riparian corridors are important migration corridors and provide connectivity between populations; for example, they allow species such as California Red-legged Frog to move between breeding ponds. Viable corridors allow animals to disperse to colonize or recolonize new areas. This adds to the resilience of the populations, and also allows them to adapt to climate change. Dispersal events are sometimes successful in colonizing a new area. Alameda Striped Racer is an example of a species whose viability can depend on habitat connectivity to maintain smaller or isolated populations. Fragmented areas can function as buffers and improve connectivity, but may also be ecological sinks.	■ Continue to acquire and protect large landscape blocks and linkages between them. ■ Land stewardship and management on existing protected lands. ■ Restore riparian corridors, which can be used to connect habitats. ■ Connect existing habitat through removal of barriers and construction or modification of crossing structures. ■ Retain and enhance fragmented habitats that still provide migratory pathways and buffer habitat, but beware of creating ecological traps. ■ Provide cover — woody debris, rock piles, etc. — that can serve as refugia for migrating species.
Road mortality Amphibians (*e.g.*, California Tiger Salamander, newts) and reptiles are prone to roadkill, particularly where roads separate breeding and upland refugia. For example, use of rural roads that traverse extensive areas of undeveloped upland habitat for California Tiger Salamander in eastern Alameda County has increased significantly in the past decade as commuters seek to bypass the gridlock on I-580 from I-680 east into San Joaquin County.	■ Using best management practices, find the right combination of drift fences and crossing infrastructure to reduce vehicle-animal conflict in key areas. ■ Study use of crossing structures, such as tunnels, to better understand how to improve attractiveness. ■ Implement best practices for roadway vegetation design that funnels species, including amphibians, away from roadways. ■ Implement road closures in migration areas at critical times to minimize vehicle mortality (*e.g.*, close South Park Drive in Tilden Park during rain events to protect newts). ■ For more information about best practices, see Laabs 2002, Jackson 1996, and Hamer *et al.* 2015.

Land use and management

Threats	Conservation actions
Grazing Ranches provide ponds for breeding habitat. Grazing is important for a number of Bay Area amphibian species, including California Tiger Salamander and California Red-legged Frog. Grazing practice matters: overgrazing can impact riparian zones and reduce vegetative cover below optimal levels. Lack of grazing leads to overgrowth of annual grasses and other invasives that impede movements and reduce populations of Ground Squirrel and Gopher. Less is known about grazing impacts/appropriate grazing practices for Alameda Striped Racer.	■ If it ain't broke, don't fix it. Be very cautious about removing grazing in areas occupied by target species. ■ Conduct additional research to identify best/most appropriate grazing regimes and biomass for target species. ■ Engage private landowners in implementing grazing management techniques that benefit amphibian species (Ford *et al.* 2013, USFWS 2006). ■ Implement adaptive management in all resource management plans, especially in long-lived plans such as HCPs.
Recreation Greater recreational use of open space and wildlands increases the potential for conflict between humans and species — for example, fishing and swimming in ponds may be detrimental to amphibian species that breed there.	■ Support studies (such as those being conducted by the East Bay Regional Parks District) of the impacts of recreation on wildlife. ■ Maintain separate open spaces for different purposes. Consider designing recreation areas within a matrix of undisturbed or inaccessible habitat. ■ Educate the public about the effects of human activity and provide signage on how to reduce impacts. ■ Restrict use of sensitive habitats during specific windows, such as during breeding periods.
Habitat conversion/ vegetation changes Increased vegetative cover along streams and ponds can reduce water temperatures, which can benefit fish species, but can eliminate needed basking sites for some amphibians. Managing for all species will require stewardship tradeoffs. Western Pond Turtle needs open grasslands for egg deposition. Scrub encroachment that leaves no accessible grassland area reduces this habitat feature (Stebbins and McGinnis 2012).	■ Build habitat mosaics to accommodate the needs of various taxa. ■ Control non-native species and scrub encroachment on grasslands where appropriate. ■ Provide woody debris for refugia. ■ Manage and remove vegetation so that it does not entirely cover ponds (Ford *et al.* 2013).

Pests and disease

Threats	Conservation actions
Invasive wildlife Turkey populations are negatively impacting amphibians through predation, for example at Jasper Ridge Biological Preserve (Launer pers. comm. 2018, Adelsheim pers. comm. 2018). Bullfrog can displace and eat important native species where conditions favor the invasive species, as in artificial deep perennial ponds near rivers, such as remnant aggregate mining pits (Fuller *et al.* 2011). Argentine Ant displacement of native ants has reduced prey availability for Horned Lizard, particularly near urban/suburban areas where Argentine Ant dominates (Stebbins and McGinnis 2012). Wild pigs are omnivores and will root through soils and turn over logs and rocks in search of prey, including amphibians and reptiles.	■ Control non-native species, including Turkey, Crayfish, Bullfrog, Argentine Ant, and wild pig. ■ Implement Bullfrog control in pond networks that span multiple ownerships. ■ Investigate Turkey gut content to learn more about their food sources and level of impact. ■ Manage streamflow regimes that support native wildlife and reduce invasive species like Bullfrog (*e.g.*, Fuller *et al.* 2011).
Disease Chytrid fungus is negatively impacting a number of amphibians (*e.g.*, Yellow-legged Frog), even more so than 20 years ago, possibly due to warming temperatures and increased drought.	■ Implement best practices for controlling the spread of disease, such as researchers washing waders and clothes to prevent cross-site contamination; more are listed in *The Declining Amphibian Task Force Fieldwork Code of Practice* (DAPTF 2019).

Blainville's Horned Lizard is known in the Mount Diablo and Mount Hamilton Range landscape units, and in limited portions of the Santa Cruz Mountains North and South landscape units. Sandy/friable soils are essential habitat features. The loss of native ants to invasive Argentine Ants appears to have reduced horned lizard abundance close to developed areas, but recent observations include McClellan Ranch adjacent to Cupertino.

Blainville's Horned Lizard. Photo cc J. Maughn.

Data Gaps

- Collect basic distribution data, which are still incomplete for many taxa, especially at finer scales.
- Conduct environmental DNA surveys to detect presence of cryptic species.
- Complete metapopulation viability analyses (similar to Alcala *et al.* 2019) for pond-dwellers to inform the sizes and configurations of pond networks.
- Study the effects of disease (*e.g.*, chytrid fungus) and pesticides on local amphibian populations.
- Conduct comprehensive surveys for Foothill Yellow-legged Frog and confirm known occurrence records (Figure 8.2).
- Better understand the effects of Turkey and wild pig on amphibian and reptile populations.
- Study responses to climate change, including opportunities for leading edge arid-adapted taxa to spread.

California Red-legged Frog at Henry Coe State Park. Photo by Rob Leidy.

Figure 8.3 ■ CLN 2.0 Amphibian and Reptile Species Conservation Targets. Species marked with an asterisk (*) were added since CLN 1.0. For a detailed list of all amphibian and reptile conservation targets with information about each species' habitat and management issues, see Appendix C.

Legal Status

BLM S	BLM Sensitive
CA C	California Candidate
CA FP	California Fully Protected
CA SSC	California Species of Special Concern
CE	California Endangered
CT	California Threatened
FC	Federal Candidate
FE	Federal Endangered
FSC	Federal Species of Concern
FT	Federal Threatened
USFS S	US Forest Service Sensitive

Common Name	Scientific Name	Legal Status
Amphibians		
California Tiger Salamander	*Ambystoma californiense*	FE (Santa Rosa Plain), FT (elsewhere), CT
Northwestern Salamander	*Ambystoma gracile*	—
Black Salamander	*Aneides flavipunctatus flavipunctatus*	—
Arboreal Salamander	*Aneides lugubris*	—
Gabilan Mountains Slender Salamander	*Batrachoseps gavilanensis*	—
California Toad	*Anaxyrus boreas halophilus*	—
California Giant Salamander	*Dicamptodon ensatus*	CA SSC
Yellow-eyed Salamander	*Ensatina eschscholtzi xanthoptica*	—
Foothill Yellow-legged Frog	*Rana boylii*	CA SSC, Candidate Threatened
California Red-legged Frog	*Rana draytonii*	FT, CA SSC
Western Spadefoot Toad	*Spea hammondii*	CA SSC
Rough Skinned Newt	*Taricha granulosa*	—
Red-bellied Newt	*Taricha rivularis*	CA SSC
Coast Range Newt	*Taricha torosa torosa*	CA SSC
Santa Cruz Black Salamander *	*Aneides flavipunctatus niger*	CA SSC
Santa Cruz Long-toed Salamander *	*Ambystoma macrodactylum croceum*	FE, CE, CA FP
Reptiles		
Western/Northwestern Pond Turtle	*Actinemys marmorata*	CA SSC, BLM S, USFS S
Northern California Legless Lizard (formerly Silvery Legless Lizard)	*Anniella pulchra*	USFS S, CA SSC
Glossy Snake	*Arizona elegans occidentalis*	CA SSC
California Whiptail	*Aspidoscelis tigris munda*	—
Rubber Boa	*Charina bottae*	—
Northern Pacific Rattlesnake	*Crotalus oreganus oreganus*	—
California Nightsnake	*Hypsiglena ochrorhyncha nuchalata*	—
California Mountain Kingsnake	*Lampropeltis zonata*	CA SSC, USFS S
San Joaquin Coachwhip	*Coluber flagellum ruddocki*	—
Alameda Striped Racer (Alameda Whipsnake)	*Coluber (Masticophis) lateralis euryxanthus*	FT, CT
Blainville's Horned Lizard	*Phrynosoma blainvilli*	CA SSC, BLM S
Gilbert's Skink	*Plestiodon gilberti cancellosus*	—
Long-nosed Snake	*Rhinocheilus lecontei*	—
Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*	BLM S
Western Black-headed Snake	*Tantilla planiceps*	—
Western Terrestrial Garter Snake	*Thamnophis elegans*	—

Common Name	Scientific Name	Legal Status
Giant Garter Snake	*Thamnophis gigas*	FT, CT
Common Garter Snake	*Thamnophis sirtalis*	—
San Francisco Garter Snake	*Thamnophis sirtalis tetrataenia*	FE, CE
Side-blotched Lizard	*Uta stansburiana*	—

CHAPTER 9

Invertebrates

Monarch on narrow-leaved milkweed in Coyote Valley, Santa Clara County. Photo by Steve Rottenborn.

Overview

Insects and arachnids are found throughout upland habitats, feeding on plants and each other, and chomping leaf litter into soil organic matter. In streams and wetlands, complex invertebrate food webs depend upon consumption of algae and aquatic plants. On land and in water, invertebrates support mammals, fish, amphibians, reptiles, and birds up the food chain, filling every ecological niche with what E.O. Wilson called “the little things that run the world” (Wilson 1987).

The invertebrates of the Bay Area are bewilderingly diverse and encompass many poorly-known taxonomic groups. Some are unique to the region. The fog belt around the Golden Gate and along the north Coast has given rise to Mission Blue, San Bruno Elfin, and several endemic silverspot butterflies. Serpentine outcrops support Bay Checkerspot and Muir’s Hairstreak butterflies. The San Francisco Forktail Damselfly persists in a few wetland sites in the fog, and California Freshwater Shrimp swim in slow North Bay waters. The few remnant Sandhills near Santa Cruz support an endemic assemblage of beetles and grasshoppers.

Fairy and Tadpole Shrimp swim and mate in vernal pools during the wet season, and through the dry season their hardened eggs await the return of the rains.

The Endangered Species Act has been a useful tool for conserving several threatened and endangered butterflies in Habitat Conservation Plans and Natural Community Conservation Plans. And while large swaths of land have been protected, the Bay Area is not immune from the recently described "insect apocalypse," where crashes in local abundance and local extinctions diminish insect biodiversity even in nature reserves (Simons 2019). Careful and deliberate stewardship of conservation lands is critical to maintain the often exacting habitat requirements of many invertebrates. Butterflies and uncounted insects have been driven off grasslands by waves of invasive annual grasses that smother insect food plants, juiced up by nitrogen fertilization from ever-present smog clouds. The same grasses unchecked can dry out vernal pools, and now these habitats rely on ranchers and their livestock to keep the grasses down. Rich coastal grasslands convert to scrub and forest in the absence of grazing and fire, posing a huge stewardship challenge.

Of course, many insects also play key ecological roles as pollinators both for native plants and for crops. Climate change disrupts temperature and moisture regimes and thus phenological relationships between plants and pollinators. As with so many other threats posed by climate change, this one can be buffered by protecting habitats that span climatic and topographic variability, so as to allow adaptation and thus minimize the disruption to these critical relationships.

Spotlight on Butterflies

Butterflies generate a disproportionate amount of conservation attention, and for good reason: in addition to being attractive, many of them are well-studied, particularly those that are endemic and/or listed for protection.

The Bay Area supports more than 100 butterfly species, and is a hotspot for threatened and endangered butterflies (Shapiro and Margolis 2007). The first recorded butterfly extinctions in the world were two species that lived only in San Francisco: Sthenele Satyr (~1880) and Xerces blue (1940s). Strohbeen's Parnassian lived in the Santa Cruz Mountains, feeding on western bleeding heart, until the mid-1950s.

Research and monitoring of protected butterflies has led to a greater understanding of their specific needs with respect to temperature and host plant phenology. Long-term datasets have revealed larger ecological trends, increasing understanding, for example, of the impact of nitrogen deposition, or of the transformation and loss of grasslands.

Butterflies are exquisitely sensitive to environmental change, especially climate and invasive species. Stewardship of even small areas can support butterfly diversity and help protect these beautiful ambassadors of the insect world.

Silvery Blue at Coyote Ridge, Santa Clara County. Photo by Steve Rottenborn.

Vernal Pool Tadpole Shrimp and four species of **Fairy Shrimp** are denizens of vernal pools, a fine-filter target with a 90% goal. These species are protected by the Eastern Contra Costa County and Solano County Habitat Conservation Plans. Appropriate grazing management is essential to keep pools from being overrun by annual grass.

Invertebrate Conservation Targets and Network Protection

The goal of CLN 2.0 is to conserve viable populations of the diversity of invertebrates in the Bay Area. Realizing the goal of a protected, contiguous network of natural land within each landscape unit will produce the mosaic of vegetation that supports that diversity.

As with Conservation Lands Network 1.0, the high goals for rare vegetation, such as serpentine variants, captures localized rarities (both known and unknown), while the provision of large diverse vegetation mosaics helps ensure that many populations of common invertebrates remain common. An emphasis on stewardship is particularly important for these taxa.

The focus team also paid close attention to specialized habitats of the rare invertebrates, along with stewardship challenges and opportunities. Specifically, the team:

- Suggested, provided, and reviewed available distribution data on invertebrate species and populations, including ranges and occurrences, to update our understanding of current distributions;
- Selected a list of invertebrates as conservation targets and compiled their respective habitat requirements / descriptions; and
- Recommended management and stewardship actions to ensure target species viability.

Mission Blue Butterfly is restricted to lupine-filled grasslands in the fog belt in the Marin Headlands, San Bruno Mountain, Milagra-Sweeney Ridge, and south into the SFPUC watershed. The vast majority of its habitat is protected, and stewardship is the key to thriving populations. A major threat is scrub succession in lupine-filled grasslands, as well as excessive annual grass growth. Since 1982, the Mission Blue has been covered by the San Bruno Mountain Habitat Conservation Plan, the first in the nation. In the last 10 years, translocations of adults from San Bruno Mountain have reestablished the Mission Blue at Twin Peaks in the middle of San Francisco, and augmented a small population at Milagra Ridge.

Starting in 2015, systematic searches across the Marin Headlands, stimulated by apparent extirpations at permanent monitoring sites, revealed widespread occupancy from Fort Baker to near Rodeo Lagoon, emphasizing the importance of basic inventory work. The agencies, scientists, and organizations involved in Mission Blue conservation and restoration meet for a "Mission Blue Summit" every few years.

Mission Blue nectaring on checkerbloom at San Bruno Mountain. Photo by Stuart Weiss.

The Mount Hermon June Beetle, one of several federally-endangered endemic invertebrates in the Sandhills of Santa Cruz County. Photo by Jodi McGraw.

Key Focus Team Determinations for Invertebrates

- As described in CLN 1.0, the vegetation goals — 50% of the common vegetation types (Rank 3) and more for rare types (Ranks 1 and 2) — meet the habitat needs of the vast majority of invertebrates.
- Explicit targeting of vernal pools covers the Fairy Shrimp and Tadpole Shrimp. The riparian goals of protecting all natural stream valleys, as well as stream buffers in urban and cultivated areas, covers freshwater shrimp and freshwater mussels. Water quality is a high concern for freshwater invertebrates.
- The high goals for serpentine and cool coastal grasslands cover the habitat needs of several listed butterflies.
- Grassland management and stewardship by grazing is particularly important for most of the listed butterflies and undoubtedly for other insects, as is the maintenance of vernal pools.
- Reintroduction and population augmentation has proved to be necessary for some species (*e.g.*, Bay Checkerspot) where habitat fragmentation has disrupted extinction-recolonization (metapopulation) dynamics.
- Climate change is particularly risky for invertebrates because they have high fecundity/high mortality life histories that drive boom and bust population dynamics, and they are very sensitive to temperature and moisture.
- The regional climate gradients and topoclimatic variability inherent in large contiguous conservation lands provide substantial buffers against climate change.
- The coverage of invertebrates in regional and local Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs) is a welcome development because these plans target key habitats and provide long-term stewardship resources.

Invertebrate Data Sources

Dataset	Source	Uses in CLN 2.0 Network Design
Range maps for butterflies by county (polygon)	BAMONA database (Lotts and Naberhaus 2017)	Create species list Mask suitability layers Habitat suitability and life history information
Various species occurrences (polygon converted to point)	California Natural Diversity Database (CDFW)	Create species list Assess coverage by draft network
Various species occurrences (point)	iNaturalist (California Academy of Sciences)	Assess coverage by draft network

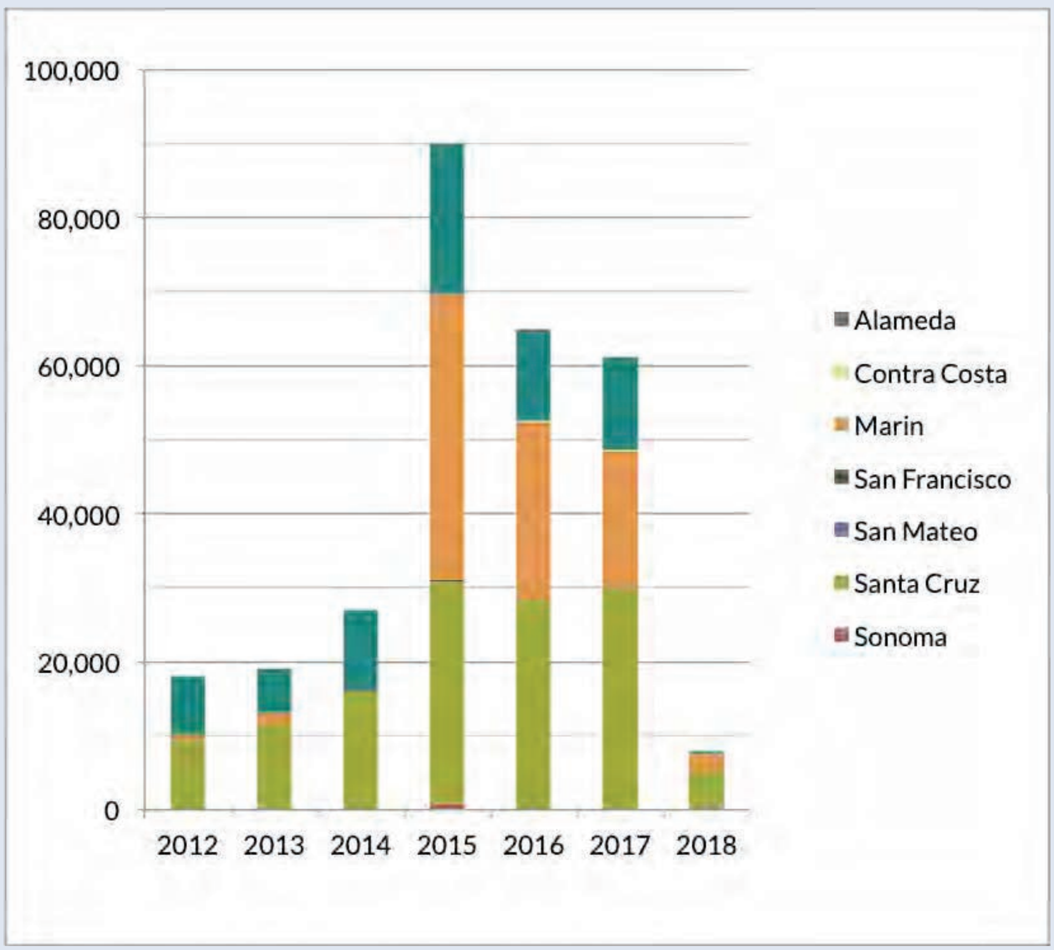
Monarch Butterfly migrates to the Bay Area from the interior west, and overwinters in groves dominated by non-native eucalyptus trees along the Pacific Ocean and the San Francisco Bay, where they seek protection from wind and freezing temperatures. The butterfly's survival depends on deliberate management of a few prime groves of these non-native trees (Pelton *et al.* 2016 2017).

During 2012-2018, Bay Area sites supported between 9% and 32% of the total California population. The complex of sites in Santa Cruz is one of the largest in California, and Alameda and Marin Counties support large aggregations in most years (Figure 9.1). Recent management plans and actions at Lighthouse Field, Ardenwood, Presidio, Albany Hill, and Point Pinole will help maintain the integrity of groves into the future. Monitoring at numerous overwintering sites relies on citizen scientists organized by the Xerces Society (Schultz *et al.* 2018).

California Monarch numbers declined from more than 1,000,000 in 1997 to less than 30,000 in 2018, raising fears of extinction for the western population. Because of a petition filed in 2014 to list the species as threatened, Monarch is in the spotlight, and in 2019 the California Wildlife Conservation Board is distributing more than $3,000,000 for habitat restoration across the state.

Monarchs in eucalyptus at Ardenwood Historic Farm in Fremont. Photo by Stuart Weiss.

Figure 9.1 ■ **Monarch Populations in the Bay Area, 2011-2018.** Source: Xerces Society Thanksgiving Counts.



Designing a Conservation Lands Network for Invertebrates

As with CLN 1.0, the focus team considered a wide range of species, starting with the state and federally listed species but casting a wide net to capture many ecological roles and specialized habitats. The focus team retained the original list of 85 taxa, including insects, arachnids, crustaceans, and mollusks, and added to the list three insect species endemic to Santa Cruz County, and the native freshwater mussel, the California Floater. The CLN 2.0 invertebrate target species are listed in Figure 9.2.

For these 89 taxa, the team used the California Natural Diversity Database (CNDDB), Recovery Plans, and Five-Year Reviews to document known distributions, habitat relationships, and data gaps, and assessed the adequacy of the vegetation, riparian, and other goals to provide sufficient habitat for targets. Importantly, the stewardship requirements of invertebrates were explicitly discussed and highlighted.

Threats to Invertebrates and Recommended Conservation Actions

The focus team identified five key influences on Bay Area invertebrates, specific threats, and recommended conservation actions. The influences, here in alphabetical order, are:

- Chemicals and pollutants
- Climate change
- Habitat connectivity
- Land use and management
- Pests and disease

Chemicals and pollutants

Threats	Conservation actions
Pesticides and herbicides Commercial, agricultural, and residential use of neonicotinoid pesticides threatens pollinators, as well as aquatic invertebrates such as mayflies and caddisflies (Code *et al.* 2016). In the Sacramento area, neonicotinoids have been associated with declines of 67 common butterfly species (Forister *et al.* 2016). Illegal cannabis grows are responsible for many harmful pesticides, and consume many agency resources.	■ Increase education regarding the harmful effects of pesticide use, particularly neonicotinoids. ■ Promote alternatives to pesticides, including integrated pest management. ■ Increase regulation and monitoring for commercial cannabis enterprises.
Pollutants Smog and other vehicular emissions create nitrogen deposition, which serves as fertilizer and thus promotes overgrowth of non-native grasses.	■ Implement broad-scale mitigation for new nitrogen sources, as in the Santa Clara Valley Habitat Plan (Santa Clara Valley Habitat Agency 2012). ■ Funding for long-term management on existing protected lands is particularly important. ■ In large areas (hundreds of acres), control non-native plants with grazing. ■ In small areas (tens of acres), use well-timed mowing to manage non-native plants and promote natives; this has been effective at Edgewood Natural Preserve (Weiss pers. comm. 2019).

Climate change

Threats	Conservation actions
Drought Butterflies are particularly sensitive to changes in temperature and humidity, and thus to climate change.	■ Protect habitat patches with diverse topographies and microclimates; landscape heterogeneity increases the chances of species' persistence over time.
Irregular and extreme weather Extreme weather events affect population stability and breeding	■ Identify and conserve areas with diverse microhabitat options and good local habitat permeability.
Fire Intense, uncontrolled wildfire can be catastrophic for terrestrial and aquatic invertebrates that are unable to escape. Fire can be used as a beneficial management tool to reduce fuel loads and residual dry matter.	■ Consider regular controlled burning in smaller, low-intensity fires, which may be easier for wildlife to escape. ■ Manual removal of vegetation and fuels can reduce the risk of extreme fire events. ■ Retain some amount of downed trees and debris post-fire to provide habitat complexity in both land and aquatic habitats.

Habitat connectivity

Threats	Conservation actions
Habitat fragmentation Connected corridors allow animals to disperse to colonize or recolonize new areas. This adds to the resilience of the populations, particularly in the face of climate change. Dispersal events are sometimes successful in colonizing a new area. Fragmented areas can function as buffers. May be poorer habitat value than core habitat, but they serve as buffers and increase connectivity. Where land is already protected, land stewardship and management place an increasingly vital role. The proportion of protected lands and available open space lands vary throughout the region.	■ Continue to protect and connect large block of diverse habitat. ■ Maintain fragmented open spaces on the top of hills so butterflies can skip from hill to hill; create combination of urbanized and open space habitats. ■ Retain and enhance fragmented habitats that can still provide stepping-stone habitat connectivity for invertebrates.
Road mortality Vehicles can cause hazards for invertebrate species such as butterflies as they move between habitat patches.	■ Implement best practices for roadway vegetation design that funnels species, including invertebrates, away from roads.

San Francisco Forktail Damselfly occurs mostly in still water habitats with emergent vegetation including seeps, ponds and flood control channels. Its historic range stretched from Monterey County to Sonoma County; now, it has one of the most restricted distributions of any North American damselfly or dragonfly. By the late 20th century, the southernmost populations were in Santa Clara County.

Most of its known remaining populations are widely separated and occur in protected areas such as Point Reyes National Seashore and the Presidio of San Francisco. A 2011-2012 survey (Pollak 2016) found only six extant populations, with the southernmost population in wetlands adjacent to San Francisco International Airport.

Threats to its survival include loss of wetlands, climate change, and hybridization with its close relative the **Black-Fronted Forktail Damselfly**. Recently, the San Francisco Zoo and the Presidio Trust began a joint effort to expand the range of the damselfly in the Presidio by releasing immature damselflies into wetland habitats.

San Francisco Forktail Damselfly at Point Reyes. Photo by John Hafernik.

Land use and management

Threats	Conservation actions
Grazing As with reptiles and amphibians, livestock grazing is important for a number of Bay Area invertebrates. For example, grazing can benefit forbs, which are used by butterflies and other insects, by reducing competition from non-native grasses. In the South Bay, grazing has been absolutely critical for the Bay Checkerspot Butterfly, reducing non-native grasses and maintaining forb-rich grasslands despite atmospheric nitrogen deposition. Grazing has also been found to be critical for Callippe Silverspot, whose host plant, *Viola pedunculata*, thrives with grazing. Grazing is important for preventing scrub encroachment of grasslands. This benefits species such as Myrtle's Silverspot and Behren's Silverspot. Unmanaged grazing, overgrazing, or lack of grazing can all have detrimental effects. There is disagreement over the appropriate/ideal amount of residual dry matter, typically used to assess the level of grazing use.	■ Conduct additional research to identify best/most appropriate grazing regimes and biomass for target species. ■ Engage private landowners in implementing grazing management techniques that benefit species. ■ Implement site-specific adaptive management. It is critical that long-term plans such as HCPs incorporate the ability to adapt as new methods and science develop. ■ Plant butterfly host plants in appropriate habitats.
Habitat conversion/ vegetation changes Scrub encroachment into grasslands reduces habitat availability for butterflies (see Grazing, above).	■ Control non-native species and scrub encroachment. ■ Protect and manage for habitat mosaics. ■ Plant butterfly host plants in appropriate habitats.
Population loss within a matrix of metapopulations Loss of part of an insect metapopulation offers opportunity for reintroduction from other populations, as was done with Mission Blue Butterfly on Twin Peaks (Wayne *et al.* 2009) and Chalcedon Checkerspot in the Presidio (Young pers. comm. 2018, Presidio Trust 2017).	■ As populations become extirpated, consider translocation and reintroduction. ■ Use captive rearing techniques to supplement populations, as has been done with Lange's Metalmark (Schultz *et al.* 2008).

The California Floater is one of the five species of freshwater mussels known from California, and the only one present in the Bay Area. Floaters have a complex life cycle with larvae attaching to fish gills. This species is extremely sensitive to flow alterations and water quality, especially sedimentation, and has disappeared from most streams. The International Union for the Conservation of Nature has deemed it "Vulnerable" to extinction.

In recent years, extensive surveys have revealed small populations including some in San Francisquito Creek. The species has been reintroduced to Mountain Lake in the Presidio, along with the native stickleback fish as a host. Many opportunities undoubtedly exist to nurture and expand remnant populations and reintroduce mussels to the area's freshwaters.

California Floater. Photo Jonathan Young.

Pests and disease

Threats	Conservation actions
Invasive wildlife Quagga Mussel is spreading and can completely alter the food webs of lakes and ponds (Wong and Gerstenberger 2011).	Enforce detection and quarantine programs for recreational boaters.
Disease Diseases of domesticated bumblebees can spread to wild populations.	Enhance habitat for native bees to minimize the need for domesticated bees.

Lange's Metalmark is known only from the Antioch Dunes, where its buckwheat hostplants once thrived on open sandy soils. The butterfly, along with the Antioch Dunes evening primrose (FE) and Contra Costa wallflower (FE) led to the establishment of the 55-acre Antioch Dunes National Wildlife Refuge, the first refuge established specifically for an insect.

Unfortunately, Lange's Metalmark is on life support. A captive rearing program collects a limited number of butterflies, rears their eggs, and releases adult butterflies the following year. Since 2017, the captive-reared population has collapsed, and a new program is anticipated at the Ellison Center for Conservation and Wildlife Care (Kurhi 2015). The open sand dunes are disappearing under annual grasses, and active restoration with imported dredged sand is underway.

Lange's Metalmark at Antioch Dunes.
Photo cc USFWS Pacific Southwest Region.

Data Gaps

- Leverage citizen scientists to add to the little that is known about the vast majority of invertebrates. The Xerces Society Thanksgiving Counts, Western Monarch Count, Monarch Mapper, and The Great Sunflower Project are good models.
- Analyze the long-term population and metapopulation dynamics of the listed species to elucidate relationships between weather, climate, and population fluctuations.
- Conduct an inventory of grassland species and places at risk from nitrogen deposition.
- Identify potential sites for translocation of selected species, both common and rare.
- Better understand pollinator relationships with native plants, which may be the key to restoration of rare plant populations.
- Better understand the connections between pesticide use and insect declines, both terrestrial and aquatic.
- Study the distribution and abundance of non-listed local endemics like the Unsilvered Silverspot and Western Meadow Fritillary.
- Learn how to enhance urban areas for insect diversity in the context of projects like Re-Oaking Silicon Valley.

Figure 9.2 ■ **CLN 2.0 Invertebrate Species Conservation Targets.** Species marked with an asterisk (*) were added since CLN 1.0. For a detailed list of all invertebrate conservation targets with information about each species' habitat and management issues, see Appendix C.

Legal Status

BLM S	BLM Sensitive
CA SSC	California Species of Special Concern
CE	California Endangered
FE	Federal Endangered
FT	Federal Threatened
USFS S	US Forest Service Sensitive

Common Name	Scientific Name	Legal Status
Arachnids		
California Tarantula	*Aphonopelma sp.*	—
Incredible Harvestman	*Banksula incredula*	—
Marin Blind Harvestman	*Calicina diminua*	—
Edgewood Blind Harvestman	*Calicina minor*	—
Edgewood Park Microblind Harvestman	*Microcina edgewoodensis*	—
Hom's Microblind Harvestman	*Microcina homi*	—
Jung's Microblind Harvestman	*Microcina jungi*	—
Lee's Microblind Harvestman	*Microcina leei*	—
Lum's Microblind Harvestman	*Microcina lumi*	—
Tiburon Microblind Harvestman	*Microcina tiburona*	—
Ubick's Gnaphosid Spider	*Talanites ubicki*	—
Crustaceans		
Midvalley Fairy Shrimp	*Brachinecta mesovallensis*	—
Longhorn Fairy Shrimp	*Branchinecta longiantenna*	FE
Vernal Pool Fairy Shrimp	*Branchinecta lynchi*	FT
Tomales Isopod	*Caecidotea tomalensis*	—
Isopod	*Calasellus californicus*	—
Vernal Pool Tadpole Shrimp	*Lepidurus packardi*	FE
California Fairy Shrimp	*Linderiella occidentalis*	—
California Freshwater Shrimp	*Syncaris pacifica*	FE, CE
Insects - Butterflies and moths		
Opler's Long-horned Moth	*Adella oplerella*	—
Lange's Metalmark Butterfly	*Apodemia mormo langei*	FE
Mormon Metalmark Butterfly	*Apodemia mormo* subsp.	—
Western Meadow Fritillary	*Boloria epithore epithore*	CA SSC
Johnson's Hairstreak	*Callophrys johnsoni*	—
San Bruno Elfin Butterfly	*Callophrys mossii bayensis*	FE
Marin Elfin Butterfly	*Callophrys mossii marinensis*	—
Muir's Hairstreak	*Callophrys muiri*	—
Green Hairstreak	*Callophrys rubi*	—
Sonoma Arctic Skipper	*Carterocephalus palaemon magnus*	—
California Dog-face Butterfly	*Colias eurydice Boisduval*	—
Monarch Butterfly	*Danaus plexippus*	—
Smith's Blue Butterfly	*Euphilotes enoptes smithii*	FE
Bay Checkerspot Butterfly	*Euphydryas editha bayensis*	FT
Edith's and other Checkerspots	*Euphydryas editha luesterae* and other subspecies	—
Mission Blue Butterfly	*Icaricia icarioides missionensis*	FE
Point Reyes Blue Butterfly	*Icaricia icarioides parapheres*	F SC

Common Name	Scientific Name	Legal Status
Great Arctic	*Oeneis nevadensis*	—
Indra Swallowtail	*Papilio indra*	—
Myrtle's Silverspot Butterfly	*Speteria zerene myrtleae*	FE
Unsilvered Silverspot Butterfly	*Speyeria adiaste adiaste*	CA SSC
Behren's Silverspot Butterfly	*Speyeria zerene behrensii*	FE
Callippe Silverspot Butterfly	*Speyeria callippe callippe*	FE
Other insects		
Ant species	*Formicidae* spp.	—
Vernal Pool Andrenid Bee	*Andrena blennospermatis*	—
Antioch Dunes Anthicid Beetle	*Anthicus antiochensis*	FSC
Sacramento Anthicid Beetle	*Anthicus sacramento*	FSC
Sacramento Valley Tiger Beetle	*Cicindela hirticollis abrupta*	—
Sandy Beach Tiger Beetle	*Cicindela hirticollis gravida*	FC
Ohlone Tiger Beetle *	*Cicindela ohlone*	FE
Globose Dune Beetle	*Coelus globosus*	FC
San Joaquin Dune Beetle	*Coelus gracilis*	FC
Valley Elderberry Longhorn Beetle	*Desmocerus californicus dimorphus*	FT
Giuliani's Dubiraphian Riffle Beetle	*Dubiraphia giulianii*	FSC
Stage's Dufourine Bee	*Dufourea stagei*	—
Hairy Water Flea	*Dumontia oregonensis*	FSC
Antioch Efferian Robberfly	*Efferia antiochi*	FSC
Delta Green Ground Beetle	*Elaphrus viridis*	FT
Redheaded Sphecid Wasp	*Eucerceris ruficeps*	—
Ricksecker's Water Scavenger Beetle	*Hydrochara rickseckeri*	—
Leech's Skyline Diving Beetle	*Hydroporus leechi*	FSC
Curved-foot Hygrotus Diving Beetle	*Hygrotus curvipes*	FSC
Middlekauff's Shield-back Katydid	*Idiostatus middlekauffi*	FSC
San Francisco Forktail Damselfly	*Ischnura gemina*	—
Bumblebee Scarab Beetle	*Lichnanthe ursina*	—
Molestan Blister Beetle	*Lytta molesta*	FSC
Hurd's Metapogon Robberfly	*Metapogon hurdi*	FSC
Antioch Multilid Wasp	*Myrmosula pacifica*	FSC
San Francisco Lacewing	*Nothochrysa californica*	FSC
Antioch Andrenid Bee	*Perdita scitula antiochensis*	FSC
Antioch Sphecid Wasp	*Philanthus nasalis*	FSC
Mount Hermon June Beetle *	*Polyphylla barbata*	FE
Wilbur Springs Shorebug	*Saldula usingeri*	—
Antioch Dunes Halcitid Bee	*Sphecodogastra antiochensis*	—
Black Petaltail	*Tanypteryx hageni*	—

Common Name	Scientific Name	Legal Status
San Francisco Bay Area Leaf-cutter Bee	*Trachusa gummifera*	—
Metallic Wood-boring Beetle	*Trachykele hartmani*	—
Serpentine Cypress Wood-boring Beetle	*Trachykele hartmani*	—
Zayante Band-winged Grasshopper *	*Trimerotropis infantilis*	FE
Serpentine Cypress Long-horned Beetle	*Vandykea tuberculata*	—
European Honeybees	Honeybees threatened by colony collapse disorder	—
Western Bumble Bee	*Bombus occidentalis*	—
Ground beetles	*Carabidae family*	—
Mayflies and Caddisflies	*Ephemeroptera and Trichoptera orders*	—
Mollusks		
California Floater *	*Anodonta californiensis*	
Peninsula Coast Range Shoulderband Snail	*Helminthoglypta nickliniana awania*	FSC
Bridges' Coast Range Shoulderband Snail	*Helminthoglypta nickliniana bridgesi*	FSC
Mimic Tryonia (California Brackish Water Snail)	*Tryonia imitator*	FSC
Robust Walker	*Pomatiopsis binneyi*	—
Marin Hesperian	*Vespericola marinensis*	BLM S, USFS S

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