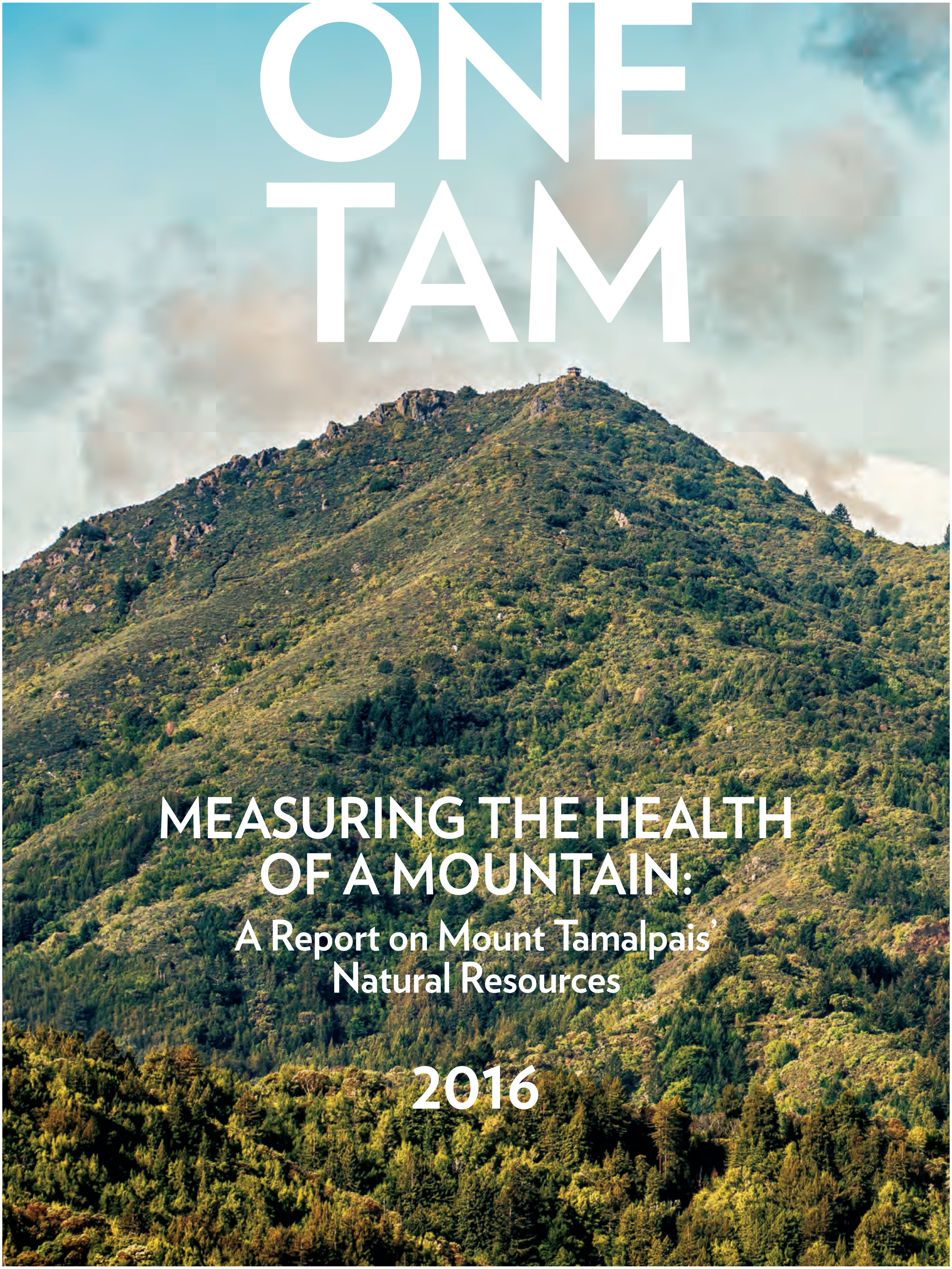
ONE TAM

MEASURING THE HEALTH OF A MOUNTAIN:

A Report on Mount Tamalpais' Natural Resources

2016



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EXECUTIVE SUMMARY

Mt. Tam's land managers have the responsibility of caring for one of the most ecologically rich and beloved places in the San Francisco Bay Area. Part of the Pacific Migratory Flyway and the California Floristic Province—a global biodiversity hotspot—the mountain is a vital refuge for many threatened, endangered, and special status species, and is an important link in a much larger network of interconnected open spaces, including the 195,000 acres of protected open space in Marin County that a myriad of other plants and wildlife depend upon.

The mountain's natural resources provide numerous ecological, economic, and social benefits to its human visitors and neighbors. However, the clean drinking water from its lakes and reservoirs, carbon sequestration provided by its grasslands, and natural beauty and solace of its forests all depend on the mountain's overall health and the well-being of the constituent species that make up each of its interconnected ecosystems.

This report represents the results of an unprecedented collaboration among Mt. Tam's land managers, the Golden Gate National Parks Conservancy, and the scientific community to use the most current data and best expert judgement to understand and evaluate the mountain's health. It provides an important benchmark by which managers can measure future change across jurisdictional boundaries. It also reveals many areas where not enough is known to draw meaningful conclusions, and represents new opportunities for future research and collaboration.

WHAT HAVE WE LEARNED ABOUT MT. TAM'S HEALTH?

There are many ways to evaluate the health of a mountain, from the condition and trend of an individual species or entire communities, to its biodiversity or climate resilience. Based on a suite of metrics developed for measuring the heath of key ecological indicators, the condition of Mt. Tam's natural resources is overall cautionary, but fairly stable. Fortunately, some of those indicators that are declining are at a point where their trajectory can still be improved.

VEGETATION

While some of Mt. Tam's plant communities are thriving, most are suffering the effects of ecological stressors such as climate change, invasive species, plant disease, and changed fire regimes.

Ecologically important and iconic communities such as maritime chaparral, grasslands, and open-canopy oak woodlands are declining, while shrublands, old-growth redwood forests, and Sargent cypress forests are in good condition and are stable or improving. However, second-growth redwood forests, which make up the majority of the redwood forests on Mt. Tam, are in cautionary condition. Based on the data available, serpentine barren plant communities—home to many rare and endemic species—may be in decline.

WILDLIFE

Most of Mt. Tam's wildlife species and communities appear to be doing well. The health of bird communities overall is good, including species that we have long-term data about, such as Osprey and Northern Spotted Owls. Preliminary results of the Marin Wildlife Picture Index Project indicate that the mountain is supporting healthy levels of mammal diversity, although more data are needed. North American river otters and California red-legged frogs have both made a remarkable comeback in recent years. Yet, populations of coho salmon, steelhead trout, and foothill yellow-legged frogs on Mt. Tam are dangerously small and of great concern.

DATA GAPS

The condition of many other important indicators of Mt. Tam's ecological health, including invertebrates, bats, lichens, hardwood forests, riparian areas, and seeps and springs, remains largely unknown. However, now that they have been identified through this process, many of these gaps in our understanding can be improved in the near future, providing important data for the next iteration of this health assessment. For example, the implementation of a mountain-wide, systematic vegetation community mapping and monitoring program would help managers understand the current state of key plant communities and detect changes over time. Closing data gaps for broad health indicators like invertebrates and certain plant communities will allow for a much better understanding of the mountain's overall health. Additionally, specific information gaps that have been revealed about the indicators included in this report can now be strategically addressed.

LANDSCAPE-SCALE MEASURES OF HEALTH

Considering the mountain's health by combining—or "rolling up"—the individual health indicators described above allows us to begin to explore how well ecological systems and landscape-level processes are functioning across the mountain as a whole. This approach provides another tool for land managers and scientists to track the mountain's health. Based on this approach, grassland, open-canopy oak woodland, and redwood forest ecological communities are in cautionary condition, while only shrublands are in good condition.

WHERE DO WE GO FROM HERE?

Science is an inherently iterative and cumulative process, and this health evaluation will grow and improve along with our understanding of the state of the mountain's natural resources.

Ongoing and future monitoring and research will reveal new insights and provide opportunities for improving the condition of key resources. Restoration and stewardship efforts can help bolster communities and species that are currently flagging. Meanwhile, factors such as climate change and ecological succession that are beyond the control of Mt. Tam's managers may change the landscape in ways we cannot yet fully predict.

This assessment is a critical first step in understanding how important aspects of the health of the mountain are faring, and articulating gaps in our current knowledge. With this new information in hand, land management agencies can determine how to further prioritize and incorporate these findings within the scope of ongoing resource work. They can use it to help measure the results of their efforts, and identify what actions can or might shift trends and the condition of health indicators. With the support and partnership of scientists, stakeholder groups, and individual community members, Mt. Tam's land management agencies can use this report to continue to meet their missions as stewards of this remarkable mountain.

GLOSSARY OF TERMS

Condition: The current state of the indicator based on the aggregation of its metrics

- **Good:** The condition goal is 75–100% met
- **Caution:** The condition goal is 26–74% met
- **Significant Concern:** The condition goal is 0–25% met
- **Unknown:** Not enough information is available to determine condition

Condition Goal: The desired, measurable state for each metric against which monitoring data are compared

Confidence: The amount of certainty with which the condition and trend are assessed

- **High:** Measurements are based on recent, reliable, suitably comprehensive monitoring
- **Moderate:** Monitoring data lacks some aspect of being recent, reliable, or comprehensive; however, measurements are also based on recent expert or scientist observation
- **Low:** Monitoring is not sufficiently recent, reliable, or comprehensive; but either some supporting data exists or measurements are also based on expert or scientific opinion

Desired Conditions: The qualitative goal for the overall indicator; the threshold or state it should be in to be considered healthy; often identified as a recovery target for rare/listed species

Indicator: The species, community, or physical process (e.g., stream flow/water quantity) that provides an essential ecological function, or are indicative of essential habitat conditions, and are measured as an indication of health; indicators are akin to human vital signs such as blood pressure and pulse: easily measured and strongly correlated with overall condition, sensitive to stressors, and an early warning of potential problems

Metric: How an aspect of an indicator is assessed or measured

Overall Condition: The combined current state of the indicator based on the totality of its metrics

Stressors: Things that challenge the integrity of ecosystems and the quality of the environment, which may be natural environmental factors, or may result from the activities of humans; some stressors exert a relatively local influence, while others are regional or global in their scope

Trend: The change in condition as determined by comparing current versus previous measures; the trend is independent of current condition (e.g., a resource may be “Declining” but still be in “Good” condition)

- **Improving:** The condition is getting better
- **No Change:** The condition is unchanging
- **Declining:** The condition is deteriorating/getting worse
- **Unknown:** Not enough information is available to state a trend

CHAPTER 1. INTRODUCTION

Mt. Tamalpais (Mt. Tam)—beautiful and rich with plant and animal life—is one of the region's greatest natural treasures. Located in one of 35 internationally recognized biodiversity hotspots, the California Floristic Province (Critical Ecosystem Partnership Fund [CEPF], 2016), the mountain's complex terrain and its location between the sea and inland San Francisco Bay Area create a remarkably diverse array of microclimates and habitats.

Despite its ecological riches and its protected status, Mt. Tam is threatened by a number of stressors including invasive species, forest pathogens, altered wildfire regimes, and climate change. The agencies that steward the land, and the community that loves it, all have a role to play in helping keep the mountain healthy and vibrant. To do so most effectively, we must first try to answer important questions such as: What is the state of our collective knowledge about how plant and wildlife communities and species are doing? Do we have a baseline against which we can see and measure change? And, wherein lie the gaps in our understanding of these resources and the physical and ecological drivers affecting them?

In the spring of 2016, the four largest land management agencies on Mt. Tam—the Marin Municipal Water District (MMWD), National Park Service (NPS), California State Parks (State Parks), and Marin County Parks (MCP)—joined together with the Golden Gate National Parks Conservancy (Parks Conservancy) and experts from around the San Francisco Bay Area to share their knowledge and set out to answer the question: How healthy is Mt. Tam?

This report is a summary of that process and its findings, which are an integration of agency data and the scientific community's perspective. It also summarizes related inventory and monitoring efforts, surveys, and research spanning multiple jurisdictional boundaries. The following chapters provide summaries of the current state of this combined knowledge, documenting the methods for how assessments were made, as well as an assessment of data gaps and potential next steps to improve the state of our collective understanding.

This report also lays the foundation for the condensed summary, *Is Mt. Tam in Peak Health?* and an interactive web tool available at *onetam.org/peak-health*. This website will also provide updated information about ongoing or new monitoring efforts, and help make the case for community support for the mountain's most pressing needs.

MT. TAM'S LAND STEWARDS

Mt. Tam has a long and multifaceted history of land ownership and management (Gibson, 2012; Spitz, 2012). It has also been a major focal point for community activism and stewardship over the last hundred years.

In 2014, the four agencies that protect the majority of the open spaces on Mt. Tam came together in partnership with the Parks Conservancy to form the Tamalpais Lands Collaborative (TLC). The TLC brings together the resources and expertise of these partners to support conservation projects and programs, to enhance education and stewardship opportunities, and to care for the mountain in a more holistic manner. One of the many goals of the ecological health assessment effort summarized in this report was to calibrate the list of proposed TLC projects and programs to ensure that they are improving the long-term health of Mt. Tam's natural resources.

The community engagement initiative of the TLC, **One Tam**, represents the agencies, partners, and community members working together to care for the mountain as a whole. See *onetam.org* for more information about the TLC, One Tam, and their ongoing work on the mountain.

This report includes natural resources within the 36,000 acres of publically managed open space that lie within the overall 46,414 acres that make up the **One Tam "area of focus"** (Figure 1.1). The area of focus encompasses the entirety of the Marin Municipal Water District's lands, Mount Tamalpais State Park, and Golden Gate National Recreation Area sites including Muir Woods, Muir Beach, Dias Ridge, Stinson Beach, and some of the northern lands managed by Point Reyes National Seashore. Marin County Parks' Open Space Preserves in the area of focus include the southern half of White Hill and all of Cascade Canyon, Baltimore Canyon, Blithedale Summit, Camino Alto, Alto Bowl, Bald Hill, Horse Hill, King Mountain, and Bothin Marsh. Other organizations such as Slide Ranch, Audubon Canyon Ranch, and the San Francisco Zen Center are also included in the One Tam area of focus, as are a small number of residential and developed areas.

The One Tam area of focus also lies at the heart of a nearly contiguous, expansive network of protected lands comprising about 147,000 acres, or 44%, of Marin County. These include lands managed by the National Park Service, California State Parks, Marin County, individual cities, homeowner groups, agricultural interest groups, and non-profit entities (Figure 1.2).

FIGURE 1.1 ONE TAM AREA OF FOCUS MAP

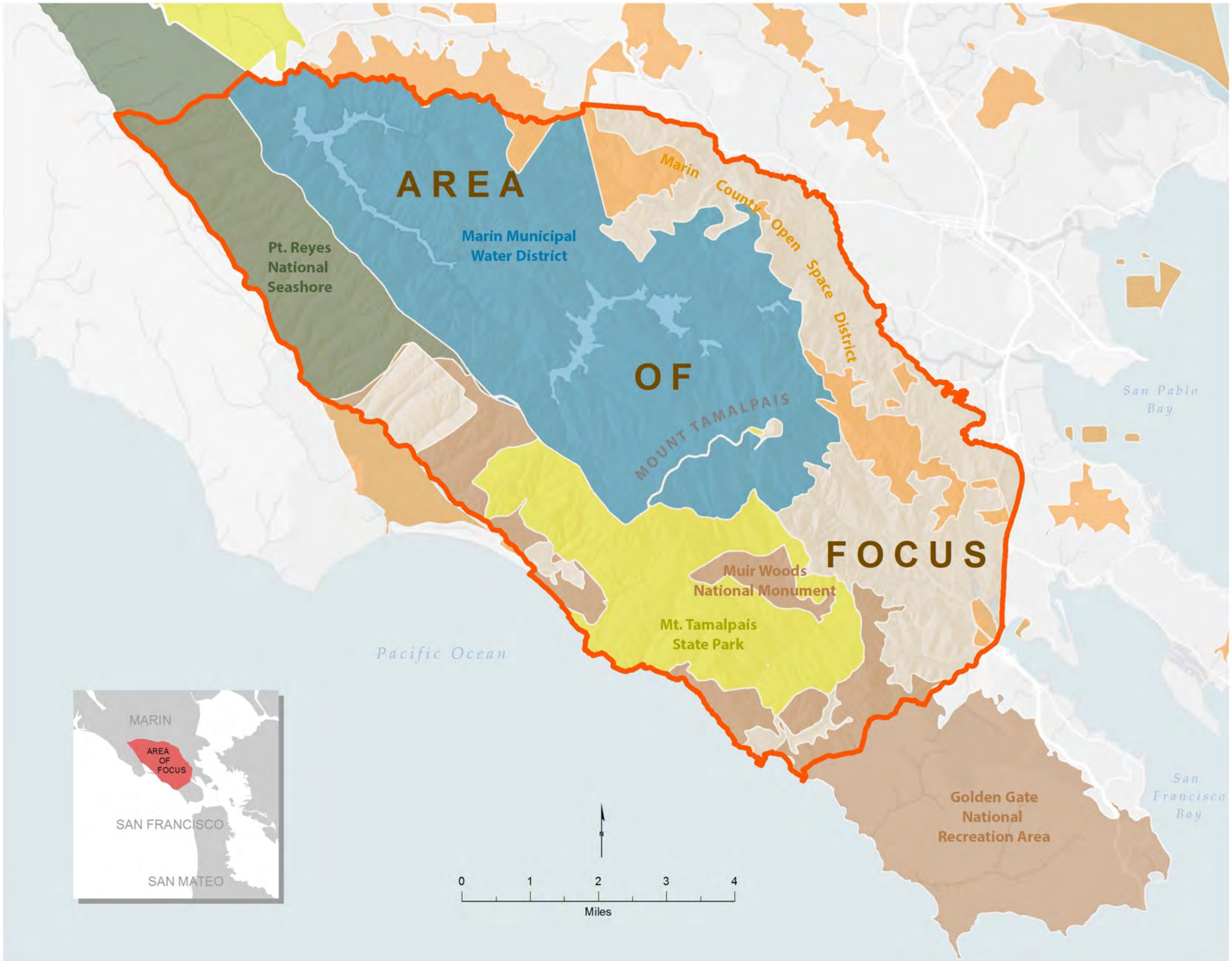


FIGURE 1.2 MAP OF ONE TAM AREA OF FOCUS WITHIN THE REGIONAL NETWORK OF OPEN SPACES AND AGRICULTURAL AREAS

MT. TAM'S ECOLOGICAL SETTING

GEOLOGY

The mountain and the surrounding region have a complex and convoluted geologic history. Most of Mt. Tam's underlying geologic substrates predate the formation of the San Andreas Fault. Some of the base geologic substrates include Franciscan chert formed by metamorphosed sedimentary rocks made from the silica shells of marine plankton, serpentine soils derived from ultramafic (igneous) rocks that were metamorphosed under high pressure, and sedimentary sandstones, among many others (Blake et al., 2000).

These varied geological substrates produce an even higher diversity of soil types due to the influences of topographic complexity, climatic history, past vegetation, ecosystem processes, past and ongoing erosion, and other significant geologic events that have taken place over very long periods of time. The resulting variety and patchy distribution of soil types is critical to explaining Mt. Tam's extraordinary levels of biodiversity (see Biodiversity section below). Spatial heterogeneity of soil types can translate to vegetation type diversity, structural heterogeneity, and increased species turnover between patches of vegetation (Davies et al., 2005; Pickett & Cadenasso, 1995; Tuomisto et al., 1995).

The spatial organization of serpentine soils on Mt. Tam illustrates these points well. Soils formed by serpentine rock are characterized by elevated heavy metal concentrations and relatively low plant-available macronutrients. While the chemical composition of these soils can vary widely within and between patches, they typically have a low calcium to magnesium ratio, which results in limited exchange of soil nutrients to plants (*reviewed in* Barbour et al., 2007). Thus, the resulting soils have decreased productivity and can appear inhospitable for plant growth. Interestingly, some native plant species have evolved to tolerate these unique soils and many of Mt. Tam's rare species are restricted to serpentine areas. The juxtaposition of low productivity serpentine soils in a matrix of non-serpentine soils results in habitat heterogeneity that contributes to the biocomplexity of this landscape (see Figure 2.2 Vegetation Communities and Hydrology of the One Tam Area of Focus).

BIODIVERSITY

The San Francisco Bay Area is part of a nationally and internationally recognized biodiversity hotspot (Critical Ecosystem Partnership Fund [CEPF], 2015) and part of the UNESCO Golden Gate Biosphere Reserve (2016). These designations are in large part because of the region's Mediterranean climate, topographic complexity, and coastal influence, which together foster high levels of biodiversity.

Located on San Francisco's doorstep, Mt. Tam is a critical link in a larger network of open spaces (Figure 1.2), and a refuge for many species that are now are limited in distribution and range due to increased development and other stressors (see the Ecological Stressors section below). The mountain is also home to several endemic plant species, including the Mt. Tamalpais thistle (*Cirsium hydrophilum* var. *vaseyi*) and Mt. Tamalpais manzanita (*Arctostaphylos montana* ssp. *montana*). In addition to its remarkable ecological values, Mt. Tam's biodiversity provides a number of essential ecosystem services including high-quality drinking water, erosion control, and clean air, and offers diverse natural landscapes for recreation and tourism (Leonard Charles Associates [LCA], 2009).

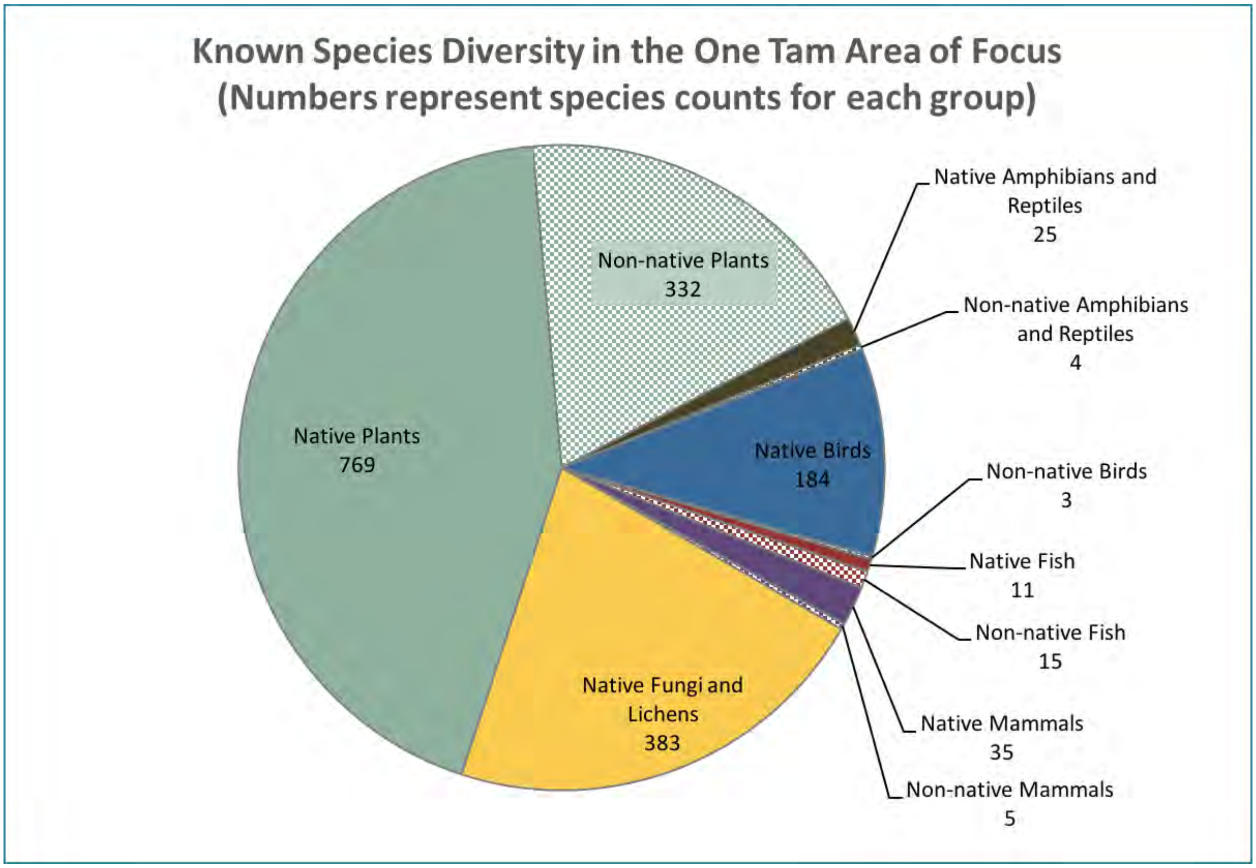
Mt. Tam's varied topography, and its location near the coast in an important marine upwelling and convergence zone, create a confounding array of microclimates in a relatively small geographic region. The One Tam area of focus extends from sea level to over 2,500 feet in elevation, and then back down to the San Francisco Bay. Seasonal differences in climate are affected by these changes in elevation and topography. There are also dramatic differences between coastal and interior (bay-facing) aspects of the mountain.

A wide range of soils—including harshly metallic serpentine, a product of California's state rock, serpentinite—create unique niches for different plant communities and the wildlife that depends upon them (see Geology section above). The over 36,000 acres of open space on Mt. Tam host 10 times the number of native plants per acre as Yosemite, which is almost 20 times as large. Furthermore, Marin County is located along the Pacific Flyway, which is a major migration corridor for birds, and represents the range limit for some species like the Northern Spotted Owl.

Current species lists (Appendices 5–11) represent information compiled by One Tam partner agencies, and will likely be updated in the future through further review of additional technical reports, inventories, and the validation of other data sources. These lists were compiled using a combination of existing lists provided by each land management agency for the One Tam area of focus. These data were the result of inventory and monitoring work by agency staff, as well as inventories conducted by third parties, such as the Christmas Bird Count, agency bioblitzes, and surveys by the California Native Plant Society, and as such, were all verified sightings. Species that had not been reported since 1970 were not included. Certain taxonomic categories are currently missing or under-represented, and coverage does not always extend to the whole area of focus. This is primarily due to a lack of inventories for certain taxonomic groups and the limitations of only accepting expertly verified sightings.

Based on these current data, Mt. Tam's native species diversity includes over 250 animals, over 50 of which are officially listed as threatened, endangered, sensitive, or rare (see Figure 1.3 and species lists Appendices 8–11). Mt. Tam is also home to over 1,000 total known plant species, several of which are only found on the mountain and over 40 are listed as threatened, endangered, or rare (see Figure 1.3 and plant lists in Appendices 5 and 6). About 30% of the total plant species on Mt. Tam are non-native (see Non-native Species section below). There are also 68 native plant and 7 animal species that are believed to have been extirpated from the mountain (see Appendix 7 and Chapter 11).

FIGURE 1.3 KNOWN SPECIES DIVERSITY IN THE ONE TAM AREA OF FOCUS



ECOLOGICAL STRESSORS

While Mt. Tam's plants and wildlife live in protected open spaces, the health of the mountain's natural resources are threatened by global climate change, altered fire regimes, invasive, non-native plants and animals, habitat fragmentation, plant diseases, noise, light, and air pollution, and other human impacts. These ecological stressors can directly result in the loss and degradation of habitats and negatively affect the size, range, and reproductive capacity of plants and wildlife. Interactions among these stressors (e.g., between climate change and fire frequency, or between fire and plant diseases) further compound their effects and make managing them much more challenging. A summary of some key stressors affecting Mt. Tam is below.

CLIMATE CHANGE

Mt. Tam has the potential to serve as a refuge for plant and animal species in the face of climate change and associated changes in temperature, precipitation, fog, and soil moisture. Although climate change models show a range of potential future scenarios for Marin County and the San Francisco Bay Area, some common trends are emerging.

Temperature: Average temperatures rose significantly from 1950–2000 across the entire western United States, including the San Francisco Bay Area, and both winter and summer temperatures are predicted to continue rising under future climate change scenarios (Ackerly et al., 2012).

Temperature projections from all greenhouse gas emissions scenarios show an increase in annual average temperatures of 2.7°F (1.5°C) between 2000–2050, and 3.6–10.8°F (2–6°C) by the end of the 21st century (Ackerly et al., 2012).

Precipitation: Future precipitation patterns for Mt. Tam are more uncertain than temperature predictions, with increased variability and projections ranging anywhere from 25% more to 25% less rainfall (Micheli et al., 2016). In addition to changes in the overall amount of precipitation, more frequent extreme rainfall events may increase ecological disturbance and affect the condition of Mt. Tam's streams and wetlands.

Fog: Fog is an important source of moisture on the mountain, particularly during the spring and summer. A 2010 study found that the amount of fog in redwood areas along California's coast has fallen 33% over the past 100 years (Johnstone & Dawson, 2010). Fog-dependent plant communities on Mt. Tam such as coast redwood forests and maritime chaparral may become drought-stressed under conditions of less fog and higher temperatures.

Soil Moisture: Marin County is becoming more arid due to rising temperatures. Even under higher future rainfall scenarios, higher temperatures will increase evapotranspiration and reduce soil moisture. This difference between potential and actual evapotranspiration—known as climatic water deficit—is a good indicator of drought stress. Climatic water deficit is projected to increase on Mt. Tam under all future climate scenarios (Micheli et al., 2016).

Plant and Animal Community Change: Changes in temperature, precipitation, fog, and soil moisture may make future conditions inhospitable for certain plant species or even entire plant communities. In the long term, climate change will alter the basic physical conditions under which native plant communities on Mt. Tam evolved, forcing a gradual shift in their composition and distribution. This shift will likely be accelerated by short-term (episodic) disturbances such as fires and floods, which will become more frequent in a changing climate. The sensitivity of vegetation to climate change is heterogeneous and somewhat difficult to predict, but models for Marin County suggest an expansion of climate conditions suitable for more drought-tolerant species and communities, such as coastal sage scrub and chamise chaparral, as climatic water deficit increases (Ackerly et al., 2012; Micheli et al., 2016).

The effects of climate change on animals are similarly varied and challenging to predict, and few studies have been done on how climate change will affect wildlife in the San Francisco Bay Area (Ackerly et al., 2012). However, changes in vegetation communities will undoubtedly affect the wildlife that depend upon them, and these effects may then also ripple up and down trophic levels. Wildlife that require cool, wet conditions may be at greatest risk. Warmer temperatures may change migration patterns, and rising sea levels will likely affect coastal, bay, and lower floodplain areas in the One Tam area of focus. Changing ocean conditions may also impact species such as endangered coho salmon (*Oncorhynchus kisutch*) and threatened steelhead trout (*O. mykiss*) that spend part of their lives in Mt. Tam's streams and part at sea. Any known or predicted effects of climate change that are of concern for different plant and wildlife species or communities are described in each respective chapter of this report.

FIRE

Mt. Tam has not seen a large, stand-replacing fire for over 70 years due to fire suppression policies and practices. While fire suppression is important for protecting local air quality and nearby property, plant communities on Mt. Tam are naturally dynamic and largely mediated by fire cycles (LCA, 2009).

The removal of fire is resulting, in part, in the succession of grasslands to shrublands, shrublands to woodlands, and woodlands to Douglas-fir (*Pseudotsuga menziesii*) dominated stands. Fire suppression also has implications for the regeneration of fire-dependent species, such as Sargent cypress (*Cupressus sargentii*) and Marin manzanita (*Arctostaphylos virgata)*. There are many questions about how the seed banks of these and other fire-dependent species will respond to future fires—or the lack thereof—on Mt. Tam. More detail on the effect the lack of fire is having on these communities may be found in their respective chapters of this report.

In addition to these direct impacts, changed fire regimes and fire suppression are interacting with other ecological stressors on Mt. Tam in a variety of ways. Increases in fuel loads caused by forests impacted by Sudden Oak Death may increase the intensity of any fires that occur. Large fires burn hotly, and can kill large numbers of trees over a wide area. This both releases nutrients into the soil and increases the amount of light reaching the ground, which can be exploited by non-native, invasive plant species (LCA, 2009).

Climate change is expected to increase fire frequencies on the order of 20% for Mt. Tam under projected climate scenarios (Micheli et al., 2016), but underlying factors can combine in ways that make specific effects difficult to predict. In general, drier and warmer conditions are more favorable to wildfires.

Statewide fire management policies continue to require suppression of all unplanned wildland fires. In Marin County, the number of wildland fires—from both accidental and deliberate ignitions—has trended upward over the last several decades, but the total area burned per decade has declined (California Department of Forestry and Fire Protection [CDFFP], 2015). This is largely due to more effective fire suppression efforts. So, while models predict more intense fires, suppression policy will continue to maintain the fire regime in an altered state. This will likely lead to infrequent, but large and intense, wildland fires driven by extreme fire weather that will burn many acres despite efforts to control them.

NON-NATIVE, INVASIVE SPECIES

A plant or animal that has been introduced—either intentionally or not—to a new region of the globe is non-native, but not necessarily invasive. Invasive species display particular characteristics like fast growth, abundant offspring, and rapid maturation that, when combined with a lack of the natural predators and diseases that help control them in their native environment, allow them to rapidly grow and spread, frequently displacing native species.

Non-native, invasive species in Marin County come in myriad forms, including water molds, plants, invertebrates, fish, amphibians, birds, and mammals. The major threats posed by invasive species include changes in fire frequency or intensity, groundwater depletion, changes to soil chemistry, competition with native species, and a loss of native species diversity (LCA, 2009).

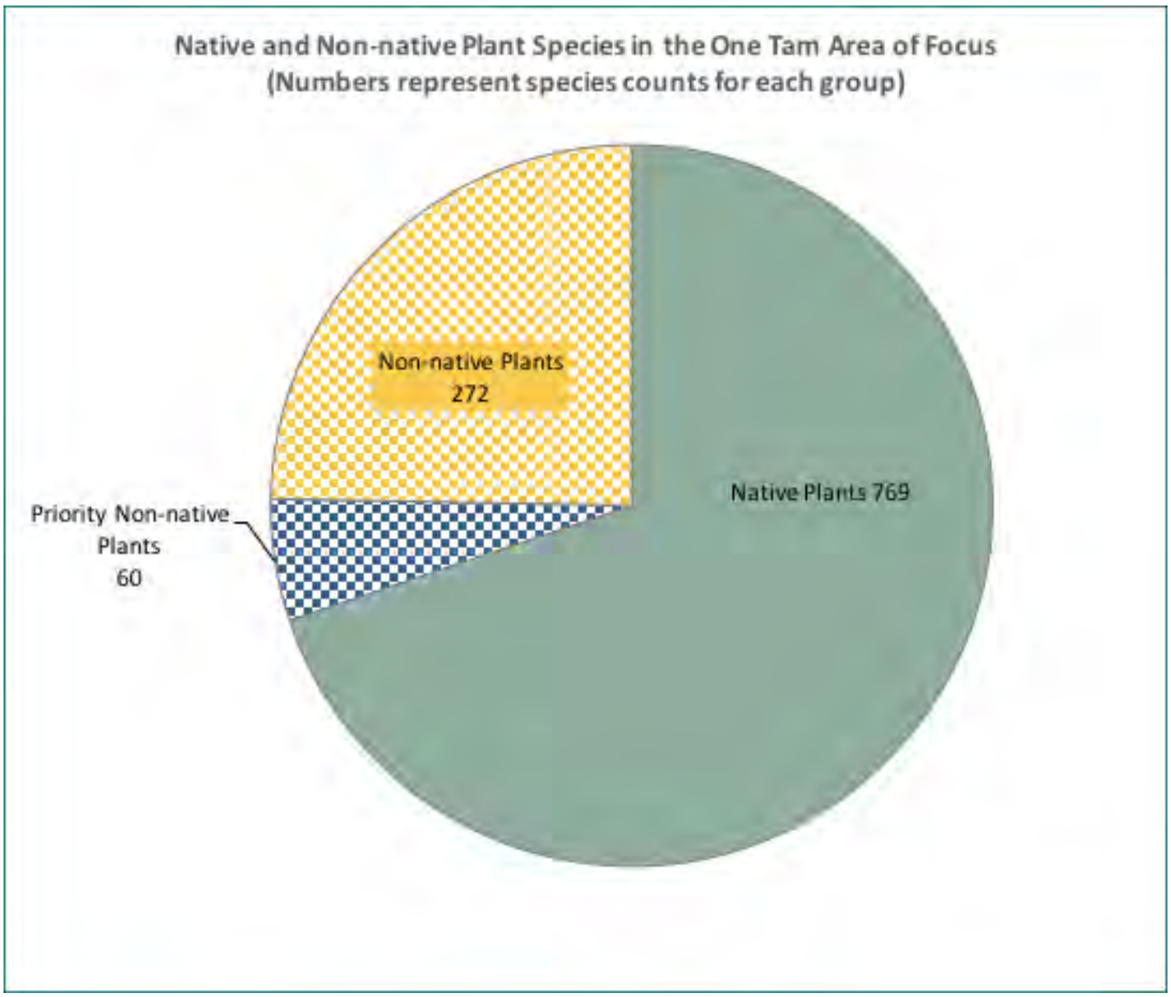
NON-NATIVE, INVASIVE PLANTS

While all natural areas on Mt. Tam face some degree of threat from invasive plant species, some are more resistant to invasion than others due to varying soil types, moisture levels, and canopy density. Furthermore, small patchy habitats have more gaps for invasive species to take hold, as well as have more peripheral areas that may be exposed to invasion. Larger, more intact habitat patches and more remote parts of the mountain, on the other hand, may have fewer vectors for invasive species dispersion such as roads, trails, or human development corridors.

The higher winter temperatures, longer and warmer growing seasons, and more frequent drought or storms predicted under future climate change scenarios may impact native ecosystems that are adapted to existing conditions by reducing resiliency and increasing the risk of spreading invasive plants (Frey et al., 2015).

Currently, about 30% of the known plant species on Mt. Tam are non-native (Figure 1.4). Out of those, around 60 are priority species targeted for early detection, mapping, and control by the One Tam Conservation Management Team (Tables 1.1A and 1.1B).

FIGURE 1.4 KNOWN NUMBERS OF NATIVE AND NON-NATIVE PLANT SPECIES IN THE ONE TAM AREA OF FOCUS



Highest priority species are not currently widespread in Marin County or on Mt. Tam but have demonstrated a capacity to do harm to ecosystems in other regions or adjacent counties. Suitable habitat for these species is found on Mt. Tam, thus finding and managing incipient populations in the early stages is critical. In 2016, the One Tam Conservation Management Team was able to treat all instances of these highest priority species found during early detection surveys.

Other locally detected species are often widespread in the county and/or on Mt. Tam. These are the species that the mountain's land management agencies manage heavily in their existing vegetation programs using staff and volunteer support. These species may become high priorities for removal when found in small amounts far from source populations.

Not every species in Tables 1.1A and B is managed by each agency to the same degree, and there are invasive plant species not on this list that are managed by partner agencies outside of the One Tam partnership.

TABLES 1.1A AND B PRIORITY TARGETED NON-NATIVE, INVASIVE PLANT SPECIES IN THE ONE TAM AREA OF FOCUS

Highest Priority Invasive Plant Species	
Aegilops triuncialis	Barbed goatgrass
Ailanthus altissima	Tree of heaven
Albizia lophantha	Plume acacia
Arctotheca calendula	Cape weed
Bromus tectorum	Cheatgrass
Buddleja davidii	Butterfly bush
Carex pendula	Hanging sedge
Centaurea calcitrapa	Purple star thistle
Clematis vitalba	Old man's beard
Cytisus striatus	Portuguese broom
Dittrichia graveolens	Stinkwort
Elymus caput-medusae	Medusa head
Hypericum grandifolium	Canary Island St. John's wort
Iris pseudacorus	Horticultural iris
Maytenus boaria	Mayten
Sesbania punicea	Rattlebox
Solanum aviculare	New Zealand nightshade
Stipa manicata	Andean tussockgrass
Stipa miliacea	Smilo grass
Ulex europaeus	Common gorse

Other Locally Detected Invasive Plant Species			
Acacia melanoxylon	Blackwood acacia	*Foeniculum vulgare*	Sweet fennel
Ageratina adenophora	Thoroughwort	*Genista monspessulana*	French broom
Arctotheca prostrata	Prostrate cape weed	*Hedera canariensis*	Algerian ivy
Brachypodium distachyon	False brome	*Hedera helix*	English ivy
Calendula arvensis	Field marigold	*Helichrysum petiolare*	Licorice plant
Centaurea solstitialis	Yellow star thistle	*Hypericum perforatum*	Common St. John's wort
Cortaderia jubata	Pampas grass	*Ilex aquifolium*	Holly
Cortaderia selloana	Uruguayan pampas	*Lathyrus latifolius*	Everlasting pea
Cotoneaster franchetii	Francheti cotoneaster	*Leucanthemum vulgare*	Oxeye daisy
Cotoneaster lacteus	Milkflower cotoneaster	*Ligustrum lucidum*	Glossy privet
Cotoneaster pannosus	Silverleaf cotoneaster	*Pennisetum clandestinum*	Kikuyu grass
Crataegus monogyna	Hawthorn	*Phalaris aquatica*	Harding grass
Cytisus scoparius	Scotch broom	*Pittosporum crassifolium*	Stiffleaf cheesewood
Delairea odorata	Cape ivy	*Pyracantha angustifolia*	Narrowleaf firethorn
Digitalis purpurea	Foxglove	*Romulea rosea var. australis*	Rosy sand crocus
Dipsacus fullonum	Fullers' teasel	*Rubus armeniacus*	Himalayan blackberry
Ehrharta erecta	Panic veldtgrass	*Rytidosperma caespitosum*	Tufted wallaby grass
Eucalyptus globulus	Blue gum	*Rytidosperma penicillatum*	Purple wallaby grass
Euphorbia oblongata	Eggleaf spurge	*Spartium junceum*	Spanish broom
Festuca arundinacea	Reed fescue	*Tradescantia fluminensis*	Small leaf spiderwort

NON-NATIVE PLANT PATHOGENS

Sudden Oak Death (SOD), caused by the introduced pathogen *Phytophthora ramorum*, was first documented in the United States on MMWD and State Parks lands in Marin County in 1995 (Garbelotto & Rizzo, 2005). The pathogen has killed tens of thousands of trees on Mt. Tam in the years since. Vegetation mapping done in 2004, 2009, and 2014 (Aerial Information Systems [AIS], 2015) has tracked the rapid spread of the disease across MMWD lands. The 2014 update found that 84% of forested vegetation types were impacted by SOD, although the degree of impact varies by the species composition of the forest and by woodland canopy characteristics (AIS, 2015).

The SOD mortality rate exceeds 80% for tanoak (*Notholithocarpus densiflorus*), which has resulted in the transformation of thousands of acres where this species was once dominant in the canopy. Mortality rates are lower but still significant among coast live oaks (*Quercus agrifolia)* and California black oak (*Q. kelloggii*). Dozens of other native tree and shrub species also experience damage and/or lower levels of mortality. White oaks including valley oaks (*Q. lobata*) and Oregon oak (*Q. garryana*) are not impacted (Animal and Plant Health Inspection Service [APHIS], 2013).

In addition to causing dramatic changes in habitat structure, dying and dead trees are increasing fuel loads. The effects of the loss of oak trees on species dependent on them for food and shelter (e.g., dusky-footed woodrat, Acorn Woodpecker) are not yet known (Nik et al., 2016).

Several other disease-causing forest pathogens have either been observed on the mountain or have a high likelihood of invading in the near future. In particular, *Phytophthora cinnamomi* is deadly to Pacific madrone (*Arbutus menziesii*) and some species of manzanita. This pathogen is known to occur in Marin County, including several locations on Mt. Tam (T. Swiecki, personal communication). Although *P. cinnamomi* spreads more slowly than *P. ramorum*, it has a much broader range of host species and the potential to kill a wider variety of species (Sims et al., 2016).

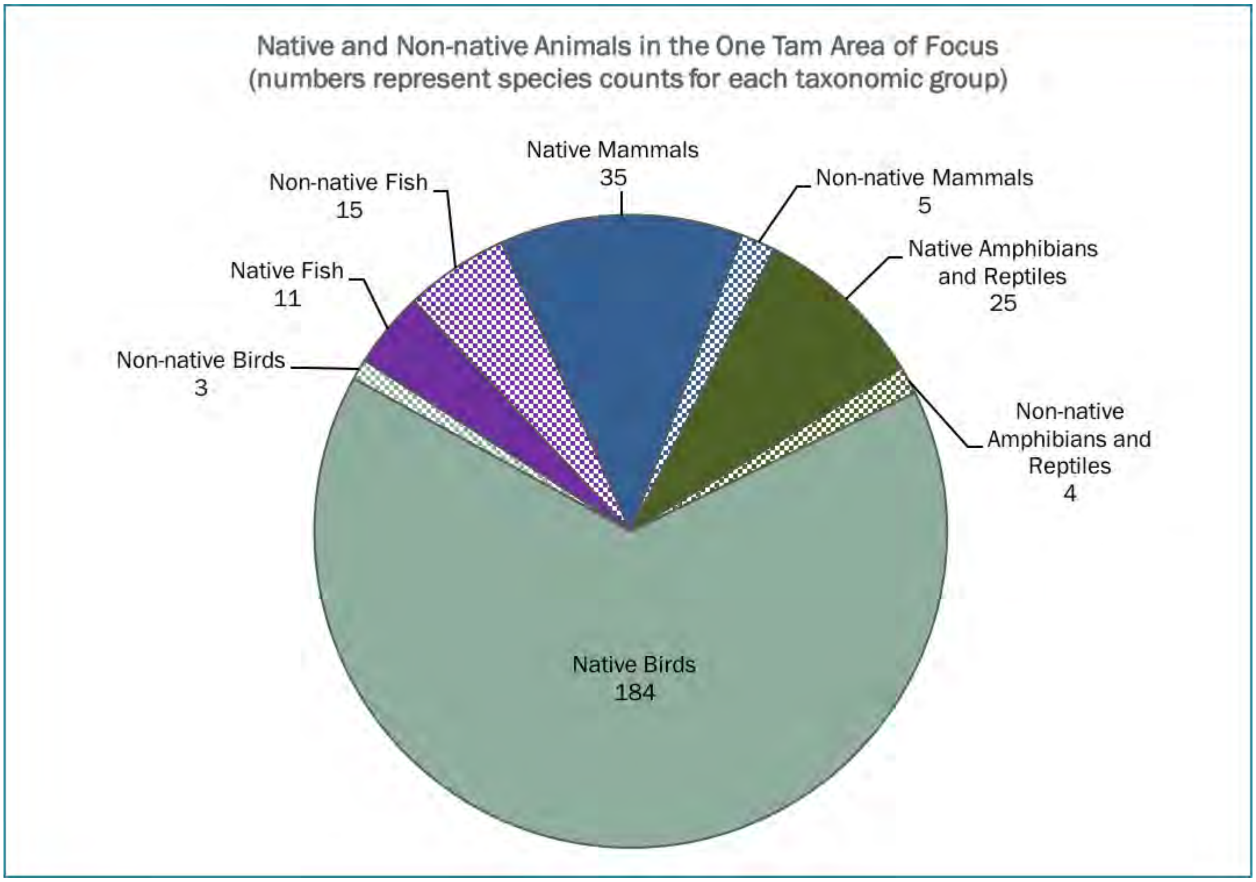
These other pathogens have many of the same ecosystem effects as SOD, including changes in species composition and ecosystem functions, loss of wildlife food sources, changes in fire frequency or intensity, decreased water quality due to increased erosion, and increased opportunities for weed invasion in newly open areas (LCA, 2009).

NON-NATIVE, INVASIVE ANIMALS

Non-native, invasive animals compete with native species for food, shelter, and nest or den sites. Some of them also prey directly on native species (see list below). There are over 20 known non-native animal species on Mt. Tam (Figure 1.5). Species of particular concern include:

- American bullfrogs (*Lithobates catesbeianus*) compete with and prey upon other amphibian species including federally threatened California red-legged frogs (*Rana draytonii*) as well as foothill yellow-legged frogs (*Rana boylii*), which are a federal and state species of concern.
- Signal crayfish (*Pacifastacus leniusculus*) prey upon juvenile foothill yellow-legged frogs.
- Red-eared sliders (*Trachemys scripta elegans*) and other non-native turtles compete with and prey upon native aquatic wildlife.
- Domestic and feral cats (*Felis catus*) prey on native birds, rodents, and reptiles.
- Wild turkeys (*Meleagris gallopavo*) eat seeds, invertebrates, small vertebrates, and other food needed by native species, and their foraging damages native vegetation and causes soil disturbance and erosion.

FIGURE 1.5 NUMBERS OF NATIVE AND NON-NATIVE ANIMAL SPECIES IN THE ONE TAM AREA OF FOCUS



RECREATIONAL USE

Protecting and improving ecological resources, managing visitors, and involving the public in stewardship and community science are the cornerstones of the work undertaken by Mt. Tam's land managers. Each agency develops strategies through science-based planning efforts (e.g., roads, trails, biodiversity management plans, etc.) to facilitate recreational opportunities that are compatible with their distinct missions and their stewardship responsibilities to protect Marin's biodiversity and ecological resources.

It is well recognized that public parks and open space preserves are the primary places that most people access nature, and contact with nature has a range of human health benefits (Frumkin, 2001). Mt. Tam's network of trails provides important access for visitors to explore the natural, cultural, and recreational resources on the mountain. Recent visitor survey work by Marin County Parks (2015) and Marin Municipal Water District (Alta Planning & Design, 2014), showed hiking, walking, and cycling as the primary reason for visiting local parks and open space, immediately followed by access to nature and views.

Recreational use of Mt. Tam's open spaces, however, can also affect the mountain's ecological health. Recreation is the second leading cause of endangerment to species on federal lands (Losos et. al., 1995). For example, recreational activity can correlate with decreases in species abundances and activity levels (Garber & Burger, 1995), cause wildlife to flee or avoid otherwise suitable habitat (Taylor & Knight, 2003), or alter species composition and behavior (Ikuta & Blumstein, 2003). Studies have documented recreational activities altering the use of protected areas by carnivores (George & Crooks, 2006; Reed & Merenlender, 2011), and also dogs affecting the abundance and behavior of mammal communities near trails (Lenth et al., 2008).

Impacts from recreational activities can also be attributed to poorly designed and sited trails (Marion & Leung, 2001). Well loved, and well used for many decades, Mt. Tam's trail system was largely inherited by land managers as historic ranch, hunting, and military access roads, railroad right of ways, as well as informal trails developed by visitors. Many of these routes were not developed with the goals of sustainable alignment, resource protection, or visitor experience, and decades of deferred maintenance have resulted in negative impacts to both the trails and adjacent resources.

While significant improvements have been made to reduce erosion, develop sustainable routes, and improve circulation networks, the creation of new unsanctioned trails has increased over the past century on Mt. Tam (Marin County Parks, 2012). Increased recreational use has resulted in additional environmental impacts including wildlife habitat fragmentation, soil compaction and loss, vegetation trampling, loss, and composition changes, and the introduction and spread of non-native plants. Non-designated trails serving as vectors for non-native, invasive species spread is of high concern (van Winkle, 2014) given the potential of these species to convert already stressed vegetation communities to favor ruderal and other weedy species.

Collaboration under the One Tam initiative provides agency managers of respective road and trail networks with the unique opportunity to share information about visitor use patterns and natural resources that may help inform management decisions.

HEALTH ASSESSMENT PROCESS AND METHODS

DEFINING THE HEALTH OF MT. TAM

Even though each of the four primary land management agencies on Mt. Tam have different missions, policies, and regulations, they are all tasked with preserving biodiversity, maintaining and maximizing natural processes, and keeping a diverse array of vegetation communities healthy on the mountain in the face of environmental change. For the purposes of this assessment effort, the health of the mountain was defined as:

- Mt. Tam's ecosystems are resilient (able to function/recover despite disturbances, changes, or shocks).
- The full complement of plants, animals, and other life forms are present, can reproduce, and are able to find food, shelter, and water as long as climate conditions allow them to persist on Mt. Tam.
- Natural processes occur in a manner and frequency considered "normal" either based on historic evidence or the ability to maintain ecological functions and adapt under changing climate conditions.

METHODS

Determining how to measure the health of the mountain's resources as defined above required a collaborative, iterative, and multidisciplinary approach. The process was led by the Health of Mt. Tam's Natural Resources Advisory Committee, which consisted of a team of natural resources staff and ecologists from the One Tam partner agencies, Golden Gate National Parks Conservancy, and Point Blue Conservation Science (see Appendix 3 for a list of members).

SETTING THE STAGE

Advisory Committee members contacted a number of other groups and individuals around the country who had conducted similar ecological health assessment efforts, including the National Park Service, Chicago Wilderness Society, Conservation Lands Network, San Francisco Estuary Partnership, and the San Francisco Bay Area Wetlands Ecosystems Goals Project. Representatives from these efforts were asked about their project goals, how they structured their process, how they determined their project scope and scale, how and why they selected their health metrics, how they defined and quantified ecological health, and how their work had been received by various audiences.

Their guidance was invaluable and helped shape this health assessment process and the resulting communication tools. In particular, they emphasized setting up a structured and well-organized framework for engaging subject matter experts; choosing indicators that were ecologically meaningful and measurable; basing the initial report on existing data; and creating scientifically based, clear, and engaging public communications tools that distill a great amount of complexity and nuance in a way that accurately represents the status of the chosen ecosystem health indicators.

The Advisory Committee followed a methodology similar to that used by NPS for its Natural Resource Condition Assessments (NRCAs). Like NRCAs, this report relied on existing information to assess trends and conditions, confidence levels, stressors/threats, and critical information gaps. The depth and breadth of the resulting assessments reflect the varying levels of currently available data and expert opinion on each indicator. The process allowed for four distinct land management agencies to collect and synthesize existing information, and set baselines against which to measure and track the health of Mt. Tam. This report summarizes potential future research, monitoring, or management actions that could help support each ecological health indicator. While One Tam agency partners may use the findings in this report to help inform their management decisions, it is not a management document. More information about the NRCA process can be found at *nature.nps.gov/water/nrca/index.cfm*.

Not every biological community type, plant, or animal species on Mt. Tam was included in this health assessment process. Good indicators are measurable, have low amounts of data "noise," and reveal things about other aspects of ecosystem health. The Advisory Committee initially constructed a comprehensive list of taxonomic groups and plant and animal communities on the mountain that could be considered as health indicators (see Appendix 1 Table of All Health Indicators Considered). One or more important factors from the following list drove the selection of indicators that were ultimately put forth for consideration:

- It is present in the One Tam area of focus (Figure 1.1).
- There is existing information available and/or expert opinion to draw upon to try to determine its condition or trends.

- It is useful for measuring the health of the mountain in some meaningful way (e.g., an indicator of biological integrity and biodiversity, natural disturbance regimes, or habitat quality).

- It is a threatened, endangered, or rare species that, if lost, would have an impact on the mountain's health by the above definitions.

- It is especially iconic or charismatic, can be used to build public affinity and interest, and/or can be used to help gauge the health of the mountain by the above definitions.

ENGAGING THE BROADER SCIENTIFIC COMMUNITY

A thorough assessment of existing information, data, and reports was done for the preliminary indicators that were selected by the Advisory Committee. This information was then distilled into summary worksheets that included, to the extent possible, a preliminary assessment of the condition and trend of that indicator; the confidence level in these assessments; a rationale for choosing the species or community; a description of the resource and its significance to the health of Mt. Tam; current and desired conditions; proposed goals and metrics by which to measure condition and trend; key ecological stressors; existing information sources (e.g., research data, monitoring, restoration projects, etc.); known information gaps; and future planned and desired management actions (see Appendix 2 Sample Indicator Summary Worksheet).

Twenty-two summary worksheets were used as the basis for a day-long workshop on February 5, 2016, which was attended by approximately 40 natural resource staff scientists from all One Tam partner organizations and some staff from Point Blue Conservation Science, the National Park Service Inventory and Monitoring Program, and Point Reyes National Seashore. Participants were broken into facilitated, taxonomically based groups to review the existing information, discuss the current state of agency knowledge and data sources, identify information gaps, and provide feedback on the list of proposed indicators, metrics, and condition and trends assessments.

All of their feedback was then reviewed by the Advisory Committee and used to revise the summary worksheets. Several workshop participants also recommended the development of a species trait-status database to help aggregate and organize data across taxonomic groups. This database may be seen at *docs.google.com/spreadsheets/d/1LzdDeDBdiodylxThUBKkZEMbuBfJ9FcjZS-dyct7eus/edit?usp=sharing*.

Two additional scientist workshops were held in February and March 2016. The February workshop focused solely on potential bird species and guilds as indicators of health, ecological stressors, and landscape-scale processes. The two-day workshop in March brought together 60 local and agency scientists to consider the remaining (non-bird) indicators. Attendees were tasked with reviewing and making recommendations on metrics, goals, condition, and trend statements represented in the worksheet summaries; discussing existing data; sharing their expert opinions (see the list of workshop attendees in Appendix 3); and identifying missing information.

Workshop participants relied upon a wide array of background materials including agency reports and data sets, published papers, and gray literature. However, where data were scarce or nonexistent, they were asked to use their best professional judgment to try to make a statement about goals, conditions, and trends for the proposed indicators. They also identified data gaps and areas of uncertainty, and what further research or monitoring would be needed to fill those gaps.

As a result of these discussions and the feedback gathered at the workshops, a subset of the initially proposed indicators was selected. These indicators were deemed good representatives of the health of Mt. Tam, and they had sufficient information or opinion consensus to set metrics and assess condition and trends. These are the indicators included in this report. Indicators not included here were most often left out because of a lack of existing information necessary to make these kinds of assessments.

LOOKING AHEAD

Assessing the health of Mt. Tam is an iterative process, which should be revisited every three to five years as land managers gain more information, undertake resource-based projects, and as the state of their understanding changes and grows over time.

In addition to this technical report, several other complementary products have been developed to share this information with a variety of audiences:

- A brochure, *Is Mt. Tam in Peak Health?* summarizes the condition and trend of a limited number of select indicators, describes important ecological stressors, and shares how people can help support the health of Mt. Tam.

- An interactive web tool (*onetam.org/peak-health*) provides information on many more indicators than the above summary document, and includes multiple levels of supporting data and additional detail.

- A two-day Mt. Tam Science Summit on October 28–29, 2016 to share these findings with the public, land managers, and scientists. Agendas, presentations, and other background materials will be posted online at *onetam.org*.

HEALTH INDICATOR CHAPTERS OVERVIEW AND SECTION DESCRIPTIONS

The information presented in this report is not a comprehensive analysis of Mt. Tam's resources, but rather a methodical assessment of existing information and expert opinion about select resources that were chosen by scientists as good indicators of these defining criteria. It is also grounded in the realities of land management, and is centered on the agencies' overarching environmental goals and the resources they are currently or likely to monitor, measure, and report on over time.

The chapters for each indicator (with the exception of birds, which is only slightly modified due to methodological differences) are laid out in the following format.

INTRODUCTION SECTION

Condition, Trend, and Confidence:

The specific ways condition, trend, and confidence were assessed can be found within each chapter. However, the overall organization and approach is as follows:

- An overall condition of "Good," "Caution," or "Significant Concern" was assigned to each indicator based on an average of the condition of all the combined individual metrics. The condition as defined here reflects how a given resource is doing just within the limited geography of the One Tam area of focus and therefore, may be different from official federal or state designations of threatened, endangered, or special concern that span a broader geography.

- An overall trend of “Improving,” “No Change,” or “Declining” was similarly assigned based on an average of trend statements of all the combined individual metrics. Each trend assessment was based on what was determined to be a reasonable time scale upon which to measure change depending on the species or community in question.

- A confidence level of “High,” “Moderate,” or “Low” was assigned based on how much data currently exists.

Why Is This Resource Included?:

- A summary of the resource’s significance and why it was chosen as an indicator of the health of Mt. Tam

Overall Condition:

- Historical and currently known condition, extent, and/or population size for this indicator

Desired Condition:

- The qualities land managers and other experts consider necessary for a particular indicator to maintain its ecological function(s) and the threshold or state it should be in to be considered healthy.

  Note: Some of the vegetation community chapters list a certain number of acres as a condition goal. While acreage is a useful measure of habitat patch size and overall extent, it is not always possible to maintain a set number of acres of a particular plant community type given factors like climate change and ecological succession, which are beyond the scope of current land management efforts. In some cases, maintaining a diversity of habitats and/or ecological functions is a more realistic goal.

Stressors:

- Summaries of how various ecological and/or human-induced stressors are affecting the resource

CONDITION AND TRENDS ASSESSMENT SECTION

A high-level summary of the metrics used to measure the health of each overall indicator, including a baseline, condition goals, thresholds for moving from one condition status to another, current status, confidence level, and trend.

Condition: The current condition of the indicator based on the aggregation of its metrics

- **Good:** The condition goal is 75–100% met
- **Caution:** The condition goal is 26–74% met
- **Significant Concern:** The condition goal is 0–25% met
- **Unknown:** Not enough information is available to determine condition

<u>Trend</u>: The change in condition of the indicator based on current versus previous measure(s); independent of status (e.g., a resource may be "Declining" but still be in "Good" condition)

- **Improving:** The condition is getting better
- **No Change:** The condition is unchanging
- **Declining:** The condition is deteriorating/getting worse
- **Unknown:** Not enough information to state trend

<u>Confidence</u>: The amount of certainty with which the condition and trend are assessed

- **High**: Measurements based on recent, reliable, suitably comprehensive monitoring
- **Moderate:** Monitoring data lacks some aspect of being recent, reliable, or comprehensive; however, measurement is also based on recent expert or scientist observation
- **Low:** Monitoring is not sufficiently recent, reliable, or comprehensive; but either some supporting data exists or measurement is also based on expert or scientific opinion

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT SECTION

A more detailed description for indicator-specific monitoring, inventory, or research programs, Geographic Information Systems analyses, or other sources that served as the supporting data for condition and trends assessments.

Data Gaps:

- Identifying data gaps that need to be filled was an important aspect of this effort. If a data gap that would support a proposed metric was likely to be addressed in the near term, that metric was included and filled out to the best of the Advisory Committee's ability. Updates to this report will then allow them to track progress.

Past and Current Management, Restoration, Monitoring, and Research Efforts:

- A summary of stewardship and management activities of varying scales that have been underway for decades within the One Tam area of focus. This is by no means a comprehensive list, but is intended to provide a sense of the type and scale of work that has been undertaken to monitor, protect, and restore the health indicators included in this document.

Future Actionable Items:

- A preliminary summary of actionable needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

  Actions may include:

- Inventory and monitoring to track priority indicator metrics, increase our understanding, and improve our ability to monitor the health of Mt. Tam's biological resources
- Existing program support
- Research to address critical questions and help inform resource management

SOURCES SECTION

A list of references cited, important supporting materials, authors, and agency staff and other subject matter experts who participated in the workshops and/or provided a technical review of the chapter.

SOURCES

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CHAPTER 2. VEGETATION INDICATORS FOR THE HEALTH OF MT. TAM

The mountain's plant communities, and their arrangement on the landscape (see Figure 2.2), are the foundations of ecosystem health. Rare plants—important aspects of biodiversity in their own right—also play a role in indicating the health of particular ecosystems. Both vegetation communities and individual rare plant populations may show the effects of stressors such as alteration of natural disturbance regimes (e.g., grazing, fire), climate change, and invasion by non-native species.

Mt. Tam hosts a rich array of native plants (Figure 2.1 and Table 2.1 below; Appendix 5 Plant Species of Mt. Tam) However, not every plant community type or rare plant species is included in this health assessment process. Good indicators are easily measured, have low data "noise," and often reveal some other aspect of ecosystem health. With this in mind, certain plant species and community types were chosen as a suite of indicators for this project.

FIGURE 2.1 PERCENTAGE OF VEGETATION TYPES IN THE ONE TAM AREA OF FOCUS

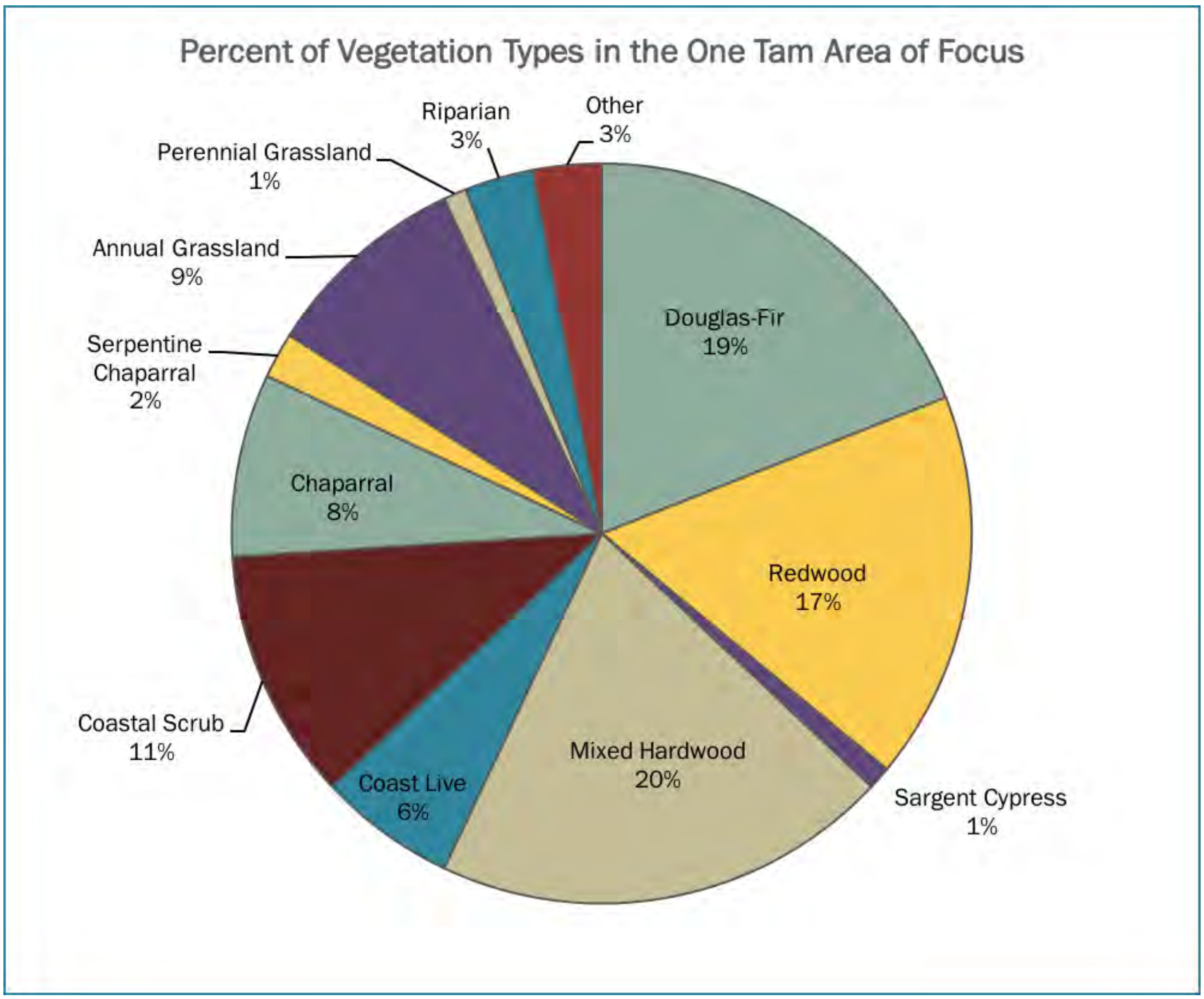


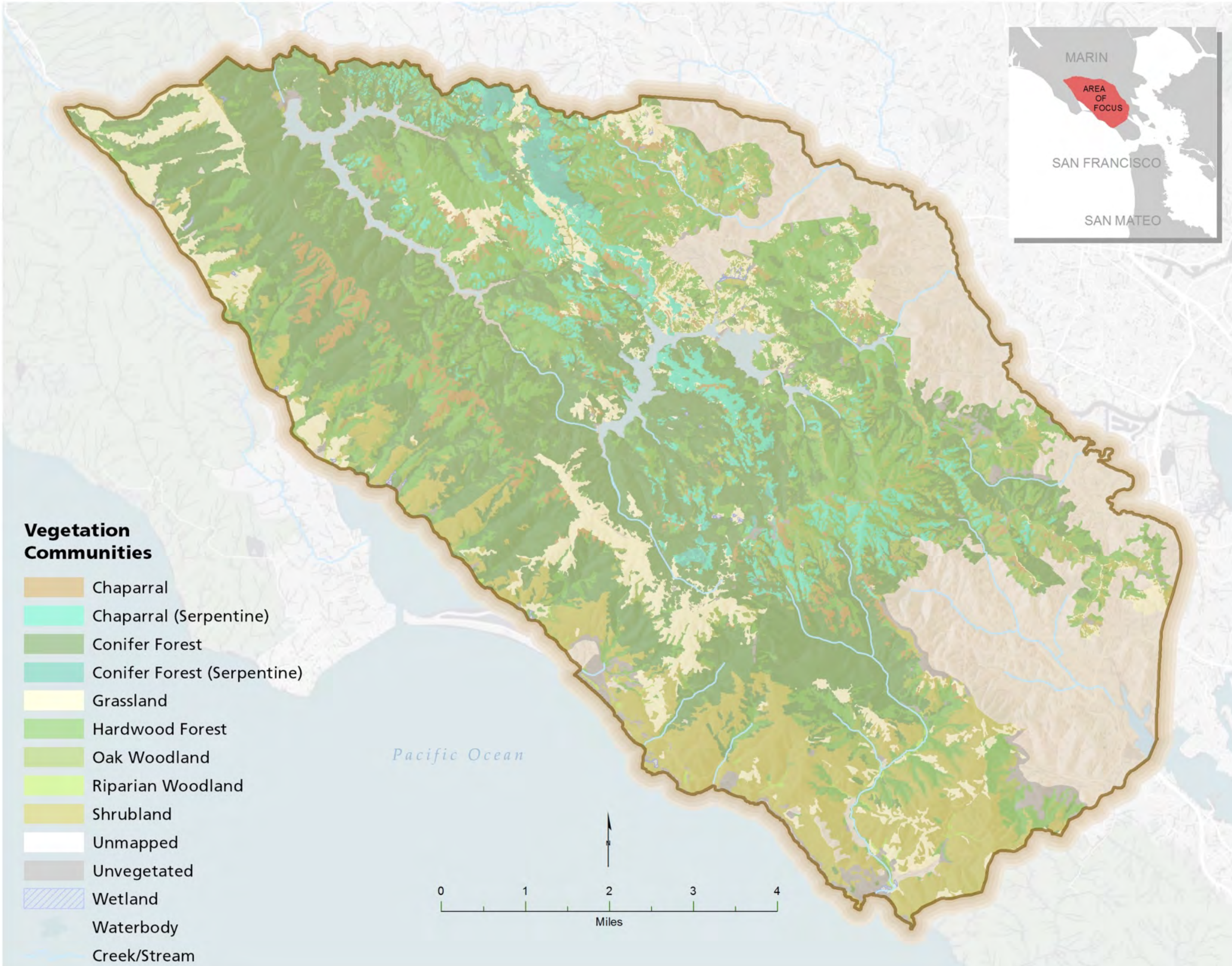
TABLE 2.1 ACRES OF VEGETATION TYPES BY LAND MANAGEMENT AGENCY

NPS = National Park Service
State Parks = California State Parks
MMWD = Marin Municipal Water District
MCP = Marin County Parks

Community Type	NPS Acres	State Parks Acres	MMWD Acres	MCP Acres	Total Acres
Conifer					**13492**
Bishop pine	14	0	23	0	37
Douglas-fir	1456	1664	3649	74	6843
Redwood	1705	417	3758	340	6220
Sargent cypress	0	0	336	30	366
Monterey pine/cypress	10	2	15	0	26
Mixed Hardwood	1283	647	4570	610	**7110**
Oak Woodland					**2154**
Coast live	332	352	890	524	2098
Oregon white	No Data*	No Data*	6	10	16
Interior live	No Data*	No Data*	25	2	27
Valley oak	No Data*	No Data*	2	11	13
Shrubland					**8161**
Coastal scrub	1630	2088	107	39	3864
Chaparral	372	88	2197	414	3071
Serpentine chaparral	No Data*	No Data*	811	64	875
Sensitive manzanita	53	0	88	0	142
Invasive shrubland	92	46	26	44	209
Grasslands					**3515**
Annual	1001	839	1155	209	3204
Perennial	120	22	24	17	183
Serpentine	No Data*	No Data*	128	0	128
Barrens					**70**
Serpentine	No Data*	No Data*	30	2	32
Non-serpentine	No Data*	No Data*	29	8	38
Seeps and Wet Meadows	79	No Data*	20	0	**99**
Riparian					**837**
Intermittent	128	39	214	22	403
Perennial	120	52	233	29	434
Beach or Marsh	61	18	0	0	**79**

*Mapping resolution was too low to capture this community type.

FIGURE 2.2 VEGETATION COMMUNITIES AND HYDROLOGY OF THE ONE TAM AREA OF FOCUS



SELECTED INDICATOR PLANT COMMUNITIES OVERVIEW

Mt. Tam's iconic, sweeping **grassland** vistas and stately **open-canopy oak woodlands** serve as habitat for numerous plants and animals, and hold tremendous biodiversity. They have also been impacted by ecological succession as a result of alterations in natural disturbance regimes, and by the invasion of non-native plants. In addition, coast live oak woodlands are losing large trees due to Sudden Oak Death (SOD). Native grasslands are at 1% of their historic extent in the state, and Mt. Tam preserves some of the best examples of remnant grassland ecosystems in the region (Noss & Peters, 1995).

Coast redwood forests (*Sequoia sempervirens*) are another iconic vegetation type undergoing changes due to Sudden Oak Death, climate change, and invasion by non-native species. The One Tam area of focus has a small amount of old-growth coast redwood forests, but the majority are second-growth, having been logged at some point in the past.

Sargent cypress (*Cupressus sargentii*), particularly the pygmy forest along San Geronimo Ridge, is a rare vegetation type that hosts several California Native Plant Society-listed and locally rare plant species. Unlike many of the other communities chosen as indicators, Sargent cypress appears to be relatively disease- and weed-free, and may expand its range in the face of stressors negatively affecting other dominant plant species.

Shrubland communities on Mt. Tam are of two general types. **Chaparral** cover is dominated by drought- and fire-tolerant, hard-leaved, woody evergreen species such as manzanitas. **Coastal scrub** areas are primarily dominated by soft-leaved, woody, drought-deciduous or evergreen shrubs such as California sagebrush (*Artemesia californica*) and coyote brush (*Baccharis pilularis*).

The majority of Mt. Tam's rare plants fall into a few community types, and certain suites of species were chosen to indicate the status of those communities. Approximately half the rare plants—by both number of taxa and number of populations—are serpentine endemics. Rare plants within the **serpentine barrens** plant community were sorted into "relatively common" and "relatively uncommon" to measure both biodiversity and the health of open-canopy serpentine types. Lower elevations of Mt. Tam that receive a marine influence—in the form of summer fog—contain **maritime chaparral**, which is also associated with several special status plants.

See Chapters 3–9 for additional details about the health of these plant communities on Mt. Tam.

EXTIRPATED SPECIES

Another way to examine ecosystem health is to consider the species that are no longer present, and to try to understand the factors that contributed to their loss. The current list of likely extirpated plant species (Appendix 7) includes native species historically found within the One Tam area of focus. However, these species have not been seen in over 50 years, or their last known locations have been searched more recently and the population is gone. This list does contain many species that require fire to germinate and which may be present in the seedbank but are not observable and therefore effectively absent. Furthermore, the longer these species go without fire, the higher the likelihood that their seeds in the soil will no longer be able to grow if a fire does occur.

Historic presence was established primarily through comparing the One Tam species list with the *1970 Marin Flora: Manual of the Flowering Plants and Ferns of Marin County, California* (Howell, 1970). Taxa indicated as growing on Mt. Tam in this book, but not listed as present on the current species list, were compared against herbarium records (Consortium of California Herbaria [CCH], 2016) and recent observations within the online databases Calflora (2016) and NPSpecies (2016). Additional staff and local expert knowledge were used to document extirpations and known locations in order to add or remove species from the list.

One Tam agency staff continue to survey for species thought to be extirpated from the mountain, and have removed several from the list since the start of the 2016 growing season. It will be necessary for additional botanical experts to verify herbarium specimens upon which some otherwise unsubstantiated records are based to ensure the species presence is not based on misidentification or taxonomic changes. A list of plants that are likely to be extirpated in the near future is also currently under development.

Extirpated species lists serve as a compelling and dramatic example of the changes that have taken place in the recent past, and indicate the trajectory of plant species on Mt. Tam. For example, some potentially extirpated plants may have disappeared from the aboveground flora due to lack of fire, or already appear to be shifting their range northward and westward away from the mountain and towards the coast, possibly as a result of climate change.

INFORMATION GAPS

One Tam land managers lack the data necessary to assess the condition and trends of some proposed indicator plant communities. While there are many information gaps related to the health of Mt. Tam, the plant communities listed below are considered high priority for additional monitoring and research, and more data may be available in the near future.

Seeps, springs, and wet meadows are other plant communities that may be partially measured through the presence of certain rare plant species. In combination with other metrics related to hydrology and certain animal taxa (e.g., chorus frogs, butterflies, dragonflies), they may tell us about changes in function of these essential areas.

Agencies will continue to monitor other **rare plant species** per their respective protocols. Data from these species, or groupings of species, may be integrated into this health assessment in the future. Short-lived perennial species such as Mt. Tamalpais thistle (*Cirsium hydrophilum* var. *vaseyi*) and coast rockcress (*Arabis blepharophylla*) appear to be a particularly sensitive and declining group. These species have neither the dramatic population swings of annuals nor the lag time of geophytes and woody plants, and those with a lifespan of less than 10 years may be good indicators of change.

The extent and condition of other plant communities such as **Douglas-fir** (*Pseudotsuga menziesii*) **forests**, **riparian woodlands**, and **hardwood forests** may be captured through future mapping and/or monitoring efforts. Specific metrics for these communities will be explored at a later date. **Lichens**, which are very good indicators of air quality, may also be included as health indicators for Mt. Tam in the future.

See Chapter 10 for more information about these vegetation community data gaps and recommended next steps to help fill them.

MANAGEMENT AND MONITORING

Mt. Tam's land management agencies strive to preserve biodiversity and functioning ecosystems, and to do so in the face of a changing environment largely out of their control. Because nature is not static, preserving things exactly as they are is neither a realistic nor desirable goal.

For example, vegetation succession is an ongoing natural process, and one that is also affected by the land management policies of different agencies. Therefore, maintaining a certain number of acres of a particular vegetation community over a large landscape might not be the management target of a particular agency, but monitoring shifts in acreages over short periods of time can be useful to help managers understand how ecosystems and their functions might be changing.

OVERARCHING VEGETATION MANAGEMENT AND MONITORING EFFORTS

Several large-scale programs that manage or track plant communities and species on Mt. Tam are described below. Past and current management, monitoring, restoration, and other efforts that only support specific plant communities are summarized in each respective chapter.

Weed Monitoring, Surveying, and Management: One Tam staff and partner agencies survey roads, trails, facilities, and recently disturbed sites for a prioritized list of invasive plant species year-round, though primarily from March through September. Survey areas are prioritized based on their rates of human use and on habitat health. Work groups aim to survey all roads and trails every three to five years. NPS surveys began in 2008, with other land managers launching their programs in subsequent years. One Tam staff initiated surveys in 2016, with the goal to increase surveys and add capacity to partner agency efforts.

Species are placed into two categories: highest priority and local detections (Tables 1.1A and B). Highest priority species are novel or relatively new to the mountain. They are mapped at all size classes. Local detections are priority weeds with wide distributions. They are mapped when patches are 100 square meters or less. Inter-patch distance is 20 meters for both categories. Surveyors record data on patch size, number of individuals, phenology, and percent cover. Early detection and treatment of these new infestations and patches of widespread weeds helps mitigate their impacts and reduce the costs of invasive plant management.

Large-scale Weed Management Program: One Tam partner agencies commit significant resources to mapping, monitoring, and managing invasive vegetation on their lands. Volunteer-based efforts to control invasive plants include regular drop-in days for adults and their families, numerous school groups from elementary to college-aged students, and special volunteer events like Hands on Tam and Muir Woods Earth Day that bring hundreds of volunteers to the mountain every year. Full-time and seasonal staff and interns are dedicated to providing volunteer management and leading these stewardship activities.

Contractor-based vegetation management is also conducted by all agencies to both control and map invasive plants. In 2012, NPS and State Parks staff launched a comprehensive watershed-wide approach to controlling target invasive plants in the Redwood Creek Watershed that increased efficiencies and ensured that priority weeds are managed across jurisdictional boundaries. Land managers invest significant resources on contract labor to control targeted invasive plant populations and keep fuelbreaks free of broom and other weedy vegetation. Wide Area Fuel Load Reduction special projects on both MMWD and MCP lands are implemented by contractors with the dual purpose of fuels management and resource enhancement.

In addition to working closely with volunteer groups and contractors, many staff work directly in the field controlling, mapping, researching, and monitoring invasive plant populations and past control efforts.

Rare Plant Monitoring: Mt. Tam supports more than 40 rare, threatened, and endangered plant species. Location and population data are available for many of these species through field surveys conducted by One Tam land managers and partners including the California Native Plant Society's Marin Chapter. The scale of each monitoring program varies based upon staff and volunteer resources. For example, NPS staff conduct yearly rare plant monitoring, with individual populations visited once every three to five years; MMWD staff are in the process of re-inventorying their rare plant populations and have updated data on approximately 80% of the over 400 individual patches on watershed lands within the past five years. All agencies collect data in accordance with California Natural Diversity Database guidelines, including a count or estimate of the number of individuals; the percent of the population that is vegetative, flowering, and fruiting; notes on the threats; notes on location and condition of the population; and re-mapping of population boundaries, if warranted.

Plant Community Monitoring: NPS staff monitors the structure and composition of redwood forest and coastal scrub plant communities at Bolinas Ridge, Muir Woods, and Green Gulch. This long-term monitoring program began in 2015, and randomly located, permanent vegetation plots are revisited once every four years. Trends analysis will be performed periodically to better understand community dynamics (i.e., succession, temporal variability, etc.), and to examine correlations between climate change, land use, and biological interactions (Steers et al., 2016).

FUTURE ACTIONABLE ITEMS

Below is a preliminary summary of management and monitoring needs identified by agency and local scientists as a part of the technical paper development. These are actions not currently funded as a part of agency programs, but are high priority and will be further evaluated and prioritized for future funding and implementation.

- **Complete Historical Conditions Analysis for Priority Taxa:** Many of the condition statements made about health indicators on Mt. Tam are based on comparison to historic range or population statuses. For some species, especially rare ones, historic information is available electronically and has been incorporated. Often though, not all available museum collection information has been collected or can be readily accessed. Historic field notes and notebooks are rarely searchable online, and old reports are often on shelves, not servers. Partnering with natural history museums to get collections data computer-searchable, and tracking down historic notes and reports, will allow us to compare the past to the present and paint a more complete picture as we look to the future.

- **Complete Regional Vegetation Map:** Perhaps the highest priority need for assessing condition and trend of key vegetation community and rare plant indicators is having accurate and consistent mountain-wide spatial vegetation data. This report uses a compilation of data collected over more than several decades, with the NPS and State Parks data collected in 1997, MCP in 2008, and MMWD most recently in 2014 (see Indicator Analysis Methodology section below).

Vegetation community, alliance, and association data are essential for supporting the following:

- Community succession analyses and identification of landscape-level changes over time
- SOD and other plant pathogen assessments
- Wildfire risk assessments and mitigation planning
- Wildlife and special status species habitat modeling and monitoring
- Infrastructure and environmental impact assessments

Due to the nature and potential shortcomings of a vegetation dataset based on interpretation of aerial photography, it should be used carefully as a guide. However, these datasets will use standard methods of mapping and classification and allow general comparisons over time. Having consistent and comparable vegetation data across the entire Mt. Tam landscape as well as adjacent public lands. These datasets could help to inform many of the vegetation community metrics. Incorporation of newer technologies such as LiDAR would generate fine-scale metrics for many aspects of vegetation community health of great interest as well as improved abiotic spatial data.

Examples of additive data products that can come from LiDAR enhanced mapping include:

- Forest canopy density and height
- Biomass/aboveground carbon estimates
- Bare earth and impervious surface delineations
- Stream centerline delineation
- Hydrological datasets including flow accumulation, flow direction, and stream confluence point identification
- Baseline for change detection at a three- to five-year interval (to be determined)

- **Institute Systematic Plant Community Monitoring**: There is a great need to transfer the San Francisco Bay Area Network Inventory & Monitoring (SFAN I&M) approach to tracking long-term changes in a suite of vegetation communities to other agencies. This approach uses a network of strategically placed plots to monitor fine-scale floristic change over time in specific communities. Currently included are coastal prairies at Point Reyes National Seashore, redwood forests at Muir Woods National Monument, mixed chaparral at Pinnacles National Park, and coastal scrub at Golden Gate National Recreation Area. Within these communities, the goal is to answer questions such as:

    - Is the number of species present in a community changing over time?
    - Which plant species are moving into a community and which are no longer present?
    - How is the ratio of native to non-native plants changing within the community?
    - Is vegetation changing at a community level (e.g., grassland to shrubland)?

  The geographic scope of the SFAN I&M program is limited. Establishing similar plots elsewhere within the One Tam area of focus and training other agencies' staff in protocols similar to those used by the SFAN I&M program will allow for the pooling and comparison of data across jurisdictions. Including additional vegetation types will improve our understanding of how the region's biodiversity is responding to various stressors and will further inform how to better protect the health of Mt. Tam's exceptional plant diversity.

- **Develop and Undertake Systematic Mountain-wide Mapping of Priority Targeted Invasive Species:** Non-native, invasive plants have been identified as a stressor for most indicator plant communities and species. Weed infestations have been mapped on Mt. Tam by each partner agency over the past two to three decades at varying levels, and using a variety of protocols and data management systems to record and analyze information. These inconsistencies limit our ability to compare, prioritize, and then treat infestations on a mountain-wide scale. This project entails developing a protocol that would meet individual agency goals and also enable a comprehensive understanding of the distribution, scale, and possible impact of target species. Having that perspective would facilitate the development, implementation, and assessment of mountain-wide weed management actions. Systematic mapping would be phased geographically, targeting areas that support high-priority sensitive resources and key indicators.

- **Develop a Mt. Tam Climate Adaptation Strategy to Further Inform Vegetation Management Actions:** The San Francisco Bay Area's climate is changing in ways that will likely impact the spatial patterns or distributions of native plant communities. Several recent studies and predictive modeling efforts (Thorne et. al., 2016; Ackerly et. al., 2012) provide insights into climate-related vulnerability for existing vegetation communities and the possible future distribution of dominant plant species under various climate futures. Exploring the connections between these models and their projections for Mt. Tam's vegetation is a vital step in crafting adaptive strategies that will sustain vibrant, diverse ecosystems into the future. For example, blue oak (*Quercus douglasii*) is a species that is currently rare inside the Mt. Tam area of focus. However, predictive models suggest this is a species that has the potential to expand in a more arid future. One Tam partners may want to consider adding this and other currently uncommon or absent species or genotypes into restoration planting palates as part of a climate adaptive strategy that looks to a functionally drier future rather than referencing the past.

  Additional climate-referenced datasets are available or in development and have the potential to improve One Tam programs currently underway. Most immediately, the Cal-IPC CalWeedMapper interactive tool now provides spatial data and reports for invasive plant trends based on climate suitability. This allows land managers to predict which invasive species may emerge as new problems under various climatic futures. Integrating this information into One Tam weed detection efforts will increase the likelihood that resource conservation crews and volunteers will spot and eradicate emergent weed species before they become entrenched problems.

INDICATOR ANALYSIS METHODOLOGY

VEGETATION COMMUNITY MAPPING AND ANALYSIS

Vegetation community mapping is a two-stage process. In the first stage, aerial or remotely sensed images are analyzed and "stands" of vegetation that are similar in composition and structure are digitized (drawn in a Geographic Information System [GIS]) and classified into hierarchies, primarily using the National Vegetation Classification System (NVCS) at *mtnhp.org/ecology/nvcs/*. The resulting polygons are then attributed to a community type, and a subset is ground-truthed for accuracy.

All data for the analyses presented in this report were provided in GIS format by One Tam agency staff via six different vegetation maps. All six maps were developed using the California Native Plant Society protocols for vegetation sampling, classification, and mapping, with minor variations between agencies and years. Over the course of two decades, imagery and mapping technology has improved, and so more recent maps delineate vegetation at a finer scale and provide additional information regarding canopy disease and stand structure. Nonetheless, the combined datasets are largely comparable and provide an unusually detailed description of the vegetation of Mt. Tam at a landscape scale. These data sets include:

- The 1994 National Park Service Vegetation Map included all of the Golden Gate National Recreation Area, parts of Point Reyes National Seashore, and all of Mount Tamalpais State Park (Schirokauer et al., 2003).

- The 2004, 2009, and 2014 Marin Municipal Water District Vegetation Maps included all of the watershed lands. Note: Only The Marin Municipal Water District has a time series of maps (2004, 2009, 2014) that can be used to detect changes over time. All the data from the 2004 and 2009 maps are summarized in the report for the 2014 mapping project (Evens & Kentner, 2006; Aerial Information Systems [AIS], 2015).

- The 2008 Marin County Parks-Marin County Open Space District Vegetation Map included all of the agency's preserves (Aerial Information Systems [AIS], 2008).

Each vegetation layer exceeded the administrative boundaries of the agencies, and was clipped to the One Tam area of focus in ArcGIS. To ensure that baselines and goals in each chapter reflect only parts of the One Tam area of focus that are under agency administration, each vegetation layer was further clipped to the relevant administrative boundary layer. The NPS vegetation map was split into NPS-owned lands and Mount Tamalpais State Park. Vegetation acres were then recalculated in GIS, and attribute tables were exported to Microsoft Excel.

Using the clipped vegetation layers, data were parsed by the community types selected by the Health of Mt. Tam's Natural Resources Advisory Committee. Data were sorted by NVCS Associations and Alliances in the NPS and State Parks tables. MMWD and MCP were also parsed by NVCS Alliances and Associations when available. In some instances, these fields were empty. These two vegetation maps include a fine-scale field, MAPCLASS, which offers highly detailed information on plant assemblages and serpentine areas. In these cases, the MMWD and MCP vegetation maps allowed for finer-scale data sorting than was possible with the NPS and State Parks tables. In the future, a comprehensive vegetation map of the One Tam area of focus (see Future Actionable Items section above) may reveal more serpentine acreage in both chaparral and grassland community types.

All vegetation data were sorted into the following nine vegetation community types using a combination of NVCS Alliances and Associations, and the MAPCLASS field (when available):

- Conifers
- Oak woodlands
- Mixed hardwoods
- Shrublands
- Grasslands
- Barrens
- Riparian corridors
- Seeps, springs, and wet meadows
- Beaches, dunes, and marshes

Some of these were further parsed into subtypes to inform the individual indicator chapters within this report (Table 2.3).

The overall extent of various vegetation types and canopy-level metrics were then derived for each of the plant community indicators. These specific analyses are described in more detail in each chapter.

Potential Sources of Error:

These calculations relied on data from time periods ranging from 1994–2014. They combined two styles of vegetation mapping, which required manual parsing of many vegetation types, introducing opportunity for human error. Back calculations were computed whenever possible to ameliorate this potential source of error.

Some fields were empty within datasets, others were listed as “unable to key” or lacked land use and vegetation information. Some areas remain unrepresented in the vegetation maps, including several roads, small parcels along administrative boundaries, and 100 acres near Four Corners. These areas account for approximately 0.7% of the open space in the One Tam area of focus.

TABLE 2.3 DATA SOURCES AND ANALYSES CONDUCTED FOR EACH INDICATOR PLANT COMMUNITY

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
Coast redwood forest	• Coastal redwood • Redwood (pure) • Redwood/tanoak redwood-Douglas-fir – (mixed hardwoods) • Redwood/chinquapin • Redwood/California bay • Redwood-upland mixed hardwoods • Redwood-riparian	Acres without SOD (canopy involvement)	Summed acreage of oak woodland polygons with attribute SOD*=0
		Acres without targeted invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*
Sargent cypress communities	• Sargent cypress alliance • Sargent cypress/Mt. Tamalpais manzanita • Sargent cypress pure stands	Acres (total and distribution)	Total acreage of all Sargent cypress types; visual assessment of spatial distribution
Open-canopy oak woodlands	• Coast live oak (CLO) alliance • CLO - madrone • CLO/grass-poison oak; CLO –riparian • CLO –Douglas-fir • Oregon oak alliance • Valley oak riparian mapping unit • Interior live oak (ILO) alliance • Coastal open-canopy oak woodland	Acres without SOD (canopy involvement)	Summed acreage of oak woodland polygons with attribute SOD*=0
		Acres without broom or other targeted priority invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*
		Acres without canopy-piercing Douglas-fir	Summed acreage of oak woodland polygons with MMWD attribute ConDensity >0; MCP ConDen >0
Shrublands	• Chamise alliance • Chamise - serpentine Chaparral (relatively pure chamise on ultramafic soils) • Mt. Tamalpais manzanita	Core areas	Aggregated all mapped shrubland vegetation polygons with shared boundaries, and selected polygons in size classes > 0.5 Std. Dev. (>30 acres).

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
	serpentine chaparral • Leather oak – chamise- Mt. Tamalpais manzanita serpentine chaparral • Eastwood manzanita / interior live oak alliance • Mixed manzanita alliance • Coastal sage scrub alliance • Blue blossom alliance • Coffeeberry alliance • Coyote brush alliance • Poison oak alliance • Sensitive manzanita alliance	Acres without broom or other targeted priority invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*. NPS Early Detection Program 2008-2015**
		Acres without canopy-piercing Douglas-fir	Summed acreage of oak woodland polygons with MMWD attribute ConDensity >0; MCP ConDen >0
Grasslands	• California annual grassland alliance • Grasslands on well-developed soils • Grasslands on poorly developed soils • Grasslands with a fern or sub-shrub (golden banner component) • Tall temperate perennial herbaceous (Harding grass) • Native temperate perennial grasslands • California or Idaho fescue grasses • Purple needlegrass • Upland serpentine grassland • Wetland serpentine grassland • Community (grassland) • Introduced and coastal perennial grassland alliance	Acres (total)	Total acreage of all grassland types
		Patch size	"Dissolved" individual grassland types into one; counted contiguous patches over 50 acres

*MMWD data only
**NPS data only

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CHAPTER 3. COAST REDWOOD (*SEQUOIA SEMPERVIRENS*) FORESTS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Old-growth Redwood Forests: Total 664 acres

1. **National Park Service (Muir Woods):** 370 acres
2. **Mount Tamalpais State Park (Steep Ravine):** 294 acres

Condition: Good

Trend: Improving

Confidence: High

Second-growth Redwood Forests: 5,556 acres

Condition: Caution

Trend: Declining

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Coast redwoods are the definition of resiliency. Among the tallest trees in the world, individual redwoods may live as long as 2,000 years. Thick bark and an ability to resprout enables established adult trees to survive most wildfires, and their seedlings thrive in the mineral-rich soil left behind by fires and floods (Lorimer et al., 2009). High levels of tannins make them resistant to insect and fungal infestations. Acidic soil conditions, thick duff layers, and dense shade also make redwood-dominated stands relatively resistant to non-native plant invasions. Despite their overall resilience, historic logging practices have diminished the extent and density of old-growth redwood stands and have also altered forest conditions. As a result, coast redwood forests are on the International Union for Conservation of Nature and Natural Resources red list as “endangered” (Farjon & Schmid, 2013).

These forests store more standing carbon than any other kind in California (Van Pelt et al., 2016). Redwood foliage “harvests” fog, and the accumulated water drips slowly down to the soil, increasing total precipitation within stands, and creating a separate microclimate below the canopy (Dawson, 1998). Redwood growth rates have increased significantly in recent decades (Sillett et al., 2015), but their future growth trajectory is unknown as California becomes functionally more arid with climate change (Johnstone & Dawson, 2010; Fernández et al., 2015). Redwood forest communities are also being impacted by Sudden Oak Death (SOD), which rapidly kills tanoak (*Notholithocarpus densiflorus*) trees and other coast redwood forest understory species.

Mt. Tam's coast redwood forests provide important habitat for a number of mammals and birds, including the state and federally threatened Northern Spotted Owl (*Strix occidentalis caurina*). Endangered coho salmon (*Oncorhynchus kisutch*) and threatened steelhead trout *(O. mykiss*) also live in the Redwood Creek Watershed.

Redwood forest communities are good indicators of forest management practices, wildfire regimes, and disease processes. Coast redwood trees sprout prolifically from stumps, and many of Mt. Tam's second-growth stands have higher redwood tree densities than old-growth areas as a result of turn-of-the-century logging (Noss, 2000). In the absence of wildfire or active management, fast growing species such as Douglas-fir (*Pseudotsuga menziesii*) and tanoak have become more abundant in Mt. Tam's redwood forests. High densities of tanoak in second-growth redwood stands in the moister regions of the One Tam area of focus reflect a history of logging, followed by fire suppression and a lack of any action designed to favor redwood recruitment. Sudden Oak Death has caused wide-spread cycle of tanoak dieback and resprouting in One Tam area of focus redwood forests, as well as in mixed hardwood forests across Mt. Tam and the Coast Range (Nik et al., 2016).

Understory conditions in heavily visited redwood forests can also be indicative of recreational pressures. Soils within redwood forest systems are sensitive to compaction, which can damage both redwood tree roots and associated herbaceous species (Voigt, 2016). Finally, redwoods may serve as an indicator of climate change, particularly changes in precipitation patterns and summer fog (Micheli et al., 2016). A sudden decline in such a long-lived and resilient species would signify changes on a scale likely to be detrimental to other vegetation communities on Mt. Tam.

OVERALL CONDITION

Towering stands of old-growth coast redwoods once stretched across fog-shrouded hills and valleys from southwest Oregon to the Big Sur Coast of Central California. Less than 5% of the original old-growth redwood forests remain, although second-growth forests have persisted over much of the historic range (Fox, 1989). Within the One Tam area of focus, coast redwood forests may be found in Muir Woods on National Park Service (NPS) lands, as well as in stands on Marin Municipal Water District (MMWD), California State Parks (State Parks), and Marin County Parks (MCP) lands as follows:

- **MMWD lands:** 3,758 acres
- **MCP lands:** 340 acres
- **NPS lands:** 1,705
- **State Parks lands:** 2,122

The vast majority of redwood forests on Mt. Tam have a varied history of commercial logging prior to gaining protections within the current network of public lands. Of the 6,220 acres of coast redwood forest in the One Tam area of focus, less than 15% was protected from logging and can be considered "old-growth," including Muir Woods and Steep Ravine. Land managers have better data for Muir Woods than many other redwood stands on Mt. Tam, which is why it is considered separately in parts of this condition and trends analysis. In general, old-growth conditions represent a desirable state for redwood stands on Mt. Tam given their complex habitat structure and other ecological conditions that are resilient to wildfire and other stressors.

Although specific characteristics will vary based on site conditions, old-growth coast redwood forests include (Van Pelt et al., 2016 unless otherwise noted):

- A multi-layered, multi-aged canopy dominated by coast redwoods
- A well-developed midstory with shade tolerant species including tanoak, bay laurel (*Umbellularia californica*), and Douglas-fir
- An understory with both shrub and herbaceous components
- Large diameter trees (100 centimeters diameter at breast height [dbh] or more) with large horizontal branches, cavities, broken limbs, and burn scars
- Standing snags/deadwood and large, very slowly decaying wood/nursery logs on the ground
- Approximately 50–100 overstory trees per hectare (Lorimer et al., 2009)
- Riparian/alluvial systems and associated midstory trees that include bigleaf maple (*Acer macrophyllum*) and alder species (*Alnus* sp.) in valley bottom sites

The majority of redwood stands on Mt. Tam are considered second-growth. These stands exhibit greatly simplified structure, with an absence of larger trees in the canopy, simplified understory, and high densities of small diameter trees. The potential for second-growth stands to achieve old-growth characteristics in the near term is largely driven by site conditions. Some second-growth stands on Mt. Tam retain clusters of large diameter trees that were inaccessible or otherwise undesirable for logging. They vary widely in their characteristics and in the degree to which they have recovered from the impacts of logging due to varying site conditions and the amount of time that has passed since they were logged.

DESIRED CONDITIONS

The desired condition for **old-growth** redwood forests is to sustain complex species composition and stand structure including multi-aged, multi-storied stand structure, coarse woody debris, tree cavities, and nesting structures.

In **second-growth** forests, the desired condition is evidence that a stand is on a trajectory towards development of old-growth characteristics. This includes a reduction in the total stem density over time as well as the development of large diameter trees and a multi-storied stand structure (Lorimer, 2009). Maintenance of the existing extent of redwoods in the One Tam area of focus is considered highly desirable because of their habitat value for Northern Spotted Owls and coho salmon, their ability to store carbon and other greenhouse gases (Cobb et al., 2016, unpublished), and their iconic value.

STRESSORS

Sudden Oak Death: Since its onset in 1995, this disease has heavily impacted tanoaks within the One Tam area of focus and elsewhere on the central California coast, altering the structure of redwood stands that have a high tanoak component (Maloney et al., 2005; McPherson et al., 2010; Ramage & O'Hara, 2010). Tanoaks are among the most shade tolerant hardwood in coastal California, and one of the few species that thrives in in the dense shade of the redwood overstory. They are considered to be an important structural component of redwood forests and, as acorn producers, they are also important to wildlife (Noss, 2000; Tempel et al., 2005). As late as 1990, tanoaks were the most abundant tree on Mt. Tam and the most numerous trees in many redwood stands (Parker, 1990). The prevalence of tanoak in the second-growth stands on Mt. Tam was due at least in part to the suppression of fire, which would have killed small stems (Brown & Baxter, 2003).

In addition to the extensive canopy gaps left by dead trees, SOD damages the structural integrity of diseased trees, and infected tanoaks collapse and decay rapidly. This decreases standing snags, and only temporarily increases the presence of larger logs on the ground. Remnant tanoak stumps rapidly resprout producing high densities of brush, which in turn become diseased, collapse, and resprout again. As a result, the gaps between redwood trees fill in with brush. Fine fuels increase over the short-term as a result of SOD mortality, but evidence suggests they decrease over the long-term as the disease progresses (Forrestel et al., 2015). Evidence from wildfires in redwood forests in Big Sur found an increase in redwood mortality in areas where SOD had recently killed trees, but not in areas where the disease had progressed further (Metz et al., 2013).

Climate Change: Models generally forecast warmer temperatures and normal precipitation patterns for coastal California over the next 15 years, with the southern extent of the redwood range experiencing more warming than the northern extent (Fernández et al., 2015). How these predicted climate changes will impact the health of the redwood forest is complex, given redwoods have shown increased growth with climate changes so far (Sillett et al., 2015). Smaller redwood forest plant species may be more vulnerable to increasing aridity as climatic water deficit increases during the summer (Fernández et al., 2015; Johnstone & Dawson, 2010; Micheli et al., 2016). The loss of fog, particularly in the summer, could lower redwood forests' ability to thrive if precipitation also declines in the future. Fog has decreased by approximately one-third over the past century (Johnstone & Dawson, 2010).

Non-native, Invasive Species Encroachment: The deep shade created by the redwood overstory protects these forests from invasion by many invasive plant species. However, some species, most notably panic veldt grass (*Ehrharta erecta*), are able to persist in the redwood understory and displace native understory biodiversity.

Soil Compaction: Recreational use of redwood forests both on and off trails leads to soil compaction and disruption of understory biodiversity and abundance (Voigt, 2016).

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: FOREST STRUCTURE AND DEMOGRAPHY WITH OLD-GROWTH CHARACTERISTICS OR MOVING TOWARDS OLD-GROWTH CHARACTERISTICS

Baseline: The One Tam area of focus is located near the center of the geographic distribution of coastal redwoods. Old-growth redwood forest structure and demographics are available throughout the entire range of redwoods. Stand structure within Muir Woods most closely resembles those in southern reference stands characterized as part of the Redwoods and Climate Change Initiative (RCCI).

A forest structure study completed by NPS in Muir Woods in 2014 revealed a live tree density per hectare is 430 ± 31 individuals with approximately 24% of trees > 100 cm dbh (Table 3.1A). Stand structure in second-growth redwood forests was characterized on MMWD lands in 2015 by researchers from the University of California, Davis for an ongoing carbon and water yield study. This study revealed live tree density per hectare of 2,317 individuals with approximately 0.7% of trees with diameters > 100 cm dbh (Table 3.1B).

TABLE 3.1A MEAN LIVE TREE DENSITY PER 17.95 M RADIUS PLOT, MUIR WOODS NATIONAL MONUMENT (STEERS ET AL., 2014)

Size Class (dbh in cm)	Mean Live Tree Density (n=9)	Standard Error
Sapling	73.7	26.8
5 – 10	9.8	1.7
10 –15	5.2	5.2
15 – 20	3.6	1
20 – 25	2.6	0.7
25 – 30	1.7	0.4
30 – 35	1.7	1.3
35 – 40	1.2	0.3
40 – 45	1.4	0.4
45 – 50	0.8	0.4
50 – 75	2.6	0.3
75 – 100	2.6	0.6
100 – 150	5.1	0.9
150 – 1200	2.8	1.1
>200	2.8	0.9
Total trees per plot (excluding saplings)	**43.9**	**3.1**
Estimated trees per hectare	**430**	
Percent with dbh > 100 cm	**24**	

TABLE 3.1B MEAN LIVE TREE DENSITY PER HECTARE IN REDWOOD STANDS ON MMWD LANDS (COBB ET AL., 2016, UNPUBLISHED)

Size Class (dbh in cm)	Mean Live Tree Density Per Hectare (n=40)		
	Redwoods	Tanoak	Total
0-20	159	1646.5	1805.5
20-40	67	103.5	170.5
40-60	49.5	32	81.5
60-80	44	2.5	46.5
80-100	21	2.5	23.5
100-120	9	0.5	9.5
120-140	4.5	0.5	5
140-160	0.5	0	0.5
160-180	0.5	0	0.5
180-200	0	0	0
200-220	0.5	0	0.5
220	0.5	0	0.5
Total trees per hectare	**356**	**1788**	**2144**
% with dbh > 100 cm			**0.007**

Condition Goal: Tree density at or moving towards southern redwood forest reference conditions of 460 ± 70 trees per hectare with approximately 18% of trees > 100 cm in diameter (Van Pelt et al., 2016)

Condition Thresholds:

- **Good:** Tree density within one standard deviation of southern redwood forest (RCCI) reference conditions: 460 ± 70 trees per hectare with approximately 18% of trees > 100 cm in diameter

- **Caution:** More than one standard deviation difference from southern redwood forest (RCCI) reference conditions (Van Pelt et al., 2016)

- **Significant Concern:** More than two standard deviation difference from southern redwood forest (RCCI) reference conditions (Van Pelt et al., 2016)

Muir Woods Current Condition: Good

The estimated live tree density per hectare of 430 ± 31 individuals with approximately 24% of trees with diameters > 100 cm dbh falls within one standard deviation of the RCCI reference sites.

Second-growth Stands Current Condition: Significant Concern

The estimated live tree density per hectare of 2,317 individuals with approximately 0.7% of trees with diameters > 100 cm dbh is more than two standard deviations away from old-growth conditions in southern reference sites.

Confidence for Muir Woods: High

Our confidence is "High" for Muir Woods because of the availability of data collected following rigorous, documented protocols, and because plots were distributed throughout Muir Woods.

Confidence for Second-growth Stands: Moderate

Confidence is "Moderate" for second-growth stands because although the available data comes from rigorous, documented protocols, sample plots were concentrated in just two regions in a single jurisdiction within the One Tam area of focus. The limited sampling may not be sufficient to capture the range of variation present on Mt. Tam.

Muir Woods Trend: Improving

Wood production was observed to have increased in recent decades in a 777-year-old redwood in Cathedral Grove which is consistent with range-wide observations of a redwood growth surge in old-growth forests throughout coastal California (Sillett et al., 2015).

Second-growth Stands Trend: Declining

Time series tree density data are available for redwood stands on MMWD lands Hardwood density estimates were included in the 2009 and 2014 updates of the MMWD vegetation map (Aerial Information Systems [AIS], 2016). Hardwood densities have increased, particularly where tanoak are declining as a canopy species (Table 3.2). Much of the increase can be attributed to the proliferation of sprouts that form at the base of diseased tanoaks after the main stem has died and fallen out of the canopy.

Twenty years into the SOD (*Phytophthora ramorum*) disease process, a persistent thicket of tanoak shoots has developed in the redwood understory, and continual re-infestation by *P. ramorum* prevents these shoots from developing into midstory level trees (Table 3.1B). At present, the overall trajectory is away from, rather than toward, old-growth conditions.

TABLE 3.2 CHANGES IN HARDWOOD DENSITY IN FORESTED STANDS WITH TANOAK AS A CURRENT OR RECENT CO-DOMINATE CANOPY SPECIES ON MMWD LANDS, 2009–2014 (AIS, 2015)

Vegetation Types	-0.05	0	0.05	0.1	0.15	0.2	0.25	0.3
Tanoak-California bay-canyon oak mixed forest	8.5	147.8	12.2					
Madrone-California bay-tanoak	74.2	494.1	15.7					0.6
California bay-tanoak		47.5	15.6					
Tanoak alliance								
Redwood/tanoak		5.5		8.2				
Redwood-Douglas-fir (mixed hardwoods)	2.8	864.7	495.8	93	26.3			
Redwood-upland mixed hardwoods	12.1	629.2	417.9	109.6				
Redwood-riparian	3.7	338.3	21.7	4.5				
Douglas-fir (mixed hardwoods)	18.6	3006	42.9	1.1	0.2			3.7
Douglas-fir -tanoak		47.1						
Total acres:	**-119.7**	**5580.1**	**1021.8**	**216.4**	**26.6**	**0**	**0**	**4.3**

METRIC 2: MID-CANOPY STRUCTURE

Baseline: Desirable old-growth conditions include the presence of a well-developed midstory canopy of shade-tolerant native trees that grow underneath towering redwoods. In alluvial sites such as Muir Woods, midstories may support bigleaf maple, alder, and willow in addition to tanoak, bay, and Douglas-fir. Midslope and ridgetop sites with a history of logging and fire suppression tend to develop midstory canopies dominated by tanoak (Van Pelt et al., 2016). This is indeed the situation in much of the One Tam area of focus. As late as 1990, tanoaks were the most abundant tree on Mt. Tam (Parker, 1990). Prior to 1995, SOD was not present on Mt. Tam and most secondary growth redwood stands supported a multi-layered tree canopy.

Condition Goal: Persistence of a multi-layered stand structure, dominated by native tree species

Condition Thresholds:

- **Good:** Presence of native tree species in the mid-canopy and in 90% of redwood forest stands

- **Caution:** Presence of native tree species in the mid-canopy and in 70–90% of redwood stands

- **Significant Concern:** Presence of native tree species in the mid-canopy in less than 70% of redwood stands

Muir Woods Current Condition: Caution

Swiecki & Bernhardt (2006) monitored disease progression in a plot network that included sites in Muir Woods. They reported a steady increase in SOD both in terms of new infections and declining tanoak health. For example, the rate of new infections in tanoak was more than 5% per year between 2000–2004. Over the same time period, infected trees died at an annual rate of 8.2% per year. For Douglas-fir and coast redwood forests, it seems that recovery of forest structure lost to the disease is relatively slow (Forrestel et al., 2015). At the same time, the losses are restricted to susceptible species, and other midstory and understory species including California bay and bigleaf maple remain present (Steers et al., 2014). Thus, while *P. ramorum* is re-organizing species composition, shifting trophic structure, and at least temporarily reducing coast redwood forest mid-canopy cover, it seems unlikely to catalyze a regime shift (Folke et al., 2004).

Second-growth Stands Current Condition: Caution

Extensive tanoak mortality has occurred on Mt. Tam since SOD first appeared in 1995. In many stands, tanoaks have been functionally lost in terms of both forest structure and wildlife food and habitat (Ramage & O'Hara, 2010; Ramage et al., 2011a; Ramage et al., 2011b; also see citations from Stressors section above). Field surveys and aerial mapping conducted by MMWD show large declines in both canopy health and the total extent of redwood stands with a well-developed midstory (Figure 3.3). Over 15% of redwood stands have lost tanoaks as a co-dominate and have been reclassified as a simpler vegetation type since 2004 (Table 3.4).

FIGURE 3.3 CHANGES IN HARDWOOD CANOPY MORTALITY AND TOTAL ACRES OF MIXED REDWOOD STANDS, MMWD (AIS, 2015)

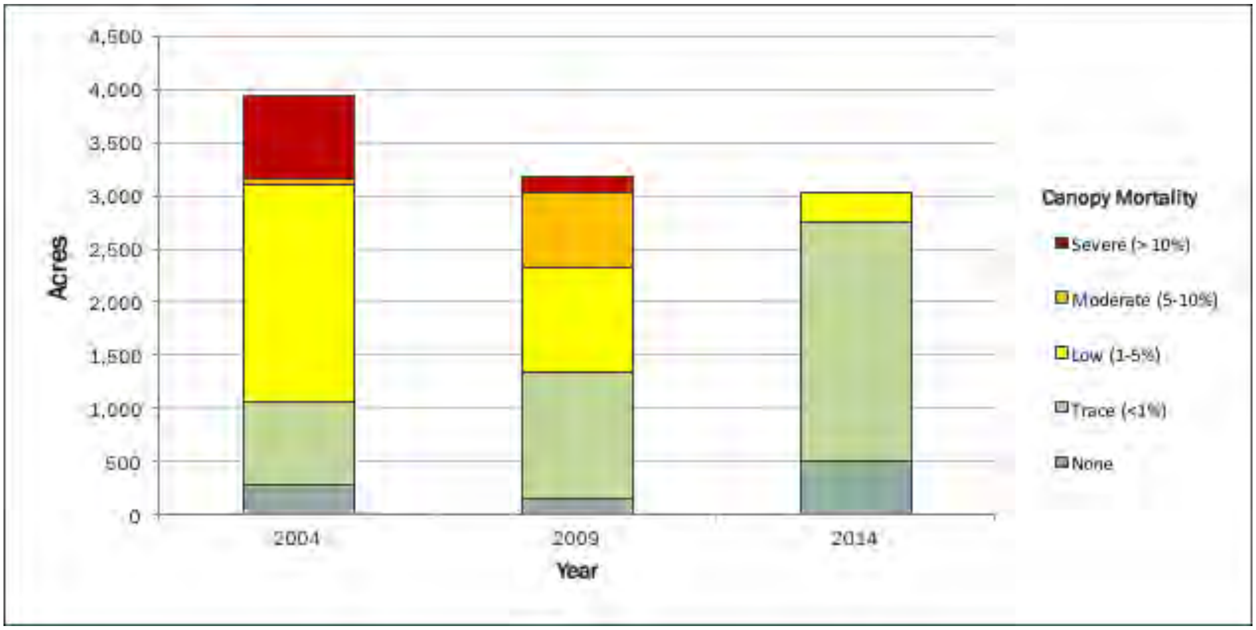


TABLE 3.4 CHANGES IN TOTAL ACRES OF FOREST STANDS WITH TANOAK CO-DOMINANCE, MMWD (AIS, 2015)

Description	2004	2009	2014	% Change 2004–2014
Redwood/tanoak	152	14	14	-0.91
Redwood-Doulas-fir - (mixed hardwoods)	1520	1520	1483	-0.024
Redwood-upland mixed hardwoods	1537	1273	1169	-0.239
Redwood-riparian	368	368	368	-
Total acres:	**3577**	**3175**	**3033**	**-15.20%**

Confidence: High

Although data are from comparisons between 2004, 2009, and 2014 vegetation maps for MMWD lands only (AIS, 2015), tanoak decline on Mt. Tam and regionally has been extensively documented and the situation on MMWD lands is presumed to be representative of other second-growth stands in the One Tam area of focus.

Muir Woods Trend: Unknown

Second-growth Stands Trend: Declining

Time series stand composition data are available for redwood stands on MMWD lands and reveal a notable simplification of stand structure where tanoaks have dropped out of the canopy or midstory layer. Approximately 15% of redwood/hardwood-dominated stands experienced significant declines in their tanoak component between 2004–2014. Recruitment of other native trees into the canopy appears to be limited.

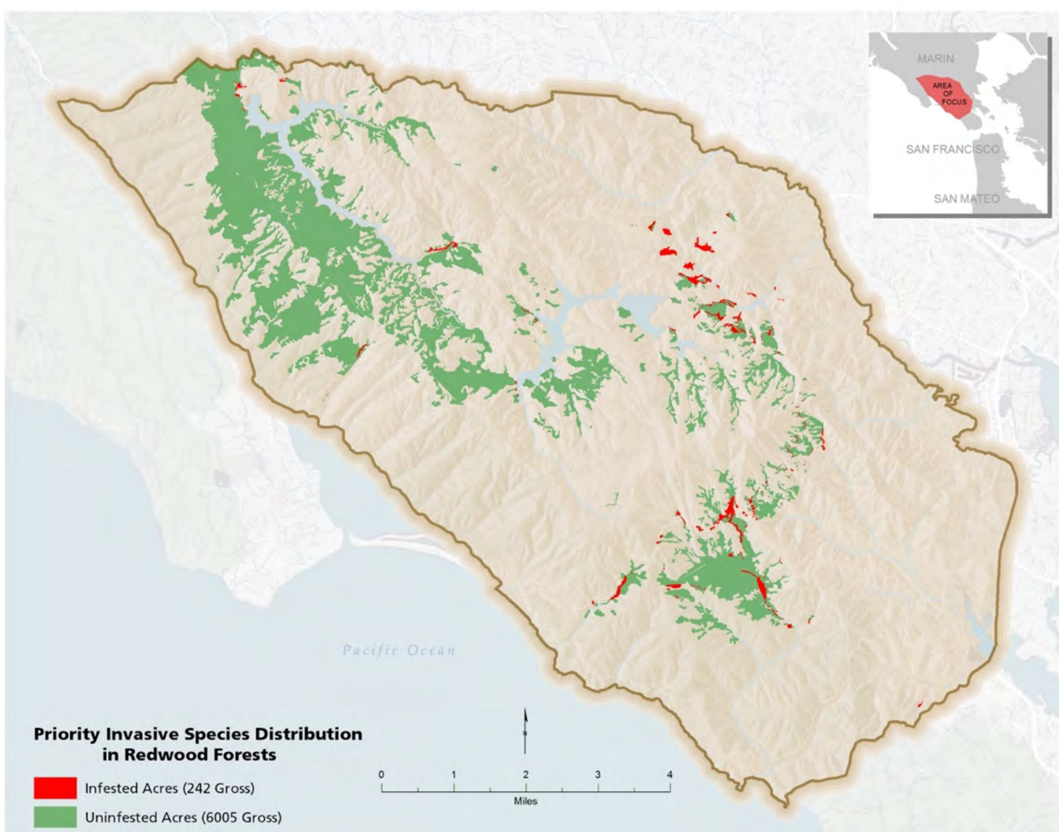
METRIC 3: TARGETED NON-NATIVE, INVASIVE SPECIES COVER

Baseline: Closed-canopy redwood stands are invaded by a limited range of non-native plant species as a result of their shade, and their acidic soil conditions may further slow the establishment of potential invaders. Field observations indicate that most non-native, invasive species in redwood communities exist at the periphery, along roads and trails where canopy gaps occur and disturbance is highest.

French and Scotch broom (*Genista monspessulana* and *Cytisus scoparius*, respectively), panic veldt grass (*Ehrharta erecta*), cape ivy (*Delairea odorata*), English ivy (*Hedera helix*), cotoneaster (*Cotoneaster* spp.), and old man's beard (*Clematis vitalba*) were introduced to Mt. Tam from other parts of the world over the last century. Panic veldt grass is the invasive species of greatest concern in old-growth forests such as Muir Woods.

Because they are relatively recent arrivals, the historic baseline is zero acres of redwood forests where these invasive species are present.

FIGURE 3.4 INVASIVE SPECIES DISTRIUBTION IN REDWOOD FORESTS ON MT. TAM 2014 (CALFLORA, 2016)



Condition Goal: Maintain 6,220 acres at or below maintenance levels for target weed species

Condition Thresholds:

- **Good:** 90% (5,600 acres) of redwood stands are at or below maintenance levels for targeted priority invasive species

- **Caution:** 80% (4,980 acres) of redwood stands are at or below maintenance levels for targeted priority invasive species

- **Significant Concern:** The acreage of redwood stands at or below maintenance levels for targeted priority invasive species falls below 4,355 (70%)

Current Condition: Good

Available data from all agencies show approximately 250 acres (4%) of second-growth redwood forests are impacted by invasive species, and approximately 0.62% of Muir Woods is impacted.

Confidence: Moderate

All One Tam partners maintain invasive species records which include spatial distribution, percent cover estimates, and management history information. However, mapping efforts and protocols are not uniform across jurisdictions (Golden Gate National Recreation Area [GGNRA], 2015) and the integration of these data is incomplete.

Muir Woods Trend: Unknown

Second-growth Stands Trend: Declining

Although weed invasion is progressing more slowly in redwood forests than in many other vegetation types on Mt. Tam, it is nonetheless a growing concern. The Golden Gate National Recreation Area's Natural Areas Condition Assessment has identified weed species that have entered Muir Woods and other redwood stands after 1987 as well as evidence of spatial expansion of species already present (GGNRA, 2015). At the same time, active weed management in Muir Woods has also increased. It is unclear from the available data whether declines achieved in some locations or with some species have offset the expansion noted by GGNRA, 2015

For broom species, MMWD time series data does account management actions: brooms within second-growth redwoods on MMWD lands increased from 119 to 135 acres between 2009–2014 (Williams, 2014; AIS, 2015).

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Data sources for acreages listed under the above metrics:

Aerial Surveys and Mapping:

- NPS 1994 vegetation map (Schirokauer et al., 2003)
- MMWD vegetation maps from 2004, 2009, and 2014 (AIS, 2015)
- MMWD broom mapping from 2003 drive-by survey, 2010 draft vegmgmt_polys_9_3, and 2013 broom remapping
- MMWD 2014 photo interpretation of SOD affected forest stands (AIS, 2015)

- MCP 2008 vegetation map (AIS, 2008)
- One Tam 2016 early detection and invasive plant mapping (Calflora, 2016)
- Larry Fox and Joe Saltenberger old-growth redwood data (Fox & Saltenberger., 2011)

ACREAGES CALCULATIONS

Old-growth acreage was derived from a GIS dataset, Old-growth Redwoods, Marin Public Lands (Fox & Saltenberger, 2011) provided by the Save the Redwoods League. The layer was clipped to Redwood Alliances listed in Table 3.5 within the Muir Woods boundary and Mount Tamalpais State Park boundary.

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

TABLE 3.5 METHODS USED TO CALCULATE ACRES OF COAST REDWOOD FOREST WITHOUT SOD AND WITHOUT INVASIVE SPECIES (AIS, 2015)

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
Coast redwood forest	• Coastal redwood • Redwood (pure) • Redwood/tanoak redwood-Douglas-fir (mixed hardwoods) • Redwood/chinquapin • Redwood/California bay • Redwood-upland mixed hardwoods • Redwood-riparian	Acres without SOD (canopy involvement)	Summed acreage of oak woodland polygons with attribute SOD*=0
		Acres without targeted invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*

*MMWD lands only

INFORMATION GAPS

Presence of Complex/Old-growth Habitat Structure: Quantification of habitat structure including measuring and mapping coarse woody debris, tree cavities, and nesting platforms is needed to inform Metric 1.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

OLD-GROWTH

- **Muir Woods and Steep Ravine:**
  - Ongoing, systematic invasive plant mapping and management on varying scales at Muir Woods for over three decades, and invasive species management and increasing Early Detection and Rapid Response (EDRR) work in Steep Ravine
  - Expansion of the EDRR program in 2012, the program through NPS-supported crews working Redwood Creek Watershed-wide, and One Tam crews focusing on detection and treatment work at Steep Ravine
- **Muir Woods:**
  - Installed more than 14,000 native plants to revitalize disturbed and compacted redwood understory habitat
  - Converted asphalt trails to raised boardwalks to reduce compaction and guide visitor access
  - Established boot-washing stations to reduce the risk of *Phytophthora* spread
  - Conducted an inventory to assess canopy health and species richness
  - Reduced the entrance parking lot size and converted part of it to a plaza
  - Improved the Hillside Trail in Muir Woods raised it above the fragile redwood root system
  - Collected LiDAR data to create topographic, stream channel, and tree canopy maps of Muir Woods and Kent Canyon which will help track changes to the forest over time

SECOND-GROWTH

- **Invasive Plant Management:** Regular invasive plant detection and response surveys along roads and trails that border and traverse redwood habitat (MMWD)
- **The Resilient Forest Project:** A series of forest treatment trials to identify ways to improve forest function and strengthen areas with high levels of SOD-related hardwood mortality including approximately 20 acres of redwood-tanoak forest initiated in 2015 and scheduled to continue for at least five years (MMWD and UC Davis)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

OLD-GROWTH

Existing Program Support:

- **Targeted Invasive Non-native Plant Species Control:** Sustain and expand targeted non-native, invasive plant control management in Muir Woods and initiate a comprehensive program at Steep Ravine to control targeted priority invasive plant species identified through the EDRR program and additional comprehensive surveys
- **Fuel Load Reduction, Roads, and Trails-related Management:**
    - Remove asphalt trails at Muir Woods, specifically adjacent to Cathedral Grove area and reduce compaction and social trails
    - Undertake a visitor use observation survey and trails planning document at Roy's Redwoods to understand and focus circulation and reduce social trails, with the goals of protecting and improving old-growth forest vegetation community and enhancing visitor experience

SECOND-GROWTH

Existing Program Support:

- **Targeted Invasive Non-native Plant Species Control:**
    - Pilot an invasive, non-native species control study (to include brooms) adjacent to or within forests occupied by breeding Northern Spotted Owls to enhance woodrat (prey) habitat
    - Document the effectiveness of increasing woodrat occupancy, including an inventory of existing woodrat nests prior to control treatment and monitoring to document potential increases
    - Expand targeted invasive plant removal program for species known to have impacts on redwood forest richness and structure, and identify priority geographic locations based upon EDRR and systematic community assessment work scheduled for 2017
- ***Phytophthora* Management:**
    - Expand the Forest Resiliency Study to State Parks lands and begin implementation once recommended management actions are identified from MMWD study
    - Implement best management practices designed to minimize the potential to import or spread invasive *Phytophthora* species

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CHAPTER 4. SARGENT CYPRESS (*CUPRESSUS SARGENTII*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: No Change

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Sargent cypress communities occur as open, scrubby forests and woodlands associated with serpentine chaparral. They are relatively limited in distribution and globally rare (Leonard Charles Associates [LCA], 2009). The “pygmy forest” of Sargent cypress along San Geronimo Ridge is a rare vegetation type that hosts several California Native Plant Society-listed and locally rare plant species.

In the One Tam area of focus, this community is characterized by an understory of navarretias, Indian warrior (*Pedicularis densiflora*), jewelflowers (*Streptanthus*), and scattered to dense Mt. Tamalpais manzanita (*Arctostaphylos montana* ssp. *montana,* a California Native Plant Society 1B species, which are Plants Rare, Threatened, or Endangered in California and Elsewhere). Sargent cypress communities provide habitat for large ground cone (*Kopsiopsis strobilacea*) and pleated gentian (*Gentiana affinis* ssp. *ovata*), which are also locally rare.

These communities are good indicators of wildfire and mechanical disturbance. Sargent cypress stands typically recruit new trees following stand-replacing wildland fires, making this a key disturbance process for their long-term persistence. Fire return intervals in Sargent cypress stands vary, but are typically multi-decadal. Too-frequent fires can threaten recruitment because individual trees need several years to mature and produce sufficient cones to create an adequate seedbank. Wildfire return intervals that are either too short (e.g., less than a decade) or too long (150+ years) can negatively impact this community (International Union for Conservation of Nature [ICUN], 2016).

Unlike many of the other vegetation communities chosen as indicators for the health of Mt. Tam, Sargent cypress appears to be relatively disease- and weed-free. A combination of shade and the properties of serpentine soils make these communities relatively resistant to weed invasion, with the exception of disturbance created by roads, trails, and fuelbreaks, which can create a point of entry for some invasive species (Leonard Charles Associates [LCA], 1995).

OVERALL CONDITION

The Marin Municipal Water District (MMWD) has data on the extent of Sargent cypress communities from 2004–2014 (Aerial Information Systems [AIS], 2015), and Marin County Parks (MCP) has surveys from 2008 (Aerial Information Systems [AIS], 2008). Based on these data, the One Tam area hosts approximately 366 acres of Sargent cypress. Stands have an even-aged appearance, a lack of visible canopy disease, and a low abundance of non-native species (Evens & Kentner, 2006). A good example of a healthy Sargent cypress community in the One Tam area of focus is the pygmy cypress forest along San Geronimo Ridge.

DESIRED CONDITIONS

Maintain more than 360 acres of Sargent cypress communities at the current spatial extent in the One Tam area of focus, supporting the current species richness and structural diversity, and with natural recruitment of Sargent cypress saplings and minimal invasive species.

STRESSORS

Changing Fire Regimes: Sargent cypress trees have an estimated life span of 300 years in the absence of disease of fire (Lanner, 1999). Cones are produced on trees that are five to seven years old, and need two years to mature. Fire plays a critical role in new tree recruitment by stimulating seed dispersal from serotinous cones and creating the bare soil conditions Sargent cypress seedlings need to establish. Consequently, even-aged stands which date from the last wildfire event are the norm for this species. A wildfire return interval of less than 10 years can damage young trees before they are able to reproduce, but one that is too great can lead to a stand's decline as older trees are not replaced (IUCN, 2016).

Roads, Trails, and Fuelbreaks: Road grading or mowing may impact trees growing along road shoulders. Roads, trails, and fuelbreaks also facilitate non-native, invasive species (mostly annual grasses such as purple false brome [*Brachypodium distachyon*]) encroachment by creating sunny openings and disturbance in otherwise closed-canopy, high-shade conditions that limit weed establishment.

Mistletoe (*Phoradendron bolleanum/pauciflorum*): Dense clusters of this species often form on bushy Sargent cypress trees in Marin County (IUCN, 2016). It is uncertain if this is detrimental to the trees, or just a result of stand age.

Douglas-fir Encroachment: Sargent cypress communities can be invaded by Douglas-fir, although that is less likely to occur in serpentine areas, as Douglas-fir is not as tolerant of those soil types.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: ACRES (TOTAL AND DISTRIBUTION)

Baseline: There are approximately 366 acres of Sargent cypress in the One Tam area of focus.

Condition Goal: Maintain more than 360 acres of Sargent cypress communities at the same spatial extent as shown in the 2004 vegetation survey (AIS, 2015)

Condition Thresholds:

- **Good:** Greater than 95% (360 acres) of Sargent cypress communities at all patches shown on the 2004 map

- **Caution:** Between 80–95% (300–350 acres) of Sargent cypress communities or the loss of one or more patches

- **Significant Concern:** Below 80% (below 300 acres) of Sargent cypress communities

Current Condition: Good

The current extent of 366 acres of Sargent cypress communities in the One Tam area of focus constitutes a current status of "Good."

Confidence: High

Updated MMWD vegetation maps from 2014 (AIS, 2015) show approximately the same extent of Sargent cypress as was seen in 2004. This, combined with field observations of little to no change in the extent of these communities, warrant a "High" level of confidence in the current status ranking.

Trend: No Change

Data from the 2014 update to the MMWD vegetation map indicate that there has not been a change in acreage of greater than 10% over the past 10 years (AIS, 2015), which would be the threshold for changing this trend to "Improving" or "Declining."

METRIC 2: RECRUITMENT OF NEW TREES AT LEAST AT REPLACEMENT LEVEL FOLLOWING FIRE EVENTS

Baseline: Unknown

Condition Goal: Seedling/sapling presence greater than or equal to tree mortality in burned stands

Condition Thresholds:

- **Good:** Seedling/sapling presence within 5% of tree mortality in 90% of burned stands

- **Caution:** Seedling/sapling presence within 5–25% of tree mortality in 80% of burned stands

- **Significant Concern:** Seedling/sapling presence within less than 25% of tree mortality in 80% of stands

Current Condition: Unknown. There is no available data on seedling recruitment following burn events on Mt. Tam. The last reported fire in Sargent cypress habitat occurred in 1945.

Confidence: Low

No data available

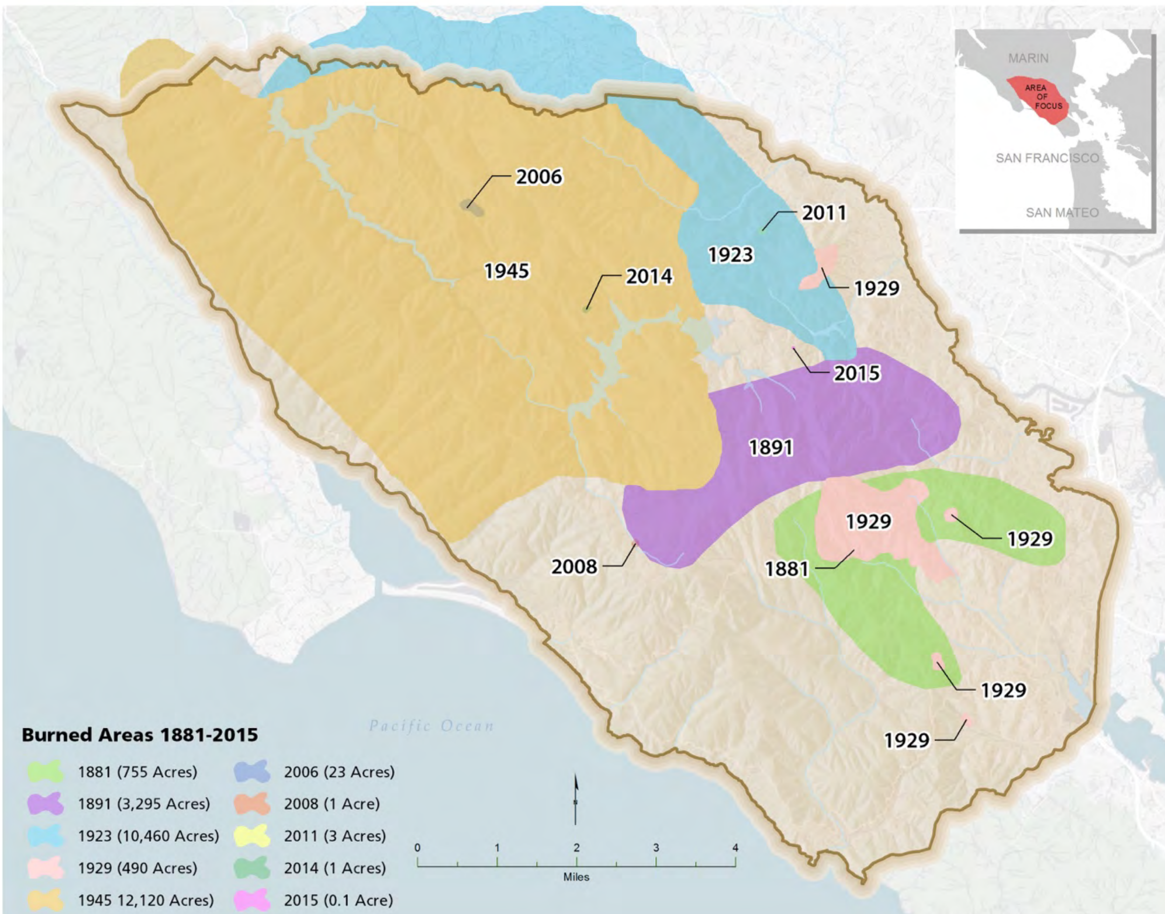
Trend: Unknown

This metric is currently dependent on wildfires in Sargent cypress habitat, which are rare events. In the absence of a systematic prescribed fire regime in this habitat type, there will continue to be insufficient data available to establish a trend.

METRIC 3: TIME SINCE LAST WILDFIRE

Baseline: Significant wildfires that extended hundreds to thousands of acres occurred on Mt. Tam in 1881, 1891, 1923, 1929, and 1945 (Figure 4.1). A regional policy of aggressive wildfire suppression and fuels management combined with improving response capabilities has greatly reduced the spatial extent of wildfires following both natural and human caused ignitions (Panorama Environmental, 2016).

FIGURE 4.1 MAP OF AREAS BURNED ON MT. TAM WATERSHED LANDS (MMWD DATA)



Condition Goal: At least 80% of Sargent cypress habitat in the One Tam area of focus has experienced a broadcast burn event within the last 150 years, with a return interval of less than one fire every 10 years

Condition Thresholds:

- **Good:** 70-80% of Sargent cypress habitat in the One Tam area of focus has experienced a broadcast burn event the last 150 years, with a return interval of less than one fire every 10 years.

- **Caution:** 50-70% of Sargent cypress habitat in the One Tam area of focus has experienced a broadcast burn event the last 200 years, with a return interval of less than one fire every 10 years

- **Significant Concern:** Less than 50% of Sargent cypress habitat in the One Tam area of focus has experienced a broadcast burn event the last 150 years, with a return interval of less than one fire every 10 years

Current Condition: Good

Over 75% of the Sargent cypress habitat has experienced at least one burn event after 1880 and nearly 70% burned as recently as 1945. Less than 25% of the Sargent cypress habitat on Mt. Tam is estimated to be older than 135 years (Leonard Charles Associates [LCA], 1995).

Confidence: High

Spatial distribution of existing Sargent cypress stands have been cross-referenced with maps of historic fires on Mt. Tam that were developed using a combination of historic records and ground surveys of burn scars and residual charcoal (LCA, 1995).

Trend: No Change

METRIC 4: TARGETED NON-NATIVE, INVASIVE SPECIES COVER

Baseline: Serpentine soils are invaded by a limited range of species as a result of their abiotic environments, and canopy shade may further limit potential invasions. Field observations indicate that most non-native, invasive species in Sargent cypress communities exist at the periphery along roads and trails where shade is low and disturbance is highest (MMWD, unpublished data).

Condition Goal: Sargent cypress stands are weed-free

Condition Thresholds:

- **Good***:* Less than 1% (or 3.66 acres in the current 366-acre extent) of Sargent cypress-dominated areas have non-native, invasive plant cover

- **Caution:** Between 1–5% of Sargent cypress-dominated areas have non-native, invasive plant cover

- **Significant Concern:** More than 5% of Sargent cypress-dominated areas have non-native, invasive plant cover

Current Condition: Good

The 13 Sargent cypress plots from the MMWD 2004 map average 0.6% invasive plant species cover (13 plots, one with 2% and one with 6%).

Confidence: Moderate

Data from 2005 measurements within the majority of the Sargent cypress area support the observations by staff that communities are largely weed-free.

Trend: Unknown

There is no repeat rélevé data. However, the level of invasive species infestation in Sargent cypress communities seems to be stable based on field observations. During rare plant surveys in 2016, One Tam staff surveyed five serpentine barrens bounded by Sargent Cypress woodlands. Target invasive species for those surveys include *Brachypodium distachyon* and *Aegilops truincialis. Brachypodium didstachyon* was recorded in or adjacent to four of five barrens. When grasslands or roadsides were also adjacent to the survey area, in one instance, *Brachypodium distachyon* cover exceeded 1%. In serpentine soils, including barrens and adjacent Sargent cypress woodlands, cover remained less than 1%.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Data Sources for Acreages Listed Under the Above Metrics:

- NPS 1994 map of Golden Gate National Recreation Area lands, and Mount Tamalpais State Park (revealed no Sargent cypress communities) (Schirokauer, et al. 2003)
- MMWD's original 2004 vegetation map, which was updated in 2009 and 2014 to track the progression of Sudden Oak Death (AIS, 2015)
- MCP 2008 vegetation map, which was created with a methodology similar to that used by MMWD (AIS, 2008)

ACREAGES CALCULATIONS

TABLE 4.1 METHODS AND DATA USED TO CALCULATE ACREAGES OF SARGENT CYPRESS COMMUNITIES

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
Sargent cypress communities	• Sargent cypress alliance • Sargent cypress / Mt. Tamalpais manzanita • Sargent cypress pure stands	Acres (total and distribution)	Total acreage of all Sargent cypress types; visual assessment of spatial distribution

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Invasive Species and Recruitment Data: Ground plots sampled for the production of the 2004 vegetation map should be resampled to determine change over time in weed abundance. Burn sites should be monitored for seedling recruitment.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Mapping and Inventories: Periodic vegetation community mapping and ongoing Early Detection and Rapid Response (MMWD)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Manage Fire-dependent Communities:**
    - Establish an adaptive management program to include installation of burn box fire plots
    - If controlled burns within plots appear to result in successful recruitment, consider future controlled burns at isolated stands (at some frequency to be determined)
    - Determine efficacy of outplanting manipulated/fire-treated seed within test plots, absent of prescribed fire

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CHAPTER 5. OPEN-CANOPY OAK WOODLANDS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Caution

Trend: Declining

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Open-canopy oak woodlands on Mt. Tam are characterized by the presence of long-lived acorn-producing trees from the genus *Quercus*. This discussion focuses on stands with dominant species include coast live oak (*Q. agrifolia*), valley oak (*Q. lobata*), Oregon white oak (*Q. garryana* var. *garryana*), and/or black oak (*Q. kelloggii*). The most common co-occurring tree species include bay laurel (*Umbellularia californica*), madrone (*Arbutus menziesii*), and tanoak (*Notholithocarpus densiflora*). Most stands dominated by interior live oak (*Q. wislizeni*), canyon live oak (*Q. chrysolepis*), Shreve's oak (*Q. parvula* var. *shrevei*), or leather oak (*Q. durata*) dominated stands are excluded because their overall structure is presently more similar to shrublands or to closed canopy mixed hardwood forest.

In California, oak woodlands are typically defined as stands with oak cover ranging between 10 and 60%. (Sawyer & Keeler-Wolf, 2009). This definition served as a general guide to identifying woodlands as distinct from forests, but was not used as a definitive rule (J. Menke, personal communication). In the future, it may be appropriate to look more broadly at currently excluded vegetation types as disease, drought, changes in the fire regime, and/or human intervention contribute to changes in forest and woodland structure.

Although open-canopy oak woodlands have many tree species in common with mixed hardwood forests, the lower density and patchier distribution of trees create a distinct habitat structure for both herbaceous plants and wildlife. Understory species also include a distinct and more varied array of grasses, sedges, and forbs than closed canopy forests (Evens & Kentner, 2006). Oak woodlands in California support 1,400 species of flowering plants and over 300 species of vertebrates, which is more species than any other habitat type in the state (Mayer et al., 1986).

On Mt. Tam, open-canopy oak woodlands can be used as an indicator of forest disease, fire regimes, and habitat quality for a number of oak-dependent birds (Rizzo et al., 2003; Holmes et al., 2008; Cocking et al., 2014). Lace lichen (*Ramalina menziesii*), which is California's state lichen, primarily grows in open-canopy oak woodlands and is a good indicator of air quality (Sharnoff, 2014). Between 80 and 90% of California's oak woodlands are under private ownership (Bolsinger, 1988; Ewing et al., 1988; Greenwood et al., 1993; Davis et al., 1998), making conservation of these community types on public lands a high priority.

OVERALL CONDITION

Mt. Tam supports approximately 2,154 acres of open-canopy oak woodlands that meet this definition, covering approximately 6% of the open space in the One Tam area of focus (see Table 2.1 in Chapter 2). The mountain is home to valley oak woodlands, which are restricted to California, and are considered a plant community that is threatened and of high priority for inventories (List of Vegetation Alliances and Associations, 2010). Mt. Tam also has the southernmost patch of Oregon white oak-California fescue (*Festuca californica*) association.

DESIRED CONDITIONS

The desired conditions for open-canopy oak woodlands in the One Tam area of focus are maintenance of the full spatial extent of this vegetation type (2,154 acres), the persistence of a discontinuous canopy dominated by trees from the genus *Quercus*, and a discontinuous shrub layer and an herbaceous layer dominated by native species. Good examples of this type can be found in the Bon Tempe/Lake Lagunitas area and in the Cascade Canyon Preserve.

STRESSORS

Sudden Oak Death (SOD): A 2014 Marin Municipal Water District (MMWD) survey found that more than 90% of open-canopy oak woodlands were impacted by SOD (Aerial Information Systems [AIS], 2015). The loss of so many trees creates canopy gaps, reduces wildlife food sources, may reduce gene flow and genetic diversity within impacted species, and can at least temporarily increase the hazard for higher severity fires around impacted trees (Rizzo, 2003).

Altered Fire Regime: Historically, wildfires in north coast oak woodlands were typified by their high frequency and limited intensity. Crown fires were relatively rare, and mature oaks typically survived. Wildfires maintained an open-canopy structure, limited the development of a shrub layer, and prevented the establishment of Douglas-fir (*Pseudotsuga menziesii*) (Holmes, 2008). Over 100 years of fire suppression on Mt. Tam has changed oak woodland stand structure, and increased fuel loads. This in turn increases the associated risks of high-intensity wildfires with the potential to kill mature oaks. Fuel loads are also increasing due to SOD-related tree mortality as well as invasion by Douglas-fir and perennial weeds like French broom (*Genisa monspessulana*) (Leonard Charles Associates [LCA], 2009).

Lack of Top Predators and Cascading Effects: In the past, Native Americans, mountain lions, and wolves all preyed on deer. The loss of these predators from the ecosystem means that deer densities are likely elevated compared to historic levels. There is ample evidence supporting the hypothesis that high densities of ungulate grazers result in elevated browsing pressure on broadleaf tree seedlings and young saplings, leading to a depressed rate of new tree recruitment (Beschta, 2005; Ripple & Beschta, 2008).

Douglas-fir Recruitment into Oak Woodlands: Due to thousands of years of deliberate human fire use and burning, less fire tolerant species such as Douglas-fir were kept out of large areas of woodlands now dominated by oaks. On Mt. Tam, the recent fire regime of very infrequent fires has allowed Douglas-fir to recruit into these oak-dominated woodlands. Douglas-firs that exceed the height of the oak canopy reduce oak growth and vigor, and may eventually lead to mortality and lower adult tree densities (Cocking et al., 2014).

Turkeys: Wild turkeys (*Meleagris gallopavo*) released in Marin and Sonoma Counties for sport hunting in the 1980s have expanded throughout the State of California. Heavy acorn predation by foraging turkeys reduces oak recruitment, and the associated soil disturbance may also create conditions favorable to invasive plant species germination (Fehring et al., 2007).

Poor Sapling Recruitment: A common perception is that oaks are not recruiting in sufficient numbers to sustain populations, but empirical evidence for this problem is sparse. Many factors have been proposed for the apparent recruitment failure in many oak species which varies by species (Garrison et al., 2002; Tyler et al., 2006). Some evidence does indicate that browsing pressure from deer and rodents is leading to depressed seedling survival for many oak species (Tyler et al., 2002; Ripple & Beschta, 2007; Kuhn, 2010; Davis et al., 2011).

CONDITION AND TRENDS ASSESSMENT

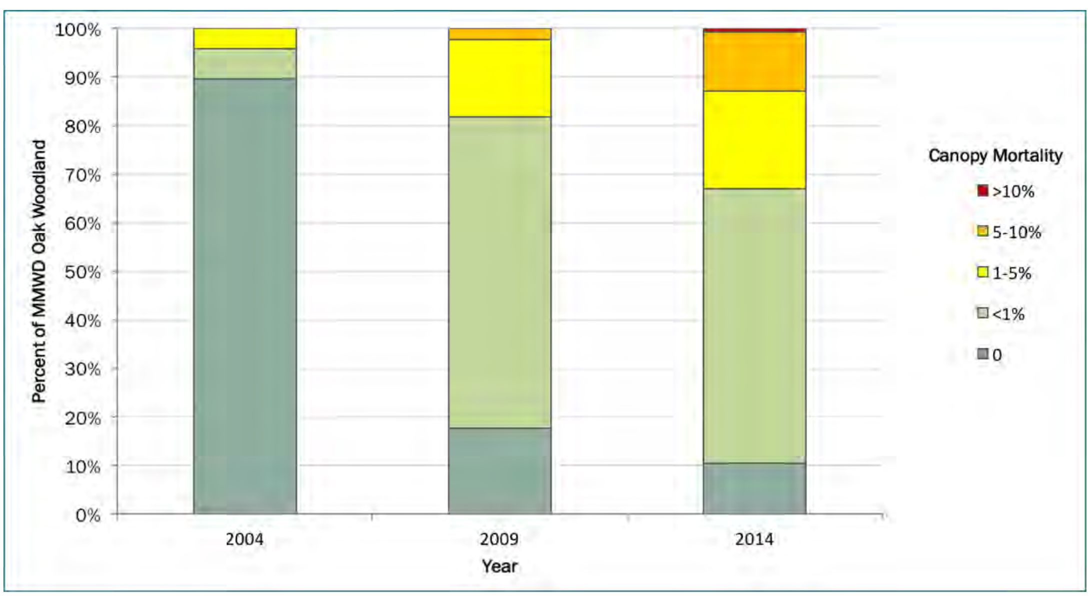
METRICS AND GOALS

METRIC 1: HARDWOOD CANOPY COVER

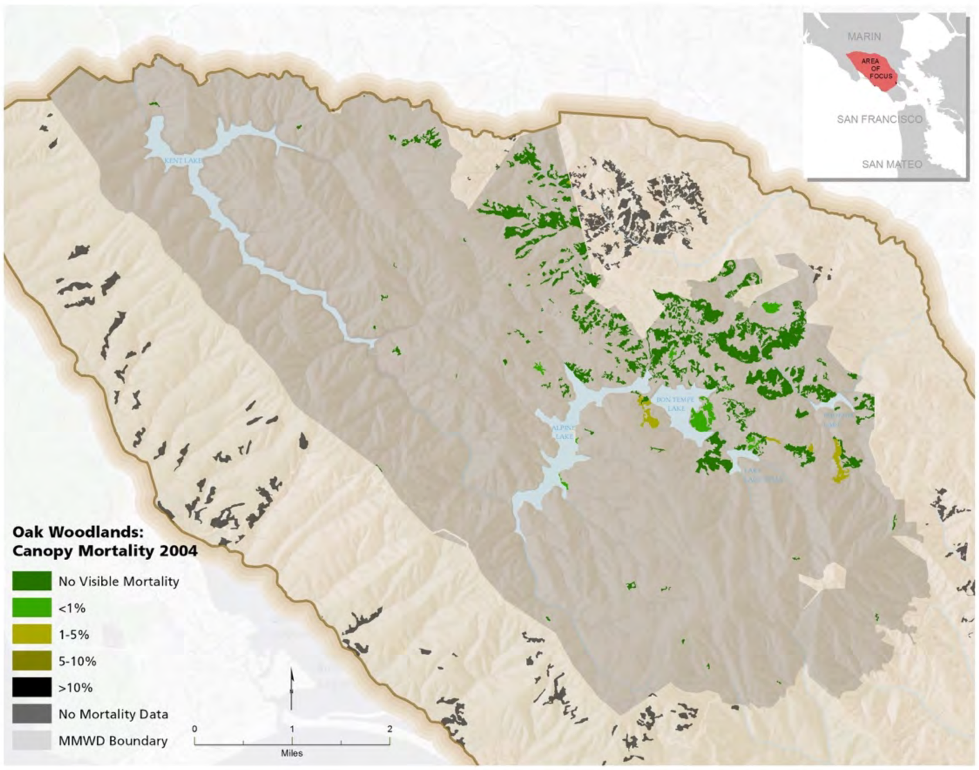
Baseline: *Phytophthora ramorum*, the pathogen that causes SOD, was unknown in Marin County prior to 1995 (Rizzo et al., 2003). It is now well established in the Mt. Tam area of focus that eradication is not likely, and the accelerated decline and death of tanoaks, coast live, and black oaks in Marin County is likely to continue into the foreseeable future (Cunniffe et al., 2016). Over the last 10 years, detectable signs of canopy disease have increased dramatically in MMWD's oak woodlands (Figures 5.1 and 5.2A and B), with similar observations made by resource staff on other agency lands.

Disease in the canopy corresponds to tree mortality. On MMWD lands, nearly 370 acres (40%) of oak woodland habitat has experienced hardwood cover decreases of 5–25% (Table 5.1) in a five-year period. The MMWD 2014 vegetation map indicates nearly 78 acres or 8% of the coast live oak woodland vegetation types have less than 25% cover of hardwoods (Table 5.1). As the SOD epidemic continues, these areas have an increased potential to convert to grassland or shrubland habitat types.

FIGURE 5.1 CANOPY MORTALITY IN OAK WOODLANDS ON MMWD LANDS (AIS, 2015)



FIGURES 5.2A AND B CHANGE IN CANOPY MORTALITY IN OAK WOODLANDS ON MMWD LANDS, 2004–2014



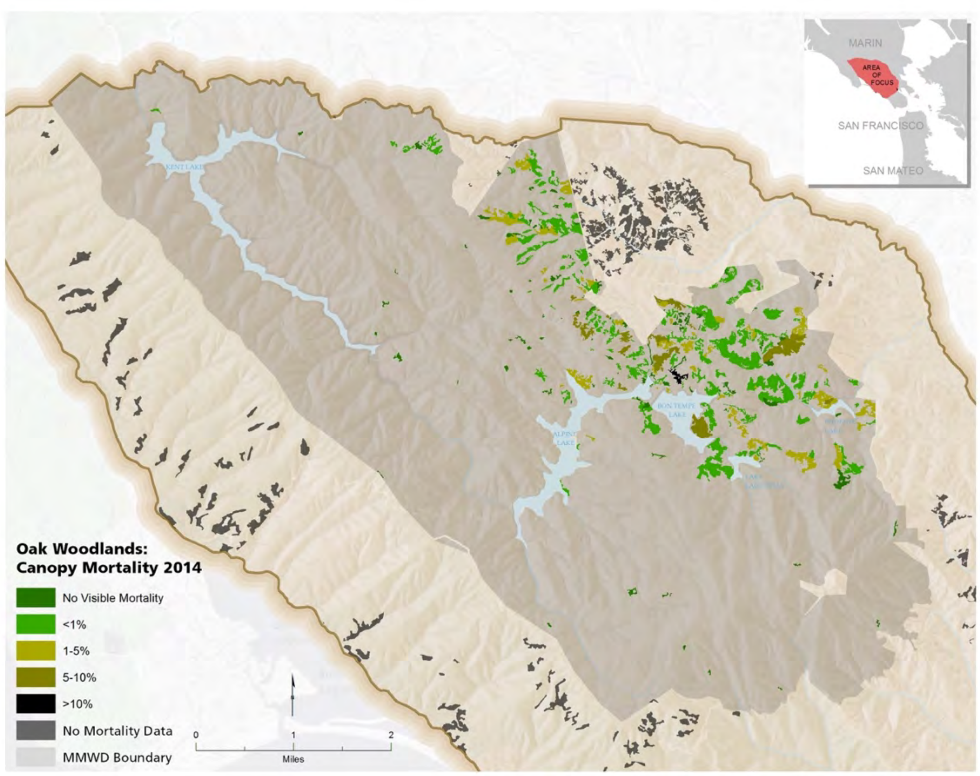


TABLE 5.1 FIVE-YEAR CHANGE IN HARDWOOD COVER IN OAK WOODLANDS ON MMWD LANDS, 2014 (AIS, 2015)

	Five-year Change in Hardwood Cover			
Acres by Vegetation Type	Increasing (+5 to 10%)	Decreasing (-5 to 25%)	Stable	Total
Black oak	0	0.5	5.2	5.7
Coast live oak	9.4	365.8	532.5	907.7
Interior live oak	0	0	24.5	24.5
Oregon oak	0	2.6	3.5	6.2
Valley oak	0	0	10	10
Total acres	**9.4**	**368.9**	**575.8**	**954.1**
% of MMWD oak woodland habitat	**1%**	**39%**	**60%**	**100%**

Condition Goal: Maintain approximately 2,150 acres of oak woodland with oak canopy cover between 25–60%

Condition Thresholds:

- **Good:** More than 1,940 acres (90%) of oak woodland with hardwood cover above 25% and the number of acres with a decline in hardwood cover of more than 5% is less than 5% (100 acres) over five years

- **Caution:** 1,500-1,940 acres (70–90%) of oak woodland with hardwoods cover above 25% and the number of acres with a decline in hardwood cover of more than 5% is between 5–10% (100–200 acres) over five years

- **Significant Concern:** Less than 1,500 acres (70%) of oak woodland with hardwood cover above 25% and the number of acres with a decline in hardwood cover of more than 10% is greater than 10% (200 acres) over five years

Current Condition: Caution

The Marin Municipal Water District's 2014 vegetation map indicates nearly 92% of the oak woodland vegetation types have more than 25% cover of hardwoods (Table 5.2; AIS 2015). Assuming this is representative of other, non-MMWD oak woodlands within the One Tam area of focus, 1,980 total acres of oak woodland are estimated to have a hardwood cover below 25%, which falls above the "Good" threshold.

At the same time, the percent cover of hardwoods has declined by more than 5% in nearly 370 acres (40%) of MMWD oak woodland habitat in five years. Assuming this is representative of other oak woodlands within the One Tam area of focus, the total number of oak woodland acres with hardwood canopy cover declines above 5% is estimated to be 800 acres which is far below the threshold for "Significant Concern."

TABLE 5.2 CANOPY COVER IN OAK WOODLANDS ON MMWD LANDS, 2014

Acres by Vegetation Type	Less Than 2%	2–10%	10–25%	25–40%	40–60%	Over 60 %	Total Acres
Black oak					0.5	5.2	5.7
Coast live oak		5.9	48.9	22.9	220.3	609.7	907.7
Interior live oak	1.6	21.5			0.8	0.6	24.5
Oregon oak						5.5	5.5
Valley oak						10	10
Total acres	**1.6**	**27.4**	**48.9**	**22.9**	**221.6**	**631**	**953.4**

Confidence: Moderate

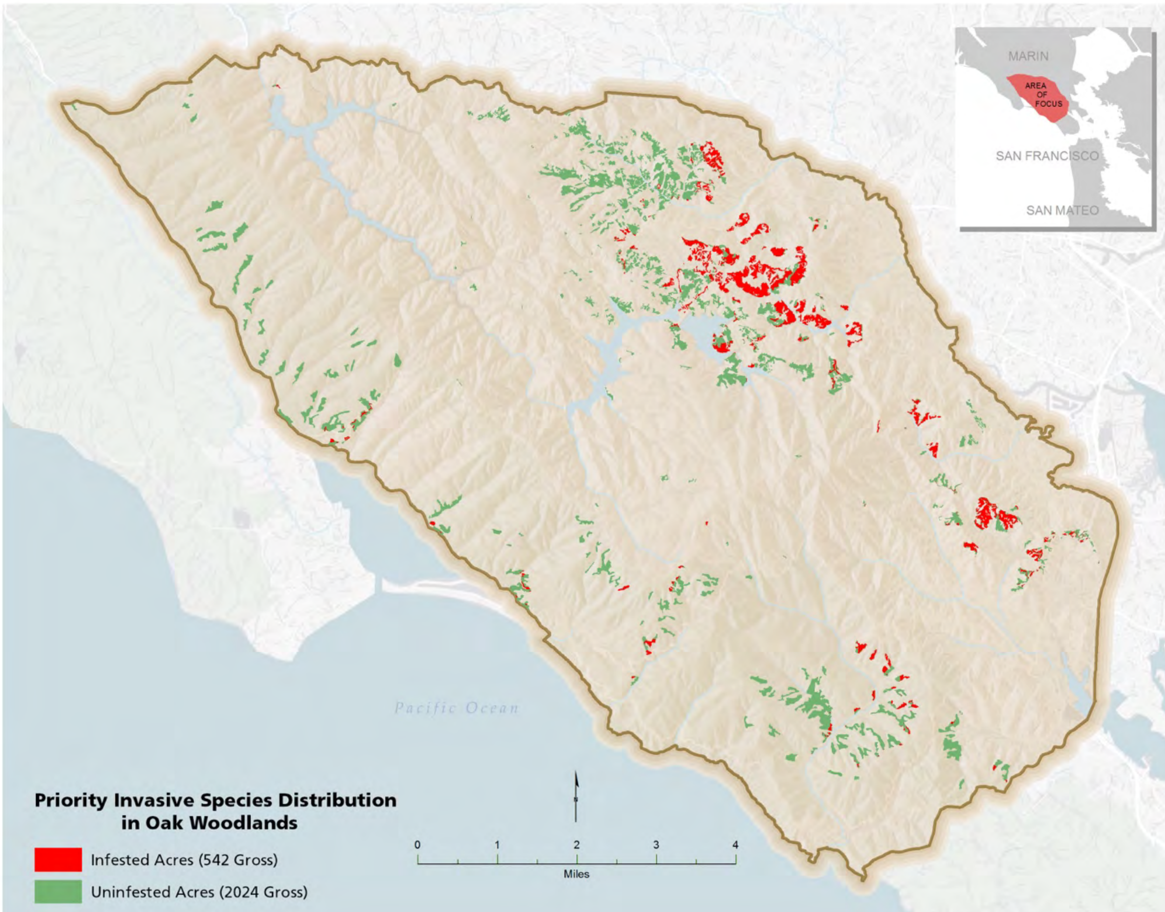
The Marin Municipal Water District's oak woodlands represent 41% of that habitat type in the One Tam area of focus and their decline is presumed to be representative of the situation on lands managed by other jurisdictions. However, these data are lacking from the other partner agencies.

Trend: Declining

METRIC 2: ACRES WITHOUT PRIORITY INVASIVE SPECIES

Baseline: French and Scotch broom (*Genista monspessulana* and *Cytisus scoparius*, respectively), as well as other invasive plant species such as panic veldt grass (*Ehrharta erecta*), cape ivy (*Delairea odorata*), and cotoneaster (*Cotoneaster* spp.) were introduced to Mt. Tam from other parts of the world over the last century. Because they are relatively recent arrivals, the historic baseline is zero acres of open-canopy oak woodlands where these invasive species are present. Healthy open-canopy oak woodlands do not have target invasive species, and broom reduction in oak woodlands has been a high priority on One Tam partner agency lands. At least 545 weed-infested acres of oak woodlands have been identified in the Mt. Tam area of focus to date.

FIGURE 5.3 INVASIVE SPECIES DISTRIBUTION IN OAK WOODLANDS ON MT. TAM, 2014 (CALFLORA, 2016)



Condition Goal:

- High priority invasive plant species at less than 5% cover in oak woodland habitat

Condition Thresholds:

- **Good:** 90% of oak woodlands with less than 5% cover invasive species
- **Caution:** 80-90% of oak woodlands with less than 5% cover invasive species
- **Significant Concern:** Less than 80% of oak woodlands with less than 5% cover invasive species

Current Condition: Significant Concern

Available data from all One Tam partners show that 545 acres (25%) of open-canopy oak woodlands are impacted by invasive species—including French and Scotch brooms, cotoneaster species, panic veldt grass, and Algerian, English and cape ivies—which falls below the threshold for "Significant Concern." Percent cover data are incomplete. However, review of records available for a single species within a single jurisdiction (French broom in MMWD oak woodlands, Table 5.3) indicate the threshold for “Caution” has been exceeded.

TABLE 5.3 PERCENT COVER OF FRENCH BROOM IN OAK WOODLANDS ON MMWD LANDS, 2013

Cover Class	Acres
<1%	36
1–10%	75
11–35%	86
36–65%	92
66–100%	43

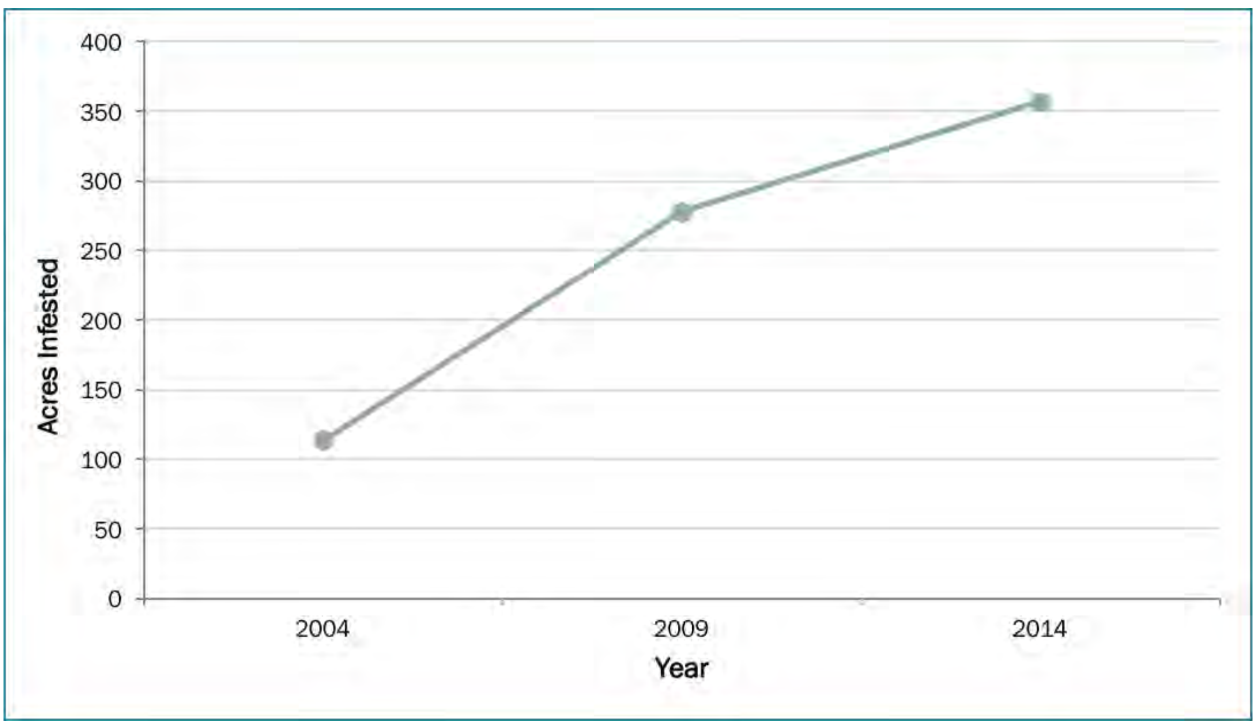
Confidence: Moderate

All One Tam partners maintain invasive species records which include spatial distribution, percent cover estimates, and management history information. However, mapping efforts and protocols are not uniform across jurisdictions and the integration of these data is incomplete.

Trend: Declining

Available data from all One Tam partners indicates the spatial extent and percent cover of invasive species in oak woodlands continues to increase. Time series data for a single species within a single jurisdiction (Figure 5.4) is presumed to be representative.

FIGURE 5.4 FRENCH BROOM SPREAD IN OAK WOODLANDS ON MMWD LANDS, 2004–2014 (WILLIAMS, 2014)



METRIC 3: ACRES WITHOUT CANOPY-PIERCING DOUGLAS-FIR

Baseline: When Douglas-fir becomes established in the canopy above hardwoods, oak woodland patches fill in and transition into mixed hardwood forest which has lower habitat value for certain bird and plant species (Cocking et al., 2014). The best available baseline data come from the 2004 MMWD survey, which found 46 acres of open-canopy oak woodlands with canopy-piercing Douglas-fir. Assuming a similar level of presence on the other One Tam partner agency lands, the total baseline would be approximately 100 acres of open-canopy oak woodlands with canopy-piercing Douglas-fir.

Condition Goal: Maintain 90% (1,940 acres) of current oak woodlands without canopy-piercing Douglas-fir

Condition Thresholds:

- **Good:** More than 1,940 acres (90%) without canopy-piercing Douglas-fir
- **Caution:** 1,455–1,940 acres (70–90%) of open-canopy oak woodlands without canopy-piercing Douglas-fir
- **Significant Concern:** Less than 1,455 acres (70%) of oak woodlands without canopy-piercing Douglas-fir

Current Condition: Caution

The most recent vegetation maps for Marin County Parks (MCP) and MMWD document 260 acres of oak woodlands with canopy-piercing Douglas-fir. This represents approximately 19% of the combined oak woodlands within these two jurisdictions. Extrapolating to the entire One Tam area of focus, approximately 400 acres of oak woodlands may have Douglas-fir in the canopy.

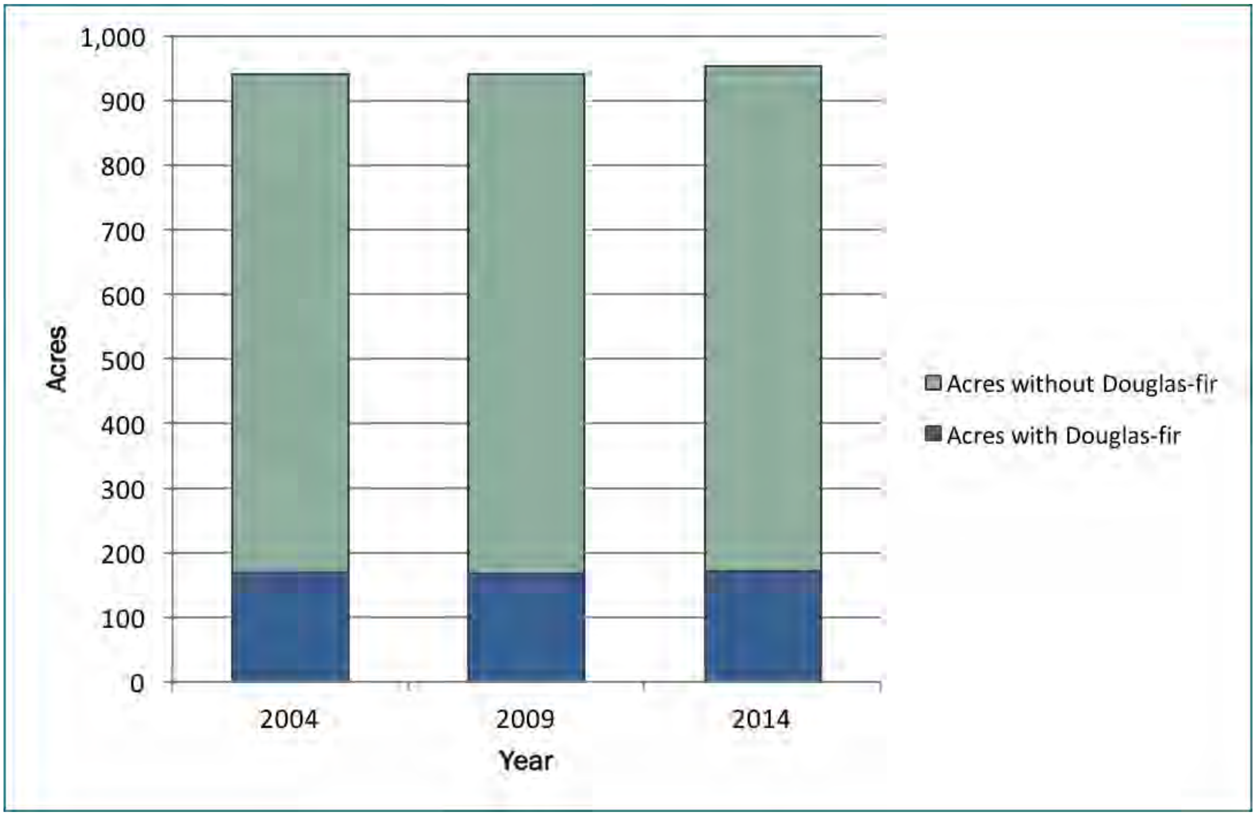
Confidence: Moderate

Data from MMWD and MCP vegetation maps represents 66% of oak woodlands in the One Tam area of focus. National Park Service (NPS) and California State Parks (State Parks) do not have similar data, but conditions are likely to be similar.

Trend: No Change

Time series data from MMWD indicates the spatial extend canopy-level Douglas-fir in oak woodlands was unchanged between 2004–2014 (Figure 5.5). Conditions on MMWD lands are presumed to be representative or slightly better than those of the One Tam area of focus as a whole because MMWD is thinning Douglas-fir saplings in select oak woodland patches while other jurisdictions are not.

FIGURE 5.5 DOUGLAS-FIR IN OAK WOODLANDS ON MMWD LANDS, 2004–2014 (AIS, 2015)



SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Data sources for acreages listed under the above metrics:

Aerial Surveys and Mapping:

- MMWD vegetation maps from 2004, 2009, and 2014 (AIS, 2015)
- MMWD broom mapping from 2003 drive-by survey, 2010 draft vegmgmt_polys_9_3, and 2013 broom remapping
- MMWD 2015 photo interpretation of SOD affected forest stands (AIS, 2015)
- MCP 2008 vegetation map (Aerial Information Systems [AIS], 2008)
- MMWD, MCP, State Parks, and NPS weed records from both Calflora Database and internal records

ACREAGES CALCULATIONS

TABLE 5.1 METHODS AND DATA USED TO CALCULATE ACREAGES OF SOD, DOUGLAS-FIR, AND BROOM

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
Open-canopy oak woodlands	• Black oak alliance • Coast live oak (CLO) alliance • CLO/grass-poison oak; CLO–riparian • CLO–Douglas-fir • Oregon oak alliance • Valley oak riparian mapping unit • Interior live oak (ILO) alliance • Interior live oak-Eastwood manzanita • Coastal open-canopy oak woodland	Acres without SOD (canopy involvement)	Summed acreage of oak woodland polygons with attribute SOD*=0
		Acres without broom or other targeted priority invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*
		Acres without canopy-piercing Douglas-fir	Summed acreage of oak woodland polygons with MMWD attribute ConDensity >0; MCP ConDen >0

*MMWD data only

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Species Richness: Some measure of the diversity of native species present was identified as an important metric for open-canopy oak woodlands. The goal would then be to maintain species richness at the reference condition for this community type. While some data may be available to support this assessment, there is not currently enough information to make any statement about condition or trend.

Age Structure of Native Trees: Another important metric, which would be useful in determining whether new trees are being recruited at a rate that is sufficient to maintain the total acres and structural integrity of open-canopy oak woodlands over time. A stable age structure follows a reverse J-curve frequency distribution, with abundant seedlings and fewer individuals in successively older age. This expected age structure is used to calculate a ratio of seedling to adult densities. This is then compared to the observed ratio. Anecdotal evidence from the county and data from throughout California indicate that at least some oak species appear to lack sufficient recruitment to replace adult mortality (Bolsinger, 1988; Tyler et al., 2006), While some data may be available to support this assessment, there is not currently enough information to make any statement about condition or trend for Mt. Tam.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration:

- Succession management through volunteer restoration workdays to pull broom and cut encroaching Douglas-fir saplings in some areas, with additional conifer removal done by staff and contractors

- Wide Area Fuel Load Reduction project at Pine Point, a joint project by MMWD and Youth2Work, that removed Douglas-fir and non-native pine invading oak woodlands and grasslands and replaced Douglas-fir with native SOD-resistant oaks to meet both ecosystem and fuels reduction goals

Monitoring:

- Aerial photo monitoring and interpretation of vegetation communities repeated every five years to examine SOD distribution and impact (MMWD)

- Invasive plant species early detection mapping and monitoring (MMWD, NPS, and MCP)

Outreach: Partnership with UC Cooperative Extension on public outreach to build awareness about SOD spread, impacts, and risk reduction measures

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Targeted Non-native, Invasive Plant Species Control:** Develop and implement mountain-wide targeted program to remove invasive plant species known to have impacts on open-canopy oak woodland species richness and structure, including panic veldt grass, cape ivy, cotoneasters, and brooms

- **Succession Management:**

    - Identify pilot locations for utilizing prescribed fire a tool for managing oak woodland succession, integrating other management techniques including initial mechanical treatment before fire is utilized

    - Sustain and expand Douglas-fir control management actions in selected oak woodland habitats as needed as a proxy for wildland fire based on assessments of the status and trends in Douglas-fir recruitment into oak woodlands (MMWD);

adaptively manage and assess efficacy and impact, with the potential goal of expanding program into other jurisdictions

- **Restoration:** Increase oak tree revegetation actions to maintain or increase native hardwood cover

- **Fuel Load Reduction, Roads, and Trails-related Management:**

    - Restore open-canopy oak woodland habitat at Kings Mountain Preserve and Cascade Canyon Preserve by strategically expanding Wide Area Fuel Load Reduction projects, which often includes the removal of target invasive species such as acacia and broom

    - Consider expanding a 20-acre project at Kings Mountain Preserve into priority areas where weed infestations within wildland interface areas are impacting open-canopy oak woodland habitat

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CHAPTER 6. SHRUBLANDS: COASTAL SCRUB AND CHAPARRAL (INCLUDING SERPENTINE CHAPARRAL)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: No Change

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Chaparral—the most widespread and characteristic type of shrubland in California—is dominated by sclerophyllous (hard-leaved), evergreen shrubs such as chamise, manzanita, and hard-leaved ceanothus species. These drought-tolerant plants are adapted to the steep slopes, shallow, rocky soils, hot, dry summers, and wet winters of the Coast Ranges. Serpentine chaparral is an open, low-growing type of this community that is associated with the harsh conditions found in serpentine soils (see Chapter 9). On Mt. Tam, chaparral tends to occupy elevations above 400 meters, the average altitude of the summer marine inversion layer (Johnstone & Dawson, 2010), where summers are hotter and drier, winters are colder, and more precipitation falls due to uplift. Maritime chaparral is a notable exception, occurring at lower elevations on isolated patches of poorly-developed soils (Sawyer et al., 2009).

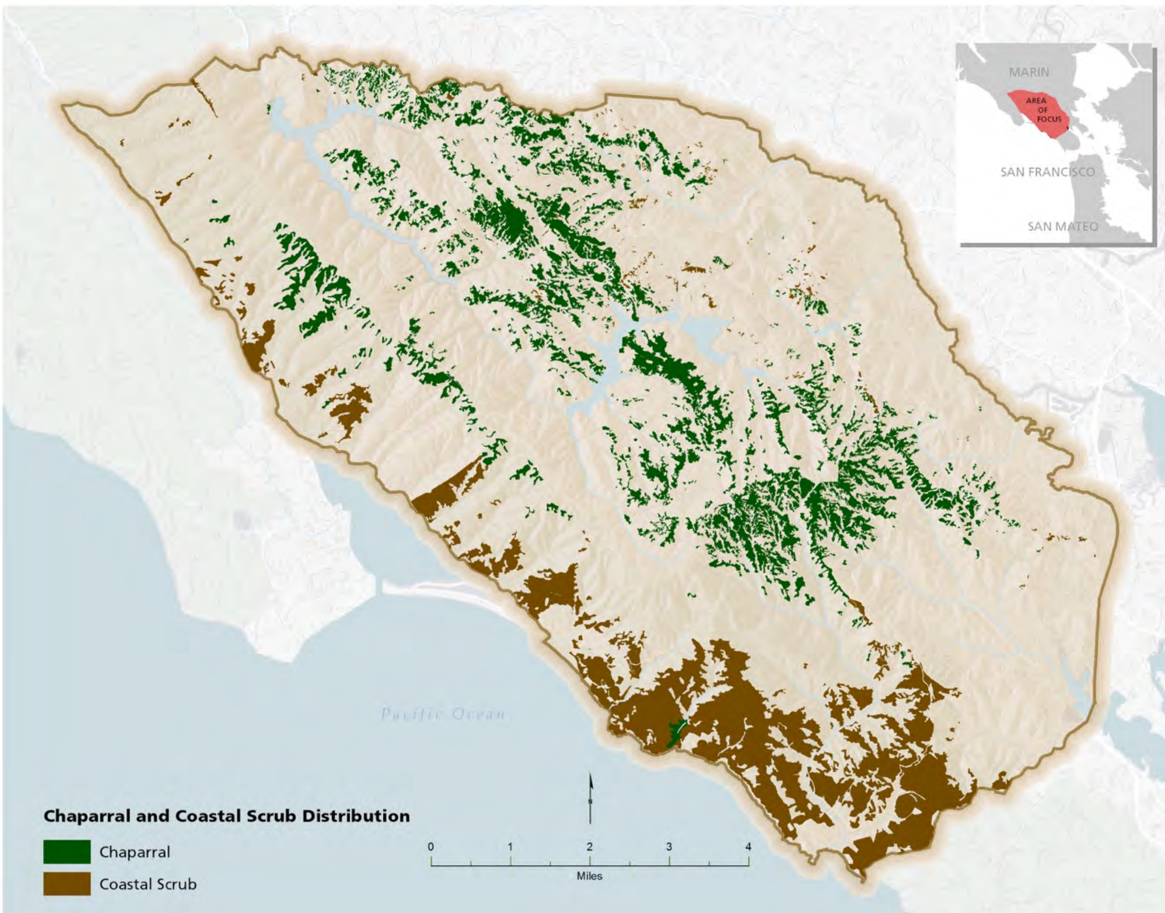
Coastal scrub is dominated by soft, woody shrubs which thrive in the narrow zone of maritime climate along the California Coast. Coyote brush (*Baccharis pilularis*), an evergreen shrub, is characteristic of the northern division of coastal scrub (Ford & Hayes, 2007), which predominates on Mt. Tam. Coastal scrub is typically found on well-developed soils below 400 meters, where summer fog is frequent. Maritime influence in this zone ameliorates summer drought stress, moderates seasonal temperature extremes, and exposes vegetation to salt-laden air masses. In hotter, drier settings drought-deciduous species such as California sagebrush (*Artemisia californica*) and sticky monkeyflower (*Mimulus aurantiacus*) are favored. In cooler, wetter settings winter-deciduous species are favored, such as brambles (*Rubus* spp.), and hazelnut (*Corylus cornuta*). Coyote brush frequently invades grasslands in the absence of grazing and fire, and stands of coastal scrub can be mid-successional to woodlands, or may persist for a long time (Heady et al., 1988).

The shrublands of Mt. Tam can be used as indicators of successional processes, disturbance, and habitat quality for terrestrial birds. Intact shrublands are fairly resistant to plant invasions, in part due to the high densities of small herbivores that shelter and forage in the understory (Lambrinos, 2002), Disturbances that create openings can be exploited by invasive plants (D'Antonio, 1993). The preservation of large blocks of coastal scrub and chaparral is also critical to the long-term viability of many bird species (California Partners in Flight, 2004).

OVERALL CONDITION

There are approximately 8,160 acres of shrublands—or approximately 21% of the open space—in the One Tam area of focus, with 3,864 acres of coastal scrub, 3,071 acres of chaparral (including maritime chaparral), and 875 acres of serpentine chaparral (Figure 2.1 and 6.1). The condition and trend of maritime chaparral are addressed separately in Chapter 7.

FIGURE 6.1 MAP OF CHAPARRAL AND COASTAL SCRUB IN THE ONE TAM AREA OF FOCUS



DESIRED CONDITIONS

The desired condition for shrubland habitat in the One Tam area of focus is the persistence of large, weed-free blocks of this vegetation type that provide habitat for shrubland-dependent plant and wildlife species that are sensitive to edge effects and fragmentation. Because some shrubland vegetation subtypes are mid-successional, maintenance of the total number of shrubland acres is less important than maintaining large, contiguous blocks (30 acres or greater in size).

STRESSORS

Invasive Plant Species: The dense canopy of mature chaparral makes it resistant to invasion by non-native plant species (Dickens & Allen, 2014). Large, intact patches of coastal scrub are also resilient to invasion, but because coastal scrub is generally less dense than chaparral, it is more vulnerable, especially in gaps and along patch edges. Key invaders of coastal scrub on Mt. Tam include licorice plant (*Helichrysum petiolare*), thoroughwort (*Ageratina adenophora*), jubata grass (*Cortaderia jubata*), broom species (*Cytisus, Genista, Spartium*), cape ivy (*Delairea odorata*), and Monterey pine (*Pinus radiata*).

Changed Fire Regime: Chaparral and coastal scrub are fire-adapted communities, but may convert to non-native annual grasslands under too-frequent fire intervals (Keeley & Brennan, 2012). Alternately, fire suppression can lead to succession of shrublands to hardwood forest and Douglas-fir (*Pseudotsuga menziesii*) stands (Cornwell et al., 2012; Keeley, 2005; Callaway & Davis, 1993).

Habitat Fragmentation: Large blocks of shrubland are resilient to invasions and other threats from edge effects, but become more vulnerable when fragmented by roads, trails, fuelbreaks, etc. (Lambrinos, 2002; Kemper et al., 1999).

Douglas-fir Encroachment: In the absence of fire, Douglas-fir invades many different kinds of plant communities, including coastal scrub (Chase et al., 2005) and particularly chaparral (Horton et al., 1999). Shade-intolerant scrub and chaparral species are vulnerable to the shading caused by conifer invasion.

Climate Change: Models generally forecast a reduction in coniferous and evergreen broadleaf forests and increases in oak woodlands, shrublands, and grasslands (Ackerly et al., 2012). However, chaparral species that have vascular systems highly resistant to drought-induced cavitation are nonetheless sensitive to prolonged droughts due to their shallow rooting depth (Paddock et al., 2013). Thus, reduced winter rainfall could have negative impacts on some of the rarer non-resprouting manzanitas and ceanothus, such as the Mt. Tamalpais manzanita (*Arctostaphylos montana* ssp. *montana*) and the Point Reyes ceanothus (*C. gloriosus* var. *exaltatus*). Coastal scrub composition may shift dramatically with changes in maritime temperature and precipitation.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: CORE AREAS

Baseline: Within the One Tam area of focus, only 40 of 1,251 distinct patches of shrubland habitat are greater than 30 acres in extent. Combined, they represent 70% of the shrubland habitat on Mt. Tam, covering 5,500 acres and constitute important core areas for shrubland plants, birds, and other wildlife that are sensitive to edge effects, habitat fragmentation, and invasion ((Aerial Information Systems, Inc. [AIS], 2008; AIS, 2015; Schirokauer et al., 2003).

Condition Goal: Maintain core areas of shrub-dominated vegetation over 30 acres in size

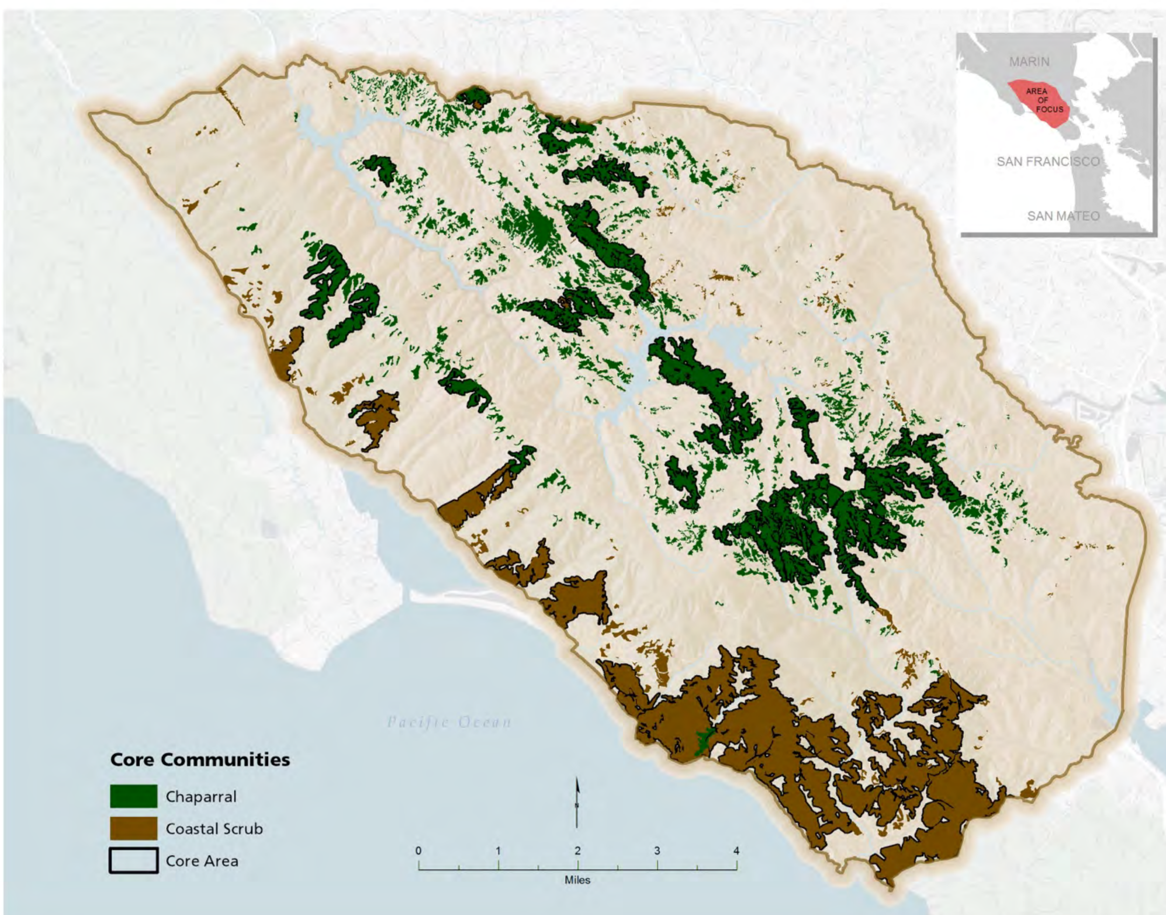
Condition Thresholds:

- **Good:** 5,500 total acres of native shrubland within patches that are 30 acres or larger
- **Caution:** Less than 5,500 acres of native shrubland within patches that are 30 acres or larger
- **Significant Concern:** Less than 4,000 acres of shrubland within patches that are 30 acres or larger

Current Condition: Good

Forty blocks of native shrub-dominated vegetation over 30 acres have been mapped in the One Tam area of focus, for a total of over 5,500 acres.

FIGURE 6.2 MAP OF CORE CHAPARRAL AND COASTAL SCRUB LOCATIONS IN THE ONE TAM AREA OF FOCUS



Confidence: Low

Time series vegetation maps from Marin Municipal Water District (MMWD) (AIS, 2015) show that overall, shrublands are stable or increasing in area. Although similar time series data are not available for Marin County Parks (MCP), National Park Service (NPS), or California State Parks (State Parks) vegetation, the trend is likely to be similar. However, confidence regarding core patch sizes is low. The NPS 1994 vegetation map was used to identify core areas in these jurisdictions, but the underlying data have not been updated since the map was originally produced. Both MMWD and MCP have active fuelbreak expansion and trail realignment programs which have the potential to fragment shrub patches at a scale that is not discernable in landscape-level mapping.

Trend: Unknown

A change of +/-10% of total acres within core areas of 30 contiguous acres or more over a five-year period is needed to indicate a change. There are currently insufficient data to establish a trend.

METRIC 2: ACRES WITHOUT PRIORITY INVASIVE PLANT SPECIES

Baseline: Invasive species threaten the composition, structure, and function of shrublands. Key invaders of coastal scrub on Mt. Tam include licorice plant, thoroughwort, jubata grass, broom species, cape ivy, and Monterey pine. Field observations indicate that most non-native, invasive species in shrubland communities exist at the periphery, at the interface between park lands and residential properties, along roads, trails, and fuelbreaks, or where the canopy has been otherwise disturbed. Approximately 120 acres of shrublands on MMWD land are infested with non-native, invasive plant species.

Condition Goal: High priority invasive plant species at less than 5% cover in native shrublands

Condition Thresholds:

- **Good:** 90% or more of native shrubland acres free of priority invasive plants or with less than 5% cover of priority invasive plants
- **Caution:** 80–90% of native shrubland acres free of priority invasive plants or with less than 5% cover of priority invasive plants
- **Significant Concern:** Less than 80% of native shrubland acres free of priority invasive plants or with less than 5% cover of priority invasive plants

Current Condition: Good

Available data from MMWD (Williams, 2014; Panorama Environmental, 2016) show that the most abundant invasive species, French and Scotch broom, have invaded less than 4% of MMWD shrublands (116 acres) and other weeds are present in lower amounts (Table 6.1).

TABLE 6.1 ACRES OF SHRUBLAND WITH INVASIVE PLANT SPECIES BY COVER CLASS ON MMWD LANDS IN 2013 (WILLIAMS, 2014)

Cover Classes	Acres
High (66–90%)	11
Low (11–35%)	18
Medium (36–65%)	20
Pioneer (<1%)	40
Scarce (1–10%)	27
Total	**116**

Confidence: Moderate

Weed maps on MMWD lands are systematically updated once every five years. While management and surveillance does not systematically cover all shrublands on NPS and State Park lands, large areas are visible from the extensive road and trail network, and are considered to be relatively free of dense infestations of invasive species.

Trend: Declining

A change of +/-5% would shift the trend from stable to “Declining” or “Improving.” French broom increased by 9% or 9.5 acres in MMWD shrublands between 2009–2013, despite an active weed management program. State Parks and NPS do not have similar surveys, although the assumption is that the shrublands on their lands are similarly impacted.

METRIC 3: ACRES WITHOUT CANOPY-PIERCING DOUGLAS-FIR

Baseline: The 2014 MMWD vegetation maps show 12% of its shrubland habitat (predominantly chaparral and serpentine chaparral types) has canopy-piercing Douglas-fir. The status of shrublands in other jurisdictions (predominantly coastal scrub) is “Unknown.”

Condition Goal: Maintain 90% (approximately 7,345 acres) shrubland vegetation without canopy-piercing Douglas-fir

Condition Thresholds:

- **Good:** More than 7,345 acres (90%) of shrublands without canopy-piercing Douglas-fir
- **Caution:** 5,710–7,345 acres (70–90%) of shrublands without canopy-piercing Douglas-fir
- **Significant Concern:** Less than 5,710 acres (70%) of shrublands without canopy-piercing Douglas-fir

Current Condition: Caution

On MMWD and MCP lands, the approximately 89% of shrublands without canopy-piercing Douglas-fir is slightly below the 90% threshold. State Parks and NPS do not have similar surveys, but the assumption is that the shrublands on their lands are similarly impacted by canopy-piercing Douglas-fir.

Confidence: Moderate

Data from MMWD and MCP surveys represent 46% of shrublands in the One Tam area. These data are lacking from the other partner agencies.

Trend: No Change

A change of +/-5% over a five-year period in needed to indicate a change. On MMWD lands, the acreage of shrubs with canopy-piercing Douglas-fir increased by only 2% over a 10-year period.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Data sources for acreages listed under the above metrics:

- MMWD vegetation maps from 2009 (AIS, 2015)
- MCP vegetation map 2008 (AIS, 2008)
- 1994 NPS vegetation map was used for NPS and California State Parks (Schirokauer et al., 2003)

ACREAGES CALCULATIONS

TABLE 6.2 METHODS AND DATA USED TO CALCULATE ACREAGES FOR SHRUBLAND VEGETATION COMMUNITIES

Indicator Plant Community	Types Included	Metrics	How Derived
Shrublands	• Chamise alliance • Chamise-serpentine chaparral (relatively pure chamise on ultramafic soils) • Mt. Tamalpais manzanita serpentine chaparral • Leather oak–chamise-Mt. Tamalpais manzanita serpentine chaparral • Eastwood manzanita/interior live oak alliance • Mixed manzanita alliance • Coastal Sage Scrub Alliance • Blue blossom alliance • Coffeeberry alliance • Coyote brush alliance • Poison oak alliance • Sensitive manzanita alliance	Core areas	Aggregated all mapped shrubland vegetation polygons with shared boundaries, and selected polygons in size classes > 0.5 Std. Dev. (>30 acres).
		Acres without broom or other targeted priority invasive species	2003 drive-by survey* for broom, 2010 draft vegmgmt_polys_9_3*, 2013 broom re-map*. NPS Early Detection Program 2008-2015**.
		Acres without canopy-piercing Douglas-fir	*Summed acreage of all mapped shrubland vegetation polygons with MMWD attribute ConDensity >0; trend determined by comparing 2004–2014 values

*MMWD data only
**NPS data only

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Shrubland Plant Community Change Drivers: Demographics are not well understood for most species in the shrubland communities on Mt. Tam. A widespread dieback of coffeeberry (*Frangula californica*) was observed by NPS staff during a historic drought in 2015. Such punctuated disturbances caused by drought, disease, or fire may cause rapid shifts in community composition that persist due to climate change. Current monitoring efforts are focused on specific vegetation types, and do not capture compositional change in all communities at the landscape scale.

Time Series Data: Shrublands, particularly coastal scrub, are among the more dynamic vegetation types in the One Tam area of focus. Vegetation maps should be updated in five-year intervals in order to detect expansions and contraction among grasslands, oak woodlands, and shrub vegetation types. Douglas-fir incursions are likely to require a longer time frame for detection. Douglas-fir encroachment may also be balanced by expansion of shrublands into grasslands.

Non-native, Invasive Species Impacts: Invasive species surveillance focuses on road and trail corridors, and does not systematically cover off-trail areas in shrublands.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Management:

- Coyote brush (*Baccharis pilularis*) reduction efforts where coastal scrub is expanding into grasslands (State Parks)
- Ongoing brush reduction in designated fuel load reduction zones, often in conjunction with grassland and open-canopy oak woodland preservation goals (MMWD and MCP)

Monitoring:

- Aerial photo monitoring and interpretation of vegetation communities is repeated every five years (MMWD)
- Weed distribution maps are also updated once every five years

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and

will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Succession Management:** Sustain and expand the removal of encroaching Douglas-fir saplings and trees in coastal scrub habitat on State Parks lands; adaptively manage and assess efficacy and impact, with potential goal of expanding program into other jurisdictions

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CHAPTER 7. MARITIME CHAPARRAL

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Significant Concern

Trend: Declining

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Special status plants and sensitive plant communities are often found clustered in areas with unusual geology, soils, aspects, elevations, or combinations of these attributes. Mt. Tam's unique geography and location near the coast have created a number of different microclimates on the mountain. The part of Mt. Tam that receives a marine influence, in the form of persistent summer fog, contains maritime chaparral, a type of chaparral that is associated with several special status plants.

Manzanita dominance is characteristic of maritime chaparral found on coastal slopes subject to summer fog or heavy winter rainfall on ocean-facing uplands. Over half of the 95 species and subspecies of manzanita in California are locally endemic, occurring in lowlands adjacent to the coast and within the summer marine fog zone (Vasey and Parker, 2014). This abundance of locally endemic shrub species along the California coast results in a pattern of exceptional *beta* diversity, or high levels of species turnover in community composition across space (Vasey et al., 2014). As a result of this diversity, maritime chaparral communities are recognized as one of the most diverse woody communities in the state (Sawyer et al., 2009). Although relatively few, maritime chaparral plant species of special interest in the One Tam area of focus include:

- The rare Marin manzanita (*Arctostaphylos virgata*) California Native Plant Society (CNPS) rank 1B.2: Plants Rare, Threatened, or Endangered in California and Elsewhere, Moderately threatened in California

- Two rare wild lilacs:
    - Mason's ceanothus (*Ceanothus masonii*) CNPS rank 1B.2: Plants Rare, Threatened, or Endangered in California and Elsewhere, Moderately threatened in California

    - Point Reyes ceanothus (*C. gloriosus* var. *exaltatus*) CNPS rank 4.3 Plants of Limited Distribution - A Watch List, Not very threatened in California

- Coinleaf manzanita (*Arctostaphylos sensitiva*), a species that is prominent in maritime chaparral and a regional endemic in the Santa Cruz Mountains and on Mt. Tam. Thus, it is a good indicator of maritime chaparral, complementing the other locally endemic manzanita and ceanothus species in this community.

Maritime chaparral species like these can be used as an indicator of biological integrity or diversity, natural disturbance regime, and habitat quality.

OVERALL CONDITION

This fog- and fire-dependent plant community is found in patches along California's central coast from Santa Barbara to Sonoma County. Maritime chaparral is a plant community of concern in California, and the community on Bolinas Ridge is the best known patch within the One Tam area of focus. Current Marin Municipal Water District (MMWD) and National Park Service (NPS) rare plant monitoring data indicate that at least 100 individuals of Mason's ceanothus persist on Bolinas Ridge. The extent of maritime chaparral on the south slope of Mt. Tam is not known but is presumably substantially less than that on Bolinas Ridge. A smaller area of maritime chaparral containing a few remnant Marin manzanitas, and characterized by coinleaf manzanita, occurs in the vicinity of Camp Alice Eastwood on the south slope of Mt. Tam above Muir Woods.

Maritime chaparral communities on Mt. Tam are experiencing heavy Douglas-fir (*Pseudotsuga menziesii*) encroachment as a result of fire suppression, and fire-dependent shrubs are not recruiting. The extent of maritime chaparral communities appears to be declining based on NPS and MMWD staff observations of an abundance of senescent and dead chaparral shrubs under encroaching Douglas-fir stands. Fog has also decreased in coastal California by approximately 30% since the early 20th century (Johnstone & Dawson, 2010). The rare species chosen for the metrics below are restricted to maritime chaparral, and are dependent on the fire and fog that allow these communities to persist. Therefore, their status and trends reflect those of the broader maritime chaparral community.

DESIRED CONDITIONS

The desired condition is to maintain viable populations of maritime chaparral community endemics over a minimum of 90 acres of endemic habitat.

STRESSORS

Lack of Fire: The vegetation mosaic on Mt. Tam is naturally dynamic, and vegetation succession occurs under natural conditions, largely mediated by the fire cycle. Removal of fire as a key ecosystem process is resulting in the successional reduction of grasslands, chaparral, and oak woodlands. Chaparral is adapted to fire return intervals from about 30 to 150 years, and requires periodic fire to regenerate (Kauffmann et al., 2015).

Forest Encroachment and Shade: In the absence of fire, Douglas-fir encroaches into many different kinds of plant communities, including maritime chaparral. Shade-intolerant maritime chaparral species are vulnerable to the shading caused by these conifers in the absence of fire, a process heavily suppressed in the One Tam area of focus.

Road and Trail Maintenance: Road and trail work can introduce plant pathogens if equipment is not cleaned properly. Rare chaparral species such as Marin manzanita do not sprout if they are cut during trail clearing or by mowing along the sides of fire roads.

Climate Change: Potential changes to fog patterns as a result of climate change could threaten maritime chaparral species that are dependent on summer fog for moisture. Marin manzanita is a particularly good indicator of shift in summer marine layer, as is coinleaf manzanita, which is restricted to lower, fog-influenced parts of the mountain. Climate scenarios predict an increase in drought stress regardless of precipitation changes, which is particularly problematic for "non-sprouting" species such as the rare species considered below, as they are relatively shallow rooting (Paddock et al., 2013).

Plant Diseases: Manzanita species in the One Tam area of focus have been affected by the fungal pathogen *Phytophthora ramorum,* which causes Sudden Oak Death (SOD). *Phytophthora cinnamomi*, which is particularly deadly to some manzanitas, is also known to be on Mt. Tam. In general, pathogen-related dieback of large stands of madrone and manzanita would be expected to cause effects very similar to those of SOD, including: changes in species composition in infested vegetation (mainly types of chaparral); changes in ecosystem functions; loss of food sources for wildlife; changes in fire frequency or intensity; decreased water quality due to increased erosion from exposed soil surfaces; and increased opportunities for weed invasion in open sites (Leonard Charles Associates [LCA], 2009).

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: NUMBER AND AGE CLASS OF INDIVIDUAL MASON'S CEANOTHUS

Baseline: National Park Service and MMWD staffed observed approximately 100 individuals of Mason's ceanothus in 2016.

Condition Goal: Maintain 200 Mason's ceanothus individuals on Bolinas Ridge

Condition Thresholds:

- **Good:** More than 160 individual Mason's ceanothus with at least 10% recruitment
- **Caution:** More than 120 individual Mason's ceanothus with any recruitment
- **Significant Concern:** Fewer than 120 individual Mason's ceanothus

Current Condition: Significant Concern

The current presence of only around 100 individuals warrants a status of "Significant Concern"

Confidence: High

Recent monitoring efforts thoroughly surveyed existing individual Mason's ceanothus plants.

Trend: Declining

Patterson (1990) noted "a few hundred" Mason's ceanothus plants, and numbers have been in decline since. With this fire-dependent species, setting trend thresholds is difficult. A change of more than 10% in number of individuals in and size class would constitute a change in trend up or down.

METRIC 2: NUMBER AND AGE CLASS OF POINT REYES CEANOTHUS INDIVIDUALS

Baseline: National Park Service rare plant data show approximately 15 Point Reyes ceanothus in 2013. Marin Municipal Water District staff have noted fewer, and no recruitment.

Condition Goal: Maintain 30 Point Reyes ceanothus individuals on Bolinas Ridge with at least two age classes

Condition Thresholds:

- **Good:** More than 24 Point Reyes ceanothus with at least 10% recruitment
- **Caution:** More than 16 Point Reyes ceanothus with any recruitment
- **Significant Concern:** Fewer than 16 individual Point Reyes ceanothus and/or no recruitment

Current Condition: Significant Concern

The presence of less than half the desired number of plants warrants a status of "Significant Concern."

Confidence: High

Recent monitoring efforts thoroughly surveyed existing individual Point Reyes ceanothus plants.

Trend: Declining

Setting trend thresholds is difficult with this fire-dependent species, but a change of more than 10% in number of individuals in and size class would constitute a change in trend up or down.

METRIC 3: NUMBER AND AGE CLASS OF MARIN MANZANITA

Baseline: National Park Service rare plant data recorded 40 individual Marin manzanitas within Golden Gate National Recreation Area lands on Bolinas Ridge between 20102016. MMWD staff have recorded fewer than 30 consistently over the past decade with no recruitment noted.

Condition Goals:

- Support 200 Marin manzanita individuals on Bolinas Ridge, with at least two age classes
- Determine potential to increase Marin manzanita individuals on south slope of Mt. Tam and better assess its presence and potential for recruitment

Condition Thresholds:

- **Good:** More than 160 individual Marin manzanita with at least 10% recruitment
- **Caution:** More than 120 individual Marin manzanita, with any recruitment
- **Significant Concern:** Fewer than 120 individual Marin manzanita and/or no recruitment

Current Condition: Significant Concern

The presence of less than half the desired number of plants warrants a status of "Significant Concern." The condition of the population on the south slope needs to be ascertained. Recovering a second population on Mt. Tam from Bolinas Ridge would increase chances for persistence of species in One Tam area of focus.

Confidence: High

Recent monitoring efforts thoroughly surveyed existing individual Marin manzanita plants.

Trend: Declining

This species appears to be in decline due to Douglas-fir encroachment in the absence of fire (Kauffman et al., 2015). Furthermore, some of the plants on Bolinas Ridge have died from SOD.

METRIC 4: EXTENT OF RARE SPECIES

Baseline: Extent of rare species in maritime chaparral on Bolinas Ridge currently stands at 90 acres.

Condition Goal: Maintain 90 acres of maritime chaparral community endemic habitat on Bolinas Ridge. Assess possibility for recovering second population of Marin manzanita on south slope to increase presence of maritime chaparral and create second viable population within the One Tam area of focus.

Condition Thresholds:

- **Good:** 90 acres of maritime chaparral
- **Caution:** Between 80 and 90 acres of maritime chaparral
- **Significant Concern:** Fewer than 80 acres of maritime chaparral

Current Condition: Good

The dispersion of occurrences of Mason's ceanothus, Point Reyes ceanothus, and Marin manzanita was calculated using the minimum convex polygon methodology as described by O'Neill & Williams (2006).

Confidence: High

This assessment is based on recent, comprehensive data.

Trend: No Change

Based on repeat mapping, the total extent does not appear to have changed within the past 10 years (Aerial Information Systems, Inc. [AIS], 2015). A change of five acres over a five-year time period would constitute a change in trend.

METRIC 5: ACRES AND SPATIAL DISTRIBUTION OF *PHYTOPHTHORA*-IMPACTED HABITAT

This was identified as an important metric, but the current condition and trends are unknown. Current mapping looks at canopy die-off to track *Phytophthora*, and chaparral lacks a susceptible canopy. Some Marin manzanita have been infected with *P. ramorum* (California Oak Mortality Task Force [COMTF], 2015) with about 10–25% mortality from 2015–2016 (MMWD staff observation, 2016). Now that land managers are aware of this issue, existing monitoring can be adapted to track this as well, potentially providing data to assess this metric in the near future.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Notes on Metrics: Information currently is only from Bolinas Ridge proper, and is based on:

- MMWD rare plant maps and surveys from 1990, 2009, 2012, and 2015
- California Natural Diversity Database data for the One Tam area downloaded January 2016 (California Department of Fish and Wildlife, 2009)

- 2014. Rare_Plant_Population.gdb. Golden Gate National Recreation Area, updated in 2016

Using rare plant data collected by MMWD and NPS, the dispersion of Point Reyes ceanothus and Mason's ceanothus individuals was calculated using a minimum convex polygon. Ninety acres of habitat was identified. This methodology was adopted from O'Neill & Williams (2006). Rare plant data from both agencies employed count ranges in their monitoring schemes at times. To arrive at a number of individuals, the midpoint of the range was taken for the most recent year of surveys, 2013. These numbers could be refined by a data collection effort that provides a count rather than a range.

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Genetics: Analysis of Mason's ceanothus is needed to determine if it is a viable species, or a series of semi-stable or introgressing hybrids between *C. gloriosus* var. *exaltatus* and *C. cuneatus* var. *ramulosus*.

Seeds: Research on germination requirements and seed life for rare species is needed to determine if maritime chaparral that has been taken over by forest can return to chaparral after a fire.

Plant Pathogens: A field study is needed to determine whether other plant pathogens are present, and any threats they pose to individual manzanita species, especially special status plants.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Management: Forest understory manipulation to reduce SOD thickets, which may reduce spore load and infection of Marin manzanitas (MMWD)

Monitoring: Rare plant surveys within Golden Gate National Recreation Area lands on Bolinas Ridge every one to three years (as resources allow) focused on confirming and mapping presence of previously recorded individual rare plants and searching for new occurrences in suitable habitat (NPS)

Conservation: Mason's ceanothus and Marin manzanita seedbanked as part of the California Native Plant Society's Rare Plant Rescue program in 2015 (MMWD)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Fuel Load Reduction, Roads, and Trails-related Management:** Assess feasibility of realigning trails within rare plant habitat to reduce both the introduction and spread of plant diseases and other potential impacts

- **Succession Management:** Remove encroaching Douglas-fir saplings and trees

- **Manage Fire-dependent Communities:**

    - Establish an adaptive management program to include installation of burn box fire plots; if controlled burns within plots appear to result in successful recruitment, consider future controlled burns at isolated stands (at some frequency to be determined)

    - Determine efficacy of outplanting manipulated/fire-treated seed within test plots, absent of prescribed fire

Inventory and Monitoring:

- ***Phytophthora* Monitoring Protocols**: Develop and implement a monitoring protocol is needed to identify assess *Phytophthora* presence and identify species if dieback is observed during routine monitoring of maritime chaparral

Potential Research:

- **Larger-Scale Succession and Fire Management:** Research how these management practices might be undertaken in maritime chaparral habitat at Bolinas Ridge to improve both overall community and rare species health

Population Enhancement:

- Assess the feasibility of recovering a second population of *Arctostaphylos virgata* on south slope of Bolinas Ridge to increase presence of maritime chaparral and create second viable population

- Assess similar enhancement actions in the vicinity of other populations of *A. virgata* to include near the Sierra Trail, above Alice Eastwood Road and at Old Stage off of Alpine Trail on State Parks lands

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CHAPTER 8. GRASSLANDS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Caution

Trend: Declining

Confidence: Low

WHY IS THIS RESOURCE INCLUDED?

Grasslands ecosystems are dominated by both perennial and annual herbaceous plants, with little to no trees or shrubs. Dominant native grassland species in the One Tam area of focus include purple needlegrass (*Stipa pulchra*), blue wild rye (*Elymus glaucus*), clovers (*Trifolium* spp.), California oatgrass (*Danthonia californica*), and red and blue fescue (*Festuca rubra* and *idahoensis*), among others. Dominant non-native species include wild oats (*Avena barbata*), perennial rye grass (*Festuca perennis*), Harding grass (*Phalaris aquatica*), and tall fescue (*Festuca arundinacea*) (Evens & Kentner, 2006).

California native grasslands are among the most endangered ecosystems in the country occupying less than 1% of their historic extent (Noss & Peters, 1995). Perennial grasslands provide ample carbon storage below ground in extensive root systems (Potthoff et. al., 2005) and some species of native grasses can live for hundreds of years (Marty et al., 2005). Grasslands are the old-growth at our feet and a rich part of Marin's natural heritage and contemporary ecology.

Nearly 90% of California's rare species listed in the Inventory of Rare and Endangered Species in California (Skinner & Pavlik, 1994) occur within California grassland settings (D'Antonio et. al., 2002) in addition to 30% of the threatened and endangered wildlife species (over 40% of terrestrial animals) (California Department of Fish and Wildlife [CDFW], 2016). American badgers (Lay, 2008) and grassland-nesting birds (Rao et al., 2008) rely on large patches of grassland for reproduction and forage. Large, connected patches are necessary in order to maintain gene flow among grassland species and to minimize edge effects. Many grassland-dependent bird and mammal species are declining elsewhere in the (Bay Area Open Space Council [BAOSC], 2011) but their status on Mt. Tam is unknown.

OVERALL CONDITION

About 10% of the open spaces in the One Tam area of focus are grasslands (see Figure 2.1 in Chapter 2), which include native species-dominated perennial grasslands, non-native annual grasslands, non-native perennial grasslands, serpentine grasslands, and seasonally wet meadows. Non-native plants are ubiquitous, primary components of most grasslands throughout Mt. Tam and the state. The Manual of California Vegetation defines a "native" grassland as one with as little as 10% relative cover of native species (California Native Plant Society [CNPS], 2016).

DESIRED CONDITIONS

The desired condition for grasslands is persistence of large, intact, and native-rich blocks of this vegetation type, which is needed to support grassland-dependent plant and wildlife species that are sensitive to edge effects and fragmentation. Because grassland habitats have decreased dramatically in extent over the last 100 years, both statewide and on Mt. Tam, preservation or expansion of grassland acreage is desirable. Good examples of this vegetation type can be found on Pine Mountain, in scattered patches along Highway 1, and adjacent to Bootjack Creek below Mountain Theatre.

STRESSORS

Non-native, Invasive Species: At nearly all grassland sites, non-native species make up the majority of the plant cover—a situation unheard of and likely intolerable in any other vegetation type found on Mt. Tam. Non-native, invasive plant species have resulted and continue to result in the loss of native species diversity, changes in nutrient cycling and hydrology, and shifts in invertebrate abundances (Marin Municipal Water District [MMWD], internal data; Evens & Kentner, 2006; Steers & Spalding, 2013; Ford & Hayes, 2007).

Woody Species Encroachment/Succession: In the absence of fire, grazing, or other landscape-scale disturbance, grasslands in northern coastal California rapidly transition into scrublands (primarily coyote brush [*Baccharis pilularis*]), woodlands, and/or forest (Ford &Hayes, 2007). This process is arrested on south-facing slopes and where soils are thin, seasonally saturated, or nutrient poor (Schoenherr, 1992).

Climate Change: The potential effects of climate change, including frequent drought conditions and increased climatic water deficit, may detrimentally affect Mt. Tam's grasslands. Models disagree on whether grasslands may decrease or increase in future climate scenarios. Within the One Tam area of focus, nearly all grasses—both by number of species and by area covered—are "cool-season," or C_3 grasses. The few (native and non-native) species of "warm-season," or C_4 grasses, are wetland species and their increased ability to take advantage of higher temperatures and CO_2 levels may be tempered by concomitantly lower water availability (Zhu et al., 2016).

Lack of Disturbance: California's grasslands evolved with episodic disturbances from both anthropogenic and natural fire, and grazing by antelope, tule elk, and black-tailed deer. The loss of these sources of disturbance has resulted in the loss of native species productivity, diversity, and the loss of grasslands themselves as they convert to woody-dominated communities. Higher fuel loads also increase fire severity (Bay Area Open Space Council, 2011), which has unknown impacts in these ecosystems.

Atmospheric Nitrogen Deposition: Air pollution contains reactive nitrogen compounds like NOx, ammonia, and nitric acid that deposit on surfaces and act as nitrogen fertilizer. Impacts of N-deposition are well documented across California (Fenn et al., 2010; Weiss, 2006), and include increased annual grass and weed growth in grasslands. Grasslands on Mt. Tam are exposed to N-deposition from <2 lbs-N ac-1 year-1 to ~10 lbs-N ac-1 year-1, which exceed the critical load needed to promote exotic annual grass growth beyond background rates (Fenn et al., 2010). Increased annual grass biomass leads to accumulation of thatch and losses of native biodiversity (Molinari & D'Antonio, 2014).

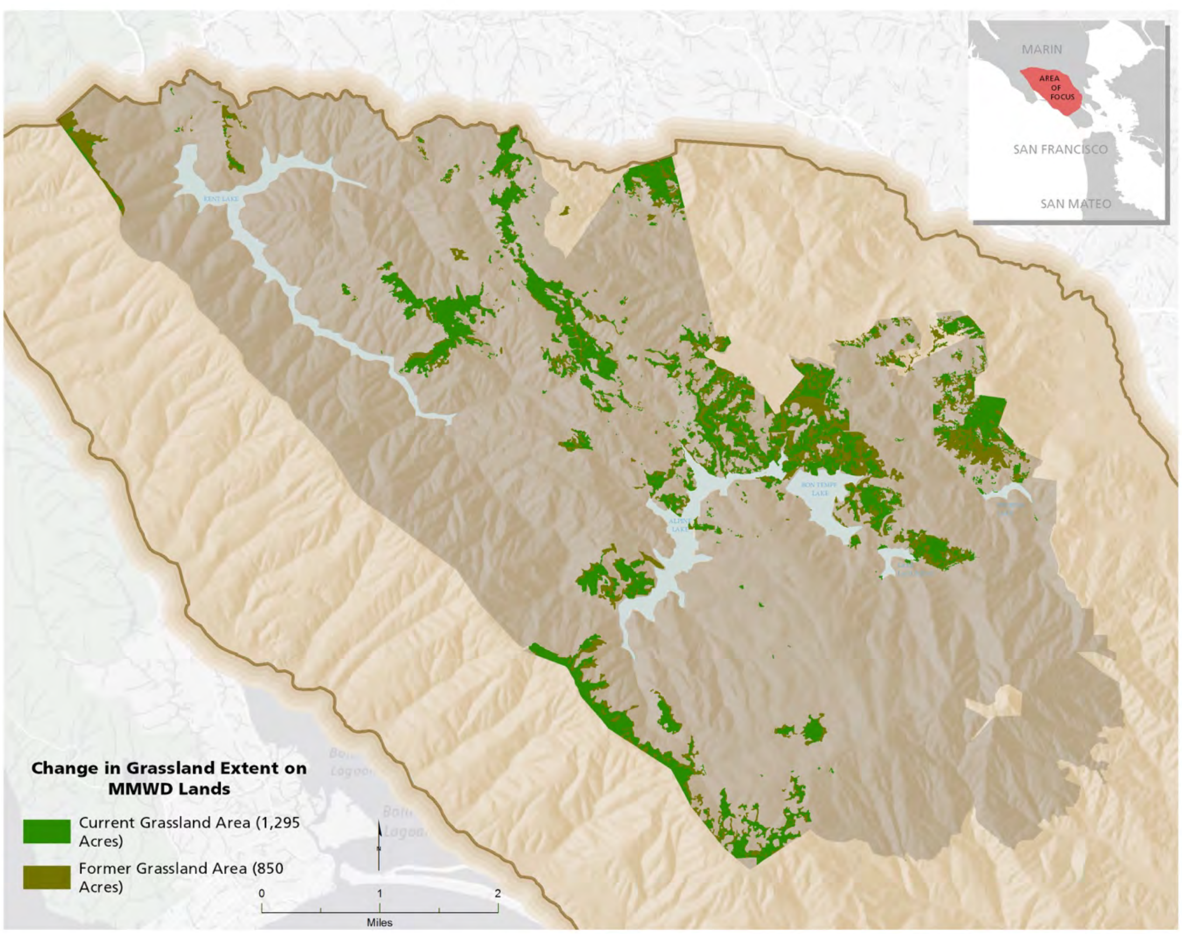
CONDITION AND TRENDS ASSESSMENT

METRIC 1: TOTAL ACRES

Baseline: A review of historic aerial photographs indicates grasslands in the One Tam area of focus have decreased steadily since the middle of the twentieth century. A systematic comparison of geospatially rectified imagery from 1943–2009 for Marin Municipal Water District (MMWD) lands detected a grassland decrease of 850 acres (40%), independent of losses caused by the construction of Bon Tempe Reservoir and the raising of Peter's Dam.

This loss is primarily attributed to succession into scrub, woodland, and forest vegetation types in the absence of fire or other disturbances, and secondarily due to encroachment from woody invasive species such as French broom (*Genista monspessulana*) and licorice plant (*Helichrysum petiolare*). Although similar analyses have not been performed for other jurisdictions, it is likely the 3,525 acres of grassland currently present in the One Tam area of focus is a significant reduction relative to what was there in the recent past.

FIGURE 8.1 MAP OF GRASSLAND LOSS ON MMWD LANDS (AERIAL INFORMATION SYSTEMS, INC. [AIS], 2008; MMWD, 2016)



Condition Goal: Reversal of woody encroachment into remnant grassland patches

Condition Thresholds:

- **Good:** Grassland extent is 2% (70 acres) greater than 2014 levels (3,515 acres)
- **Caution:** Grassland extent remains at 2014 levels or decreases by 10% (350 acres) over five years
- **Significant Concern:** Grassland extent decreases by more than 10% (350 acres) over five years

Current Condition: Caution

The current extent of grasslands in the One Tam area of focus is approximately 3,515 acres. All One Tam agencies have active weed management programs and two agencies are strategically controlling Douglas-fir and/or coyote brush from grassland margins. However, it is unclear whether these efforts are keeping pace with the rate of woody species encroachment into grasslands.

Confidence: Low

Although grasslands have been mapped on all jurisdictions, much of the available information is outdated. Grasslands on National Park Service (NPS) and California State Parks (State Parks) lands were delineated in 1994, on Marin County Park (MCP) lands in 2008, and on MMWD lands in 2004.

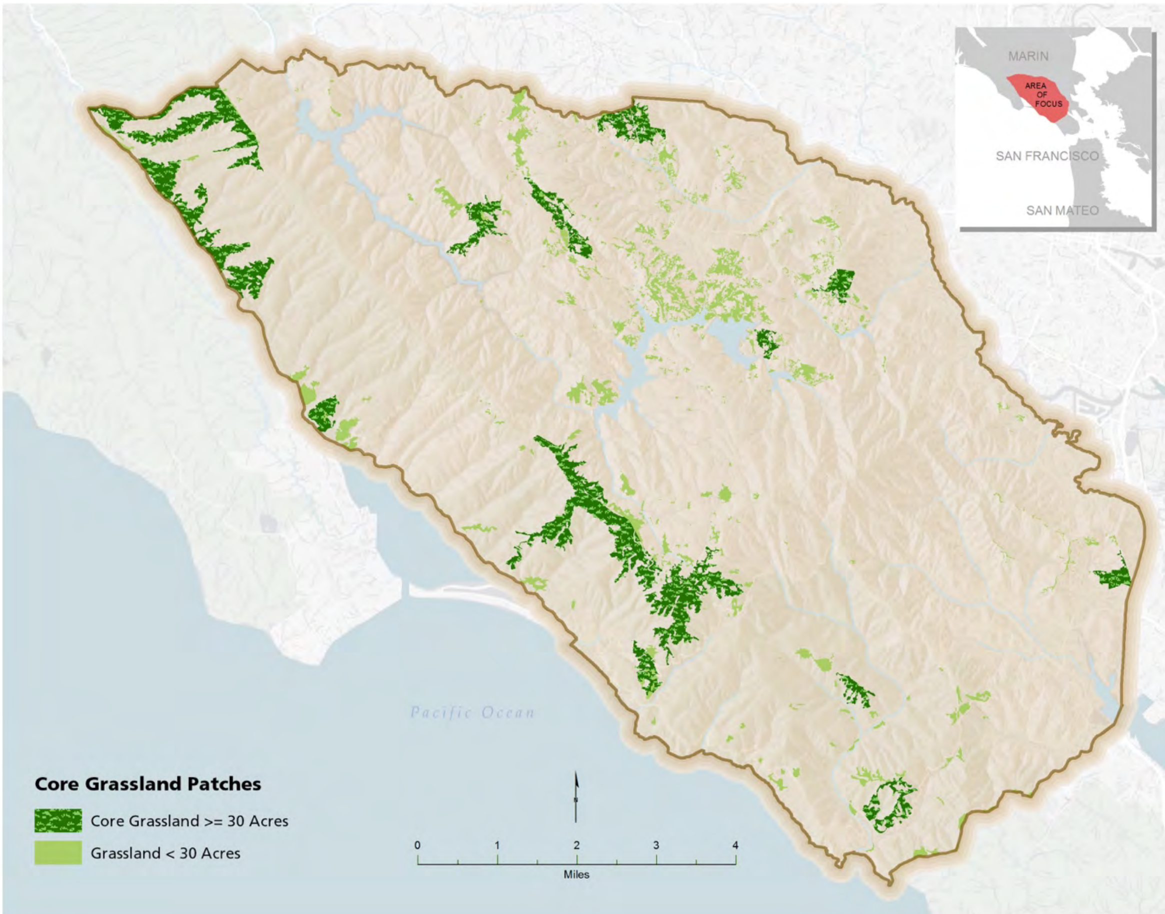
Trend: Unknown

While a significant decline in grassland acres since the mid-1940s has been documented, it is unclear what the current trend is. Underlying stressors associated with non-native plant invasion and fire suppression are still at work. Although MMWD is the only jurisdiction with time series map data, the grassland update was limited to classification changes and did not incorporate revisions of polygon boundaries. Therefore, small changes in the spatial extent of individual grassland patches were not captured. Anecdotal reports from field staff, local experts and recreationists suggest that some patches represented as grasslands in the 1994 NPS and State Parks maps or even the later MMWD and MCP maps have decreased in size or completely transitioned into scrub or forested habitat.

METRIC 2: PATCH SIZE

Baseline: Within the One Tam area of focus, 19 of 866 distinct patches of grassland habitat are greater than 30 acres in extent (Figure 8.2). Combined, they represent 65% of the grassland habitat on Mt. Tam, covering 2,050 acres and constituting important core areas for grassland native plants, birds, and other wildlife that are sensitive to edge effects, habitat fragmentation, and invasion (BAOSC, 2011).

FIGURE 8.2 MAP OF CORE GRASSLAND PATCHES IN THE ONE TAM AREA OF FOCUS (AIS, 2008 AND 2015; SCHIROKAUER ET AL., 2003)



Condition Goal: Maintain core areas of grasslands over 30 acres in size

Condition Thresholds:

- **Good:** 2,050 total acres of grassland exists within patches that are 30 acres or larger
- **Caution:** Between 1,625–2,050 acres of grassland exists within patches that are 30 acres or larger
- **Significant Concern:** Fewer than 1,625 acres of grasslands exists within patches that are 30 acres or larger

Current Condition: Good

Nineteen blocks of grassland vegetation over 30 acres have been mapped in the One Tam area of focus, for a total of 2,050 acres (Figure 8.2).

Confidence: Moderate

Maps used to identify core areas in these jurisdictions were last updated in 1994 (NPS and State Parks), 2004 (MMWD), and 2008 (MCP). Both MMWD and MCP have active fuelbreak expansion and trail realignment programs which have the potential to fragment grassland patches at a scale that is not discernible in landscape-level mapping.

Trend: No Change

Although MMWD is the only jurisdiction with time series vegetation map data, the grassland update was limited to classification changes and did not incorporate revisions of polygon boundaries. Therefore, small changes in the spatial extent of individual grassland patches were not captured. Cumulatively, these changes are unlikely to have exceeded the 10% threshold.

METRIC 3: COMMUNITY COMPOSITION AND NATIVE SPECIES RICHNESS

Baseline: Grassland quality is not easily captured by landscape-scale aerial survey techniques. A further complication is the high level of site-to-site and year-to-year variability in the relative abundance of many species. Thus, on-the-ground measurements of community composition are necessary.

Common metrics used to assess grassland community composition and quality include percent cover estimates, relative abundance, presence/absence determinations, biomass measurements, and structural measurements. While ground sampling of grassland communities did occur as part of each One Tam partner agency's initial vegetation mapping and classification efforts, these data were limited in scope and utility. Full floristics were collected in only a small subset of sampled plots. More recently, MMWD conducted a limited-scale assessment in the spring of 2016. Additionally, NPS completed a study of grasslands in the Marin Headlands in 2013 as part of the protocol development for a regional long-term, plot-based monitoring network. The Sonoma-Marin Grasslands Working Group has undertaken mapping and classification in Marin and Sonoma counties as well (Kraft et al., 2014).

At the time of this report, staff had not had the opportunity to characterize baseline species richness throughout the range of grassland habitats in the One Tam area of focus. Therefore, the thresholds for this metric have not been established, and the condition goal is contingent on the establishment of a comprehensive plot system designed to monitor changes in species richness and other composition metrics over time. Current species richness targets, overall or stratified by grassland type, will be set once data have been better analyzed.

Condition Goal: Not yet set

Current Condition: Unknown

A plot network has not been established throughout the One Tam area of focus and the limited amount of data available is insufficient to establish a condition for this metric.

Confidence: Low

While two plot studies have been conducted in the last five years, they represent only a fraction of the One Tam area of focus.

Trend: Declining

Anecdotal reports from field staff, researchers, local experts and recreationists, as well as a review of historic museum specimens suggests species richness is declining on Mt. Tam in general, and in grasslands in particular.

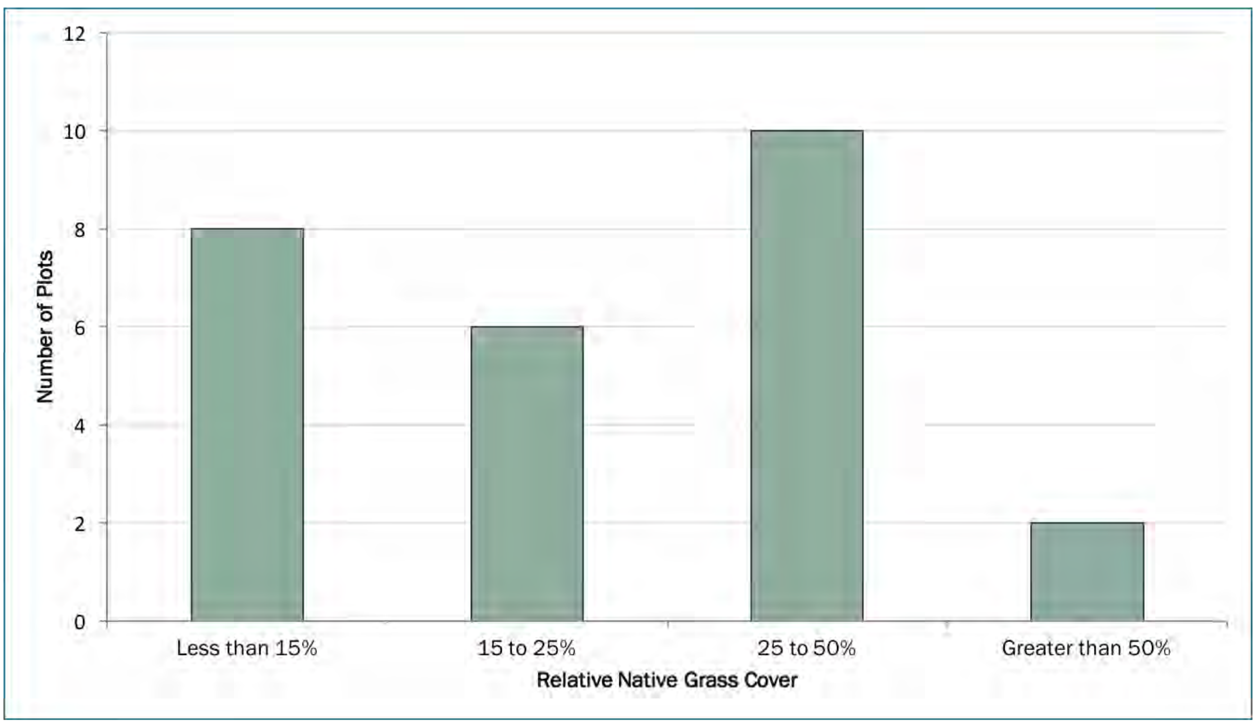
METRIC 4: PERCENT COVER NATIVE GRASSES

Baseline: The Manual of California Vegetation sets a threshold of 10% relative cover native species for a grassland patch to be classified as an alliance or association with a native grass component. The 2003 Field Key to the Plant Communities from the NPS Golden Gate National Recreation Area/Point Reyes National Seashore map sets >15% relative cover of native perennial grasses (Schirokauer et al., 2003); the MMWD map has a 10% relative cover of a dominant species or genus to key to some alliances or associations, but this does not hold for all native grassland types ((Evens & Kentner, 2006). The coastal prairie mapping project classified fewer than 5% of its total grassland area as native grassland, but set a higher bar of >30% relative cover of native grasses as the qualifier. There is currently no broadly accepted cover—relative or absolute—of native grasses, specifically, that makes a grassland a "native" grassland. For this metric, we have chosen a criterion of 15% relative cover of native perennial grasses to define "native" grassland.

Of the plots sampled in the 2012 NPS Marin Headlands study and 2016 MMWD grassland assessment, nearly 70% had 15% relative cover or more native grasses (Figure 8.2). In both studies, plot locations were targeted in grasslands believed to contain a high native species component.

While there is insufficient data to allow for generalization across the One Tam area of focus, this limited sample size suggests that some grassland patches still support a significant native grass component. However, given that the studies were specifically focused on patches that were pre-identified as meeting the native cover criterion and the classification series, and based upon recent field visits and ocular assessments by field staff in non-sampled stands which make up the majority of grassland acres, staff believe that it is unlikely that the majority of grassland patches in the One Tam area could be classified as a native grassland.

FIGURE 8.2 RELATIVE COVER OF NATIVE GRASSES IN SAMPLED PLOTS, MMWD AND NPS (STEERS & SPAULDING, 2013; MMWD, 2016, UNPUBLISHED DATA)



Condition Goal: Maintain 50% of existing grasslands with 15% or greater relative cover of native grasses

Condition Thresholds:

- **Good:** More than 80% of grasslands (2,600 acres) with 15% or greater relative cover of native grasses

- **Caution:** 60–80% of grassland (2,115–2,600 acres) with 15% or greater relative cover of native grasses

- **Significant Concern:** Less than 40–60% of grassland (2,115 acres) with 15% or greater relative cover of native grasses

Current Condition: Significant Concern

Twenty-nine percent of the recently sampled grassland plots within the One Tam area of focus contained less than 15% relative cover of native grasses despite being purposefully situated in locations where the overall quality was believed to be high. Thirty-three percent of native-grassland-targeted plots on adjacent NPS lands outside of the One Tam area of focus had a similarly low level of native grasses.

These data are insufficient for extrapolation throughout the entire One Tam area of focus. The totality of NPS and State Parks acreage of California Annual Grassland with Native Component Mapping Unit within the area of focus is 23.7 acres; 891 acres is California Annual Grassland Mapping Unit, and 139 acres is Introduced Coastal Perennial Grassland Alliance. Data from MCP were not analyzed but only represent less than 10% of total grassland acres.

Based on mapped acres of grassland types, and extrapolating from the quality of the “best” acres sampled, we estimate that significantly fewer than 2,000 acres reach the minimum cover of native grasses to qualify as “native” grassland.

Confidence: Low

Because of the small sample size, the targeted nature of plot placement, and the fact that all of the NPS plots were located outside of the One Tam area of focus, confidence is “Low.”

Trend: Declining

Time series data are not available. However, observations by field staff, local researchers active on Mt. Tam, and area experts indicate non-native grasses have expanded dramatically over the last five years. This has not been demonstrated to be to the detriment of native grass cover at this time.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Data sources for acreages listed under the above metrics include:

- MMWD vegetation maps from 2004, 2009, and 2014 (AIS, 2015)
- MCP vegetation map 2008 (AIS, 2008)
- NPS vegetation map and NPS 2013 study

ACREAGES CALCULATIONS

TABLE 8.1 METHODS AND DATA USED TO CALCULATE GRASSLAND ACREAGES

Indicator Plant Community	Vegetation Types Included	Metrics	How Derived
Grasslands	• California annual grassland alliance • Grasslands on well-developed soils • Grasslands on poorly developed soils • Grasslands with a fern or sub-shrub (golden banner component) • Tall temperate perennial herbaceous (Harding grass) • Native temperate perennial grasslands • California or Idaho fescue grasses • Purple needlegrass • Upland serpentine grassland • Wetland serpentine grassland • Community (grassland) • Introduced and coastal perennial grassland alliance	Acres (total)	Total acreage of all grassland types
		Patch size	"Dissolved" individual grassland types into one; counted contiguous patches over 30 acres

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Time Series Measurements of Grassland Extent: While grassland patches cannot be mapped remotely within the National Vegetation Classification System with the same level of accuracy as forest and scrub habitats, the delineation of grasslands as a general life form is straightforward and beneficial for the understanding of wildlife habitat quality, fire dynamics, and successional processes. Historic aerial photos are available for the entire One Tam area of focus and would allow for the change-over-time assessment of total acres and patch size that has been completed for MMWD lands.

Comprehensive Grassland Composition Data from a Permanent Plot Network: The spatial and temporal variability in the grassland types distributed across the One Tam area of focus cannot be adequately described or monitored from the sorts of sampling exercises completed to date. However, the protocols described in the 2013 NPS grassland study would generate the appropriate data needed to understand and respond to changes in grassland composition over time, if plots were established and monitored in a coordinated manner throughout all jurisdictions.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration:

- Volunteer workdays to pulled weeds and cut Douglas-fir in some areas

- Succession management: additional conifer and weed removal, plus some coyote bush cutting and mowing by staff and contractors (MMWD and State Parks)

- Grassland protection (erosion gullies removal, trail realignment, grassland species planting) as a part of the Dias Ridge trail corridor realignment process

- Wide Area Fuel Load Reduction project at Pine Point to maintain open grassland and oak woodlands included succession management (i.e., removal of Douglas-fir and coyote brush) (MMWD)

Mapping and Monitoring: Completed an analysis of species richness, spatial extent, and stressors to approximately 185 grassland patches within Mount Tamalpais State Park to prioritize restoration actions (State Parks and UC Berkeley)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Targeted Non-native, Invasive Plant Species Control:** Develop and implement mountain-wide targeted invasive plant removal program in grassland habitat for species known to have impacts on grassland health including perennial non-native grasses, brooms, cotoneaster, licorice plant (*Glycyrrhiza glabra*), and pampas grass (*Cortaderia selloana*)

- **Succession Management:**

    - Identify pilot locations for utilizing prescribed fire for succession management to help reset successional processes, decrease thatch, decrease woody species cover in the short term, stimulate perennial grasses and many native forbs, and if timed correctly, temporarily decrease cover of some exotic grasses (Note: The appropriateness of prescribed fire as a tool for grassland restoration is highly site specific and often depends on agency capacity as much as site conditions)

    - Assess efficacy and feasibility of elk reintroduction at Ridgecrest (MMWD), which (pending agency guidelines) could decrease thatch and increase micro disturbances, which would benefit native species richness

    - Sustain and expand the removal of encroaching scrub species and Douglas-fir saplings and trees; removal efforts have resulted in reduced impacts and conversion of native grassland habitats; this work is ongoing on MMWD and State Parks lands in targeted locations

- **Restoration:** Implement priority restoration actions to improve grassland richness and function by removing primary threats (e.g., non-native, invasive species, social trails, etc.), and managing natural processes to reduce thatch and non-native annual species cover; priority locations include Portrero Meadows, Bathtub Gap, Sky Oaks Meadow (MMWD), Dias Ridge (NPS and State Parks) and Ridge Crest (State Parks)

Inventory and Monitoring:

- **Spatial Extent and Species Richness of Grassland Habitat:** Conduct a comprehensive assessment across all jurisdictions in a single field season to establish baselines for species richness, perennial grass abundance, woody species and non-native, invasive species encroachment

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CHAPTER 9. SERPENTINE BARREN COMMUNITY ENDEMICS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Caution

Trend: Declining

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Serpentinite, California's state rock, creates serpentine soils, which are characterized by low amounts of calcium, high amounts of magnesium, relatively heavy concentrations of nickel, chromium, and other heavy metals, and low levels of nitrogen (U.S. Department of Agriculture [USDA], 2016). Only certain plant species are able to survive in these soils. Serpentine is a rare soil type statewide, further limiting the distribution of plants that are specifically adapted to its harsh characteristics.

Serpentine barrens are characterized by open, rocky soil and support mostly scattered annuals such as jewel flowers, rosinweed (*Calycadenia multiglandulosa*), navarretias, and a few perennial plants such as lomatiums and buckwheats. Many rare, locally rare, and Mt. Tam endemic plants may also be found within these areas.

OVERALL CONDITION

There are 96 patches of various rare taxa on 30 acres of serpentine barrens in the One Tam area of focus, constituting approximately 0.2% of the open space in the One Tam area of focus (see Table 2.1 in Chapter 2).

DESIRED CONDITIONS

Although not calculated yet, some level of historic occupancy for the two suites of species identified in Metrics 1 and 2 below is desirable.

STRESSORS

Non-native Species Encroachment: The unusual soils of these habitats make them largely resistant to invasion, but barbed goatgrass (*Aegilops triuncialis*) and purple false brome (*Brachypodium distachyon*) are encroaching upon them, and lack of fire may allow native shrubs or grasses to overtake open areas.

Trampling: The open landscapes of serpentine barrens make them attractive to recreationists, and vulnerable to trampling.

Climate Change: The relative rarity of serpentine soils limits where serpentine-adapted species could migrate if needed in response to shifting temperature and precipitation patterns predicted under different climate change scenarios (Ackerly et al., 2012).

Atmospheric Nitrogen Deposition: Air pollution contains reactive nitrogen compounds like NOx, ammonia, and nitric acid that deposit on surfaces and act as nitrogen fertilizer. Impacts of N-deposition are well documented across California (Fenn et al., 2010; Weiss, 2006), and include increased annual grass and weed growth in serpentine soils (Weiss, 1999). Mt. Tam spans a N-deposition gradient from quite clean coastal air on the west slopes (<2 lbs-N ac-1 year-1) to local hotspots (~10 lbs-N ac-1 year-1) on the eastern flanks close to urban areas (Fenn et al., 2010). Serpentine barrens may be particularly sensitive. Effects on serpentine grasslands are observed at ~6 lbs-N ac-1 year-1 (Fenn et al., 2010). Increased annual grass growth in serpentine barrens reduces open ground and crowds out the diminutive annual forbs restricted to open areas.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: NUMBER OR PERCENT OF PATCHES OCCUPIED BY "COMMON" RARE PLANT SPECIES

Baseline: Unknown. Marin County navarretia (*Navarretia rosulata*), Mt. Tamalpais bristly jewelflower (*Streptanthus glandulosus* var. *pulchellus*), Tiburon buckwheat (*Eriogonum luteolum* var. *caninum*), and Oakland star-tulip (*Calochortus umbellatus*) may be considered the more "common" rare plants. Many species in this category were not historically mapped and are not in the California Natural Diversity Database (CNDDB), so there are not enough data to set a baseline, condition goals, or trend. Observations by field staff indicate that there are good numbers of these species in the One Tam area of focus.

Condition Goal: Undefined

Condition Thresholds: Undefined

Current Condition: Good

Recent inventories by the Marin Municipal Water District (MMWD) show most populations are extant.

Confidence: Moderate

Trend: No Change

Populations, although responsive to recent drought conditions, appear to be stable. However, we have not determined the exact thresholds for what would constitute meaningful change.

METRIC 2: NUMBER OR PERCENT OF PATCHES OCCUPIED BY "RARE" RARE PLANT SPECIES

Baseline: Unknown

Marin dwarf flax (*Hesperolinon congestum*), Tamalpais jewelflower (*Streptanthus batrachopus*), and Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) may be considered the more "rare" rare plants. These species have been historically mapped, making it possible for us to give some number of populations. However, there is not agreement on what constitutes an individual patch. The goal for these species may merge with the recovery goals described in Metric 3.

Condition Goals: Undefined

Condition Thresholds: Undefined

Current Condition: Caution

Recent inventories by MMWD show most populations are at lower levels than what was historically present.

Confidence: Moderate

Three consecutive years of drought may be making recent survey results artificially low. Additional surveys in 2016 may provide additional information.

Trend: Declining

Populations appear to be declining due to encroachment, although exact thresholds for what would constitute meaningful change have not been determined.

METRIC 3: RECOVERY GOALS MET FOR MARIN DWARF FLAX AND TAMALPAIS LESSINGIA

Baseline: In the *Recovery Plan for Serpentine Soils of the San Francisco Bay Area* (Fish and Wildlife Service [USFWS], 1998), occurrences are "defined by the California Natural Diversity Database as a location separated from other locations of the species by at least one-fourth mile; an occurrence may contain one or more populations."

Agency staff survey and manage at the population level. Two populations of Marin dwarf flax are found within the One Tam area of focus. The population on Carson Ridge averages 100 plants, which falls below the recovery plan goals. The second population is south of Carson Ridge in four patches and surpasses 2,000 individuals in some years.

Four populations of Tamalpais lessingia are found within the One Tam area of focus according to data from the CNDDB (accessed July 13, 2016). One has not been seen since the initial mapping in 1960. Two populations are found along Oat Hill, one of which surpasses 2,000 individuals. The Azalea Hill population is comprised of seven patches, including Rocky Ridge serpentine areas, which exceeds 2,000 individuals. In some years, total numbers of lessingia in the One Tam area of focus exceed 20,000 plants. More than 10,000 individuals were observed in surveys of the Carson Ridge region in 2016.

Condition Goals:

As stated in *Recovery Plan for Serpentine Soils of the San Francisco Bay Area* (USFWS, 1998):

- Seven Marin dwarf flax populations from Carson Ridge north, mostly outside area of focus
- Two Marin dwarf flax populations south of Carson Ridge to San Francisco
- Six Tamalpais lessingia populations in its entire historic range
- The seeds of both species are in two seedbanks
- Populations are defined as 2,000+ plants and populations must be stable or increasing for 20 years

Condition Thresholds:

- **Good:** Two Marin dwarf flax populations in the area of focus; six Tamalpais lessingia populations in entire historic range (USFWS, 1998); the seeds of both species are in two seedbanks and each population is at least 2,000 individuals

- **Caution:** Two Marin dwarf flax populations in the area of focus; six Tamalpais lessingia populations in area of focus; the seeds of both species are in a seedbank and each population is at least 1,000 individuals

- **Significant Concern:** Number of populations falls below one and three, or population sizes fall below 1,000 for half of the populations

Status: Caution

Populations of Marin dwarf flax and Tamalpais lessingia are in decline. The former has two shrinking populations and the latter only two populations meeting the size threshold.

Confidence: Moderate

Based on best professional judgment of field staff, these populations are extant, but Marin dwarf flax numbers are low.

Trend: Declining

Populations of Marin dwarf flax and Tamalpais lessingia are in decline. The former has two shrinking populations and the latter only two populations meeting the size threshold.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

- MMWD rare plant surveys (2009–2016)

- CNDDB data for certain species (2016)

- Serpentine barrens are also visible from aerial photos and are well mapped in MMWD lands

See the Indicator Analysis Methodology section of Chapter 2 for additional information about the overall methodology used for vegetation community analyses.

INFORMATION GAPS

Patch-related Data: We do not know if “barren” patch size influences rare species composition or occupancy resilience, or if patches be subsampled or rotationally sampled to determine health of the whole system.

Potential Population Enhancement areas: We need to identify suitable areas for augmentation.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Management: Barbed goatgrass removal at Azalea Hill and Pine Mountain (MMWD)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Targeted Non-native, Invasive Plant Species Control:**

    a. Expand non-native, invasive species management work within Bolinas and Nicasio Ridge's serpentine barrens to reduce threats to rare species and protect native species richness

    b. Conduct adaptive management trials on MMWD to assess efficacy for controlling barbed goatgrass and purple false broom, and identify most effective techniques and expand to program to protect serpentine barrens

Inventory and Monitoring:

- **Serpentine Endemic Occupancy Project:** Further develop the MMWD serpentine barrens pilot inventory and monitoring program throughout the One Tam area of focus to better understand and protect many of Mt. Tam's iconic species and the habitats that support them

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CHAPTER 10. VEGETATION, SOIL, AND HYDROLOGY INDICATOR NEEDS STATEMENTS

The many things that remain unknown about Mt. Tam's vegetation communities, and associated soil and hydrological resources, are evidenced by the information gaps identified in each chapter, as well as the initial proposed indicators that did not make it into this report (see Appendix 1).

The resources described in the following chapter are a subset of that initial list of proposed indicators for which sufficient information may be attainable in the near future. For many, the missing data are relatively easy to gather and/or there are already plans to collect it soon.

The following summaries describe the current state of knowledge about these indicators and what it might take to gather enough additional information for them to be included in the next iteration of this assessment.

SEEPS, SPRINGS, AND WET MEADOWS

Seeps, springs, and wet meadows are characterized by the presence of fresh water discharge from groundwater flow systems, which rises to form distinctive wetland features. These features are often associated with unique aquatic ecosystems (Howard et al., 2010).

Springs and seeps can vary seasonally and are often classified by the volume of the water they discharge. They are considered perennial if they discharge continuously, or intermittent if their discharge is naturally interrupted or sporadic. They may also be variable at different temporal scales. For example, short-term variability may be related to loading effects, such as the syphon effect in which groundwater channels fill and create periodic spring discharge surges.

Wet meadows are a type of marsh that commonly occurs in poorly drained areas such as the land between shallow marshes and upland areas. These wetlands, which often resemble grasslands, are typically drier than other marshes except during periods of seasonal high water. Even though wet meadows are without standing water for most of the year, the high water table allows the soil to remain saturated (*www.epa.gov/wetlands/wet-meadows*).

Short-term hydrologic changes to these ecosystems may be caused by individual storms or droughts, while longer-term differences may be caused by interannual climate variation, or larger-scale climate and hydrologic changes. Spring discharge variability may affect the distribution of associated microhabitats (Springer et al., 2008), as much of the vegetation is limited by the presence of standing water. These associated plant communities may include rare plants such as *Hosackia gracilis*, *Cirsium hydrophilum* var. *vaseyi*, *Toxicoscordion fontanum*, *Perideridia gairdneri* var. *gairdneri*, and *Calochortus uniflorus*.

Surrounding ecosystems are also likely to influence habitat conditions, plant colonization, wildlife and human uses, and other characteristics. In general, steep ecological gradients of environmental stability, chemistry, moisture availability, productivity, and other factors most strongly affect levels of biodiversity and endemism in seeps, springs, and wet meadows (Malanson, 1993).

WHY IS THIS AN IMPORTANT INDICATOR

Seeps, springs, and wet meadows can be used as indicators of biological integrity and diversity, natural processes, climate change vulnerability, natural disturbance regime, and habitat quality. Springs may also function as refugia across ecological and evolutionary time scales (Springer et al., 2008).

Wet meadows can collect and store runoff and remove the excess nutrients, acting as a natural filter. This nutrient-rich environment provides vital food and habitat for many insects, amphibians, reptiles, birds, and mammals.

In addition to the aquatic, riparian, or terrestrial habitats springs and seeps may support, their associated spheres of discharge are capable of creating unique microhabitats. These microhabitats may be created by specific physical or chemical characteristics, such as temperature, water depth, dissolved ion or oxygen composition, disturbance regime, or a suite of physical variables, and some support high levels of endemic species (Baldwin et al., 2012).

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Conduct Mt. Tam-wide Springs and Seeps Monitoring: Our current knowledge of the locations, discharge rates, and size of these wetland features based on very limited monitoring and a few inventory studies, primarily on National Park Service lands. Developing a mountain-wide survey protocol and associated monitoring program that helps us understand flow and species composition will improve our understanding of how these landscape features are changing in response to climate change and other stressors.

Monitoring could include:

- Location and estimated extent
- Native plant species richness and relative cover
- Invasive plant species presence and relative cover
- Rare, threatened, and endangered species presence (data collection to include attributes consistent with agency partner rare plant monitoring protocols)
- Perennial or ephemeral classification
- Discharge rate(s), potentially measured at multiple timeframes
- Macroinvertebrate species presence/absence
- Water chemistry/quality parameters

Implement the Proposed Potrero Meadow One Tam Pilot Project: This project would realign existing trails so that they circumnavigate the diverse wetland habitat at this site. It would also identify and implement a strategy to control and remove non-native, invasive perennial grasses and stimulate revegetation with wetland species to revitalize the habitat.

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RIPARIAN WOODLANDS AND FORESTS

Riparian areas comprise less than 1% of the land in the western United States (Natural Resources Conservation Service [NRCS], 1996); however, native riparian plant communities comprise some of the most productive wildlife habitat in North America. They are critically important to the life cycle of endangered salmonid species (Federal Interagency Stream Restoration Working Group [FISRWG], 1998), as the aquatic macro-invertebrates that salmonids feed upon are correlated with healthy riparian forests. Furthermore, the linear nature of riparian ecosystems provides distinct corridors that are important as migration and dispersal routes, and as forested connectors between wildlife habitats. Of the 502 recent native species of land mammals found in California (Hall, 1981), approximately 25% are limited to, or dependent upon, riparian and other wetland communities. These systems are also responsible for the regulation of critical ecosystem functions such as nutrient cycling, energy transfer, and water purification in adjacent aquatic environments.

Riparian woodland and forest habitat is limited to approximately 850 acres within the One Tam area of focus. These areas include species such as Pacific willow (*Salix lasiandra*), Arroyo willow (*Salix lasiolepis*), Western dogwood (*Cornis sericea* ssp. *occidentalis*), blue elderberry (*Sambucus nigra* ssp. *caerulea*), California wax myrtle (*Morella californica*), California blackberry (*Rubus ursinus*), coast twinberry (*Lonicera involucrata* var. *ledebourii*), and flowering currant (*Ribes sanguineum* var. *glutinosum*).

WHY IS THIS AN IMPORTANT INDICATOR

As noted above, riparian vegetation provides important physical and biological processes that are necessary to support a diversity of plant and wildlife (Lennox et. al., 2011). Specifically, riparian vegetation helps:

- stabilize stream banks;
- act as a buffer between adjacent land uses, controlling sediment, nutrient, and pathogen inputs;
- shade creek channels to optimize light and temperature conditions for aquatic plants, fish, and other wildlife, maintain low water temperatures, and regulate dissolved oxygen levels;

- contribute substantial quantities of large woody debris, which provide in-stream complexity essential for insects and fish; and
- deposit large amounts of leaf litter, insects, and nutrients that are crucial components of aquatic food webs.

Mt Tam's riparian forest and woodland species are being impacted by many stressors including ground water depletion, climate change, and non-native invasive species. It would be important to monitor the changes and impacts to these ecosystems as they react and respond to these stressors.

POTENTIAL MONITORING AND DATA COLLECTION

Our current knowledge of both the integrity and connectivity of Mt Tam's riparian habitats is limited to past monitoring efforts focused on specific restoration projects or weed detection surveys. Developing a mountain-wide assessment and associated monitoring program will improve our understanding of the health of these communities, and how these landscape features are changing in response to climate change and other stressors.

Monitoring could include:

- Number of acres of late successional native riparian habitat (characterized by complex/layered structure that includes large floodplain trees in the overstory; understory trees and shrubs; and vines and ground cover such as *Juncus* spp., *Carex* spp., and *Leymus* spp.)
- Number of trees larger than 24 inches in diameter at breast height
- Acres of woodland and forest habitat (ephemeral, intermittent, and perennial)
- Riparian cover characteristics required for adequate sediment buffering and stream channel shading
- Presence and extent of priority non-native, invasive plant species
- Corridor length, connectivity, and width
- Fluvial geomorphic processes necessary to sustain long-term riparian succession and habitat formation

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HARDWOOD FORESTS AND WOODLANDS

Hardwood forests and woodlands are vegetation types where the canopy layer is dominated by one or more tree species other than those that were included in the open-canopy oak woodlands indicator chapter such as coast live oak (*Quercus agrifolia*), valley oak (*Q. lobata*), Oregon oak (*Q. garryana*), and black oak (*Q. kelloggii*) and those that are exclusively riparian such as red alder *(Alnus rubra*) (see Chapter 5 for a full list of these open-canopy oak woodland species).

Thus, these hardwood forests and woodlands include areas dominated by California bay (*Umbellularia californica*), madrone (*Arbutus menziesii*), tanoak (*Notholithocarpus densiflorus*), canyon live oak (*Quercus chrysolepis*), chinquapin (*Chrysolepis chrysophylla*), buckeye (*Aesculus californica*), and bigleaf maple (*Acer macrophyllum*). Hardwood forests and woodlands are found throughout the Mt. Tam area of focus, but are most abundant where Douglas-fir (*Pseudotsuga menziesii*) and coast redwood (*Sequoia sempervirens*) (moist microclimates) and chaparral (dry microclimates) are not present. The extent, integrity, and health of hardwood forests and woodlands would be an important indicator of the overall health of Mt. Tam.

WHY THIS IS AN IMPORTANT INDICATOR

Hardwood forests and woodlands are the most extensive set of tree-dominated vegetation types within the One Tam area of focus, covering 7,110 acres (or 20%) of the land (see Table 2.1 in Chapter 2). Vegetation types classified as dominated by California bay are the most abundant of all hardwood tree types in the study area at 66%. The leaves of bays are a principle browse for deer (Biswell & Gilman, 1961; Sampson & Jespersen, 1963; Stein, 1974) and their fruits are an important food source for dusky-footed woodrats (*Neotoma fuscipes*), California mice (*Peromyscus californicus*), Steller's Jays (*Cyanocitta stelleri*), and western gray squirrels (*Sciurus griseus*) (Stieneckeer & Browning, 1970; Stienecker, 1977).

California bay is also the largest contributor to the spread of Sudden Oak Death (SOD) caused by the pathogen *Phytophthora ramorum* (Davidson et al., 2005), which has been killing coast live oak, tanoak, California black oak, and other native species since it was first detected in 1995. As a result, previously oak-dominated forests and woodlands are slowly converting to stands dominated by other hardwoods, including California bay and madrone. However, California bay is susceptible to *Phytophthora cinnamomi* and may also be killed by the fungus *Raffaelea lauricola* that is spread by the non-native redbay ambrosia beetle (*Xyleborus glabratus*) (Mayfield et al., 2013) and is killing trees in the Lauraceae family in the southeastern United States (Kendra et al., 2013).

Madrone, the second most abundant hardwood type, covers an additional 21% of the acres of hardwood in the One Tam area of focus. Anecdotal evidence suggests that this species is experiencing local to widespread twig and tree mortality caused by drought stress and fungus (*Botryosphaeria dothidea*) (Bennett & Shaw, 2008). Although the extent and severity of this problem is unknown, it is likely relatively small. Madrone is also susceptible to two *Phytophthora* species (*P. cactorum* and *P. cinnamomi*). Both of these root diseases have been confirmed in Marin County. Their impact to madrone and other native species in the One Tam area of focus is unknown, but probably small.

The third most extensive hardwood is tanoak at 10%. Forests dominated by this species have been severely impacted by SOD with many stands experiencing 50–100% stem dieback (McPherson et al., 2010; Swiecki & Bernhardt, 2013). In many cases, these stands are caught in a cycle of stem death followed by regeneration and subsequent stem death.

There are also smaller extents dominated by other hardwood species that include canyon live oak, buckeye, chinquapin, and bigleaf maple. While hardwood forests other than oaks are not known to support the high wildlife biodiversity that woodlands dominated by oaks do, they still contribute to overall floristic and faunal biodiversity and are regarded as important habitat to many different wildlife taxa. Each of these tree species is also susceptible to one or more species of *Phytophthora*.

The hardwood species and the forests and woodlands they define are being impacted by many stressors including pathogens, climate change, altered fire regimes, non-native, invasive species, and others. It would be important to monitor the changes and impacts as they react and respond to these stressors.

POTENTIAL MONITORING AND DATA COLLECTION

- Impacts of stressors on the trees and their associated ecosystems
- Vegetation and associated changes driven by the stressors
- Stand demographic structure and trends
- Wildlife use and biodiversity
- Differences in stand composition and health in both burned and unburned areas

ASSOCIATIONS AND ALLIANCES INCLUDED

- California bay alliances and associations
- Madrone alliances and associations
- Tanoak associations
- Canyon live oak associations
- Chinquapin alliance
- Buckeye alliance
- Bigleaf maple association

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DOUGLAS-FIR FORESTS

Forests where Douglas-fir (*Pseudotsuga menziesii*) is the dominant canopy tree cover 6,829 acres of the One Tam area of focus. These forests are found primarily in the moister microclimates north of Kent Lake, along portions of Bolinas Ridge's western slope, and around the mountain's northern, western, and southern slopes. Although Douglas-fir is the dominant tree species in these forests, other subdominant canopy and subcanopy tree species such as California bay, madrone, tanoak, and coast live oak are usually also present.

WHY THIS IS AN IMPORTANT INDICATOR

Douglas-fir is the most dominant conifer species in the Pacific Northwest and is relatively tolerant of a wide range of climates and soils (Atzet & McCrimmon, 1990; Hermann & Lavender, 1990), though is restricted to areas with sufficient rainfall. If allowed, this species can live to 500 years or more. Native Americans used fire as a management tool for thousands of years to open up forests, effectively removing or excluding Douglas-fir from many areas. Up until the mid-twentieth century, this species was also heavily logged in Marin County. The combination of millennia of fire management and logging likely reduced the extent and density of Douglas-fir across Marin County and the One Tam area of focus.

It is believed that Douglas-fir has been steadily expanding its range and dominance since the institution of effective fire suppression and the cessation of widespread logging. This recolonization or spread is considered an invasion into other vegetation types and management actions are often directed at removing this species.

Douglas-fir and the forests it dominates are important habitats for species such as the Northern Spotted Owl (*Strix occidentalis caurina*) (Cary et al., 1990; Glenn et al., 2004). Seeds of this tree are an important component of the diet of many mammals including mice, voles, shrews, chipmunks, and squirrels (Gashwiler, 1970; Arno, 2007), as well as many birds such as Dark-eyed Juncos (*Junco hyemalis*) and White-crowned Sparrows (*Zonotrichia leucophrys*) (Black, 1969; Arno, 2007).

Although it is assumed that the historic fire regime in Douglas-fir forests was defined by frequent fires, available data indicates that fires occurred on average approximately every 100 years in coastal Douglas-fir forests (Van de Water & Safford, 2011). Many areas of Mt. Tam have not burned for over 100 years. Although Douglas-fir is widespread, there are few, if any old-growth stands.

POTENTIAL MONITORING AND DATA COLLECTION

Future monitoring could include:

- Impacts of stressors to this species and the forests it dominates
- Stand demographic structure
- Wildlife use and biodiversity
- Differences in stand composition and health in both burned and unburned areas

VEGETATION TYPES INCLUDED

- Alliances and associations with Douglas-fir listed as the dominant canopy species

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LICHENS AS AN INDICATOR OF HEALTH (CLIMATE AND AIR QUALITY)

Mt. Tam hosts a remarkable diversity of lichens for the same reasons the area supports so many different types of plants—its diverse array of habitats and microclimates. There are 350 lichen species reported from the One Tam area of focus including one rare species, Methuselah's beard (*Usnea longissimia*), and the California state lichen, lace lichen (*Ramalina menziesii*). Ecologically, lichens are important because they provide a number of ecosystem services including nesting material, food, habitat, soil development and stabilization, carbon fixation, and nutrient cycling. Many areas on the mountain have yet to be explored and it is expected that additional, possibly 50–100, lichen species will be added to the list (S. Benson, personal communication).

WHY THIS IS AN IMPORTANT INDICATOR

Climate change has been identified as a key factor that threatens Mt. Tam's biological diversity. Lichens are known for their sensitivity to air pollution and climate, and are one of the first groups of organisms to respond to shifts in environmental conditions (Gries, 1996; Hawksworth & Rose, 1976). Therefore, detecting a change in the lichen community can indicate impacts to ecosystem function and integrity.

In the last decade, research has also shown that lichens respond predictably along climate gradients, and are also correlated to temperature and moisture gradients (Geiser & Neitlich, 2007). Additionally, lichens are very responsive to nitrogen pollution. By monitoring the status and trends in the lichen community, land managers can infer the extent and severity of pollution and climate impacts on other organisms, and identify management actions to potentially reduce or ameliorate these impacts.

The benefit of using lichen as biological indicators is that they can help identify when and where environmental conditions are affecting the ecosystem. Additionally, lichen monitoring can be conducted throughout the mountain's landscapes.

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Implement a Systematic Lichen Monitoring Plot Establishment and Inventory: A lichen monitoring program would follow nationally standardized protocols and use regionally specific air quality and climate gradient models developed by the US Department of Agriculture Forest Service (United States Department of Agriculture [USDA], 2011). Four to five plots could be tied into current and future vegetation community monitoring plots and would be resampled once every five years (S. Benson, personal communication).

This research would help:

- Document a baseline for lichen community composition in order to detect sensitive indicator species before they disappear due to the present threat of environmental stressors

- Install a sustainable, cost-effective strategy for monitoring spatial pattern and temporal trends in air quality, climate, and biodiversity at multiple scales:

    1. Within the One Tam area of focus
    2. Within the broader region (as defined by the regional gradient model)

- Contribute to the One Tam lichen inventory using the species lists generated from lichen monitoring plot data

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SOILS

Soil is increasingly recognized as a critical component of ecosystem health with remarkable levels of biodiversity (Bardgett & van der Putten, 2014). Recently, the State of California funded the Healthy Soils Initiative which defines healthy soils to mean "soils that enhance their continuing capacity to function as a biological system, increase soil organic matter, improve soil structure and water- and nutrient-holding capacity, and result in net long-term greenhouse gas benefits." In addition to ecosystem health, soil biodiversity is increasingly recognized as providing benefits to human health because it can suppress disease-causing soil organisms and provide clean air, water, and food (Wall et al., 2015).

Despite so much recent attention given to the importance of soils, little information exists on soil biodiversity and function in general, and none on Mt. Tam specifically. Yet, Mt. Tam may host an impressive amount of soil biodiversity given its array of vegetation communities, soil types, diverse topography, and microclimates.

WHY THIS IS AN IMPORTANT INDICATOR

The benefit of soils as an indicator is that they are known to be affected by a wide variety of human-induced changes, including climate change, and they influence so many other aspects of ecosystem and human health.

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and

will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Develop and Implement Baseline Soil Sampling: Developing a survey protocol and collecting baseline data will help provide a more complete picture of biological diversity on Mt. Tam and establish a benchmark against which future resampling efforts can be used to assess the mountain's health.

Because no information on the biodiversity of soils currently exists, it will be necessary to consult experts in the field to:

- Align on the best metrics for inventorying and monitoring soil biodiversity
- Determine if additional elements of soil health should be included (e.g., soil organic carbon)
- Conduct an inventory of soil biodiversity and other elements, if judged important
- Align on monitoring goals and establish a protocol that most efficiently meets those goals

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HYDROLOGIC FUNCTIONS

Hydrologic functions across Mt. Tam are governed by complex interactions between global climate dynamics, regional- and landscape-scale physical drivers (e.g., precipitation, streamflow, fog dynamics, and groundwater recharge) and watershed- and site-scale conditions (e.g., watershed geology, vegetation communities, and fluvial geomorphology). Hydrologic functions are central to the mountain's health, and include indicators such as the quantity and quality of stream flows available for fish and other aquatic organisms, soil moisture to support plant establishment and growth, the delivery of sediment from watersheds into streams, and much more. These functions are highly vulnerable to a range of human impacts, including global climate change, the construction and operation of dams and other infrastructure, fire protection activities, and vegetation management.

WHY THIS IS AN IMPORTANT INDICATOR

Despite (or because of) their fundamental importance to ecosystem health and vulnerability to anthropogenic change, hydrologic functions can be challenging to monitor, analyze, interpret, and integrate into decision-making. In a discussion of stream metrics for San Geronimo Creek, Booth and Singer (2009) provided an excellent overview of the difficulties facing those who attempt to develop hydrologic metrics within a management framework:

"Although 'stream monitoring' is an ever-more common activity of jurisdictions, many such efforts either lack a coherent conceptual framework or appropriately chosen methods, and as such, do not provide adequate information to reach their intended goals… The problem is generally not with executing specific monitoring protocols—many guidance documents exist that specify proper techniques for data collection. Instead, the major shortcoming is in choosing an approach that will provide sufficient data to answer particular management questions and that is feasible for the institutional context and available resources."

The challenges that Booth and Singer describe are magnified by the fact that the mountain's four public land managers each have distinct missions, management goals, institutional and administrative structures, and financial and staffing resources. However, the identification of hydrologic functions as an important indicator for measuring the health of Mt. Tam offers an opportunity to define and apply a coherent, integrated, and fiscally feasible monitoring approach across the mountain.

Existing monitoring of hydrologic functions on Mt. Tam is dominated by metrics with a regulatory nexus, such as streamflow, water quality, and bed composition in Lagunitas and Redwood creeks (relevant to salmonids), the depths and distribution of pool habitat along Carson Creek (relevant to foothill yellow-legged frogs [*Rana boylii*]), and others. In these cases, the monitoring, analysis, and reporting methods are typically dictated by resource agencies such as the California Department of Fish and Wildlife, the San Francisco Bay Regional Water Quality Control Board, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. The questions that these data seek to address are typically narrow in scope, and are often of limited utility to broader management planning. Watersheds with a limited regulatory nexus, such as Corte Madera Creek, Arroyo Corte Madera del Presidio, Coyote Creek, and many others, are typically only monitored on an opportunistic basis, often by local advocacy groups, streamkeepers, and related organizations.

POTENTIAL MONITORING AND DATA COLLECTION

The absence of a landscape-scale, management-driven approach to monitoring hydrologic function makes it difficult for land managers to understand and address Mt. Tam's watershed health. Critically, the patchwork nature of data describing existing conditions will make it even harder for land managers to assess the future impacts of climate change, including likely shifts in fundamental hydrologic drivers such as precipitation and temperature. While a complete description of hydrologic metrics, methods, and analyses is outside the scope of this document, future monitoring should at the very least address the following elements across the mountain:

- **Stream peak and low flows:** The spatial extent and temporal intensity, magnitude, and duration of peak flows and low flows drive the evolution of stream habitats and dependent plant, fish, and wildlife communities. Changes in these metrics can signal significant landscape changes.
- **Watershed runoff vs. infiltration:** Watersheds that favor infiltration instead of runoff are more likely to establish functional connections between groundwater and surface waters, and support surface flows in streams and seeps even during periods of extended drought.
- **Road density and conditions**: The density and condition of roads (particularly unpaved fire roads) within watersheds are major influences on sediment delivery to streams, and can also act as vectors for the spread of invasive vegetation species (see Ecological Stressors section of Chapter 1).
- **Floodplain connectivity:** Streams with higher degrees of floodplain connectivity provide better structural habitat and food web support for aquatic organisms, particularly salmonids, and can be indicative of watershed-scale hydrologic, hydraulic, and sediment transport processes.

The process of developing a mountain-wide monitoring approach should be guided by the creation of an interdisciplinary technical advisory team that includes experts in watershed hydrology, water quality, fluvial geomorphology, vegetation communities, and fisheries, as well as representatives from Mount Tamalpais land managers and relevant resource/regulatory agencies.

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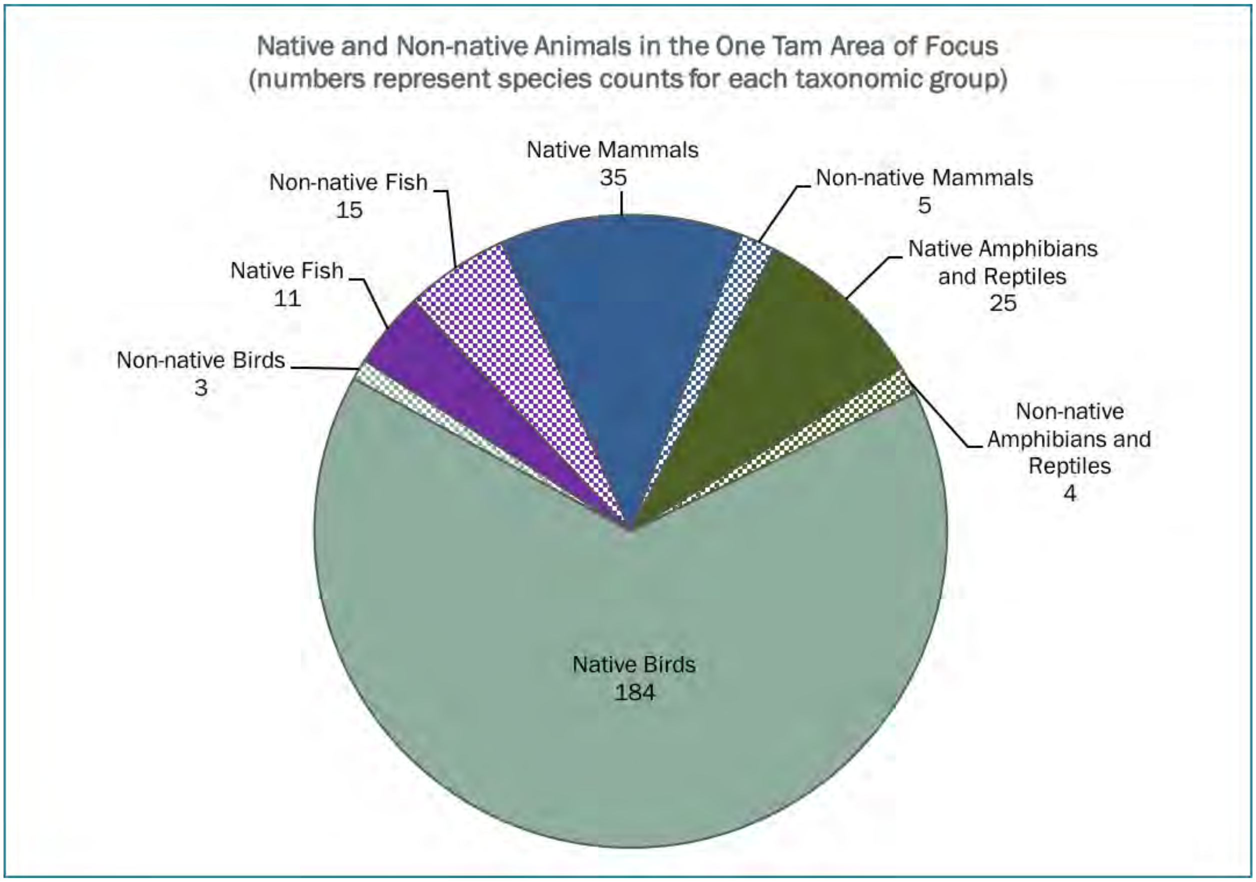
CHAPTER 11. WILDLIFE INDICATORS FOR THE HEALTH OF MT. TAM

Mt. Tam is home to many native wildlife species, including at least 35 mammals, 184 birds, and 25 amphibian and reptiles (Figure 11.1 and species lists in Appendices 8–11). However, these numbers only represent the best current knowledge of the One Tam land management agencies and are likely higher in actuality. Changes in the abundance, distribution, and community composition of wildlife can be tied to stressors such as alteration of natural disturbance regimes (e.g., grazing, fire), climate change, and invasion by non-native species, and as such, can be used to reveal important things about the health of the mountain.

The wildlife indicators chosen for this report were, in part, selected based on the amount of information available. Data on the mountain's wildlife vary widely depending on whether they have ever been inventoried, or if they are regularly monitored. Some species, such as the threatened Northern Spotted Owl (*Strix occidentalis caurina*), have been monitored for years, whereas mammal monitoring is just now underway. Other groups, like invertebrates, have never been systematically inventoried or monitored on Mt. Tam.

However, some wildlife indicators were also chosen if their condition and/or trend might reveal something about other aspects of ecosystem health, even if existing information on their condition or trend was limited. For example, American badgers (*Taxidea taxus*) are good indicators of grassland ecosystem extent and quality, and North American river otters (*Lontra canadensis*) can reveal a number of things about both riparian and terrestrial habitats, although current data on these species on Mt. Tam are limited.

FIGURE 11.1 NUMBERS OF NATIVE AND NON-NATIVE ANIMAL SPECIES IN THE ONE TAM AREA OF FOCUS



SELECTED INDICATOR WILDLIFE TAXA OVERVIEW

Mammals are good indicators of ecological conditions because they are responsive to habitat change (Andren, 1994). Data from remote cameras installed in 2014 as a part of the Marin Wildlife Picture Index Project (MWPIP) are beginning to shed light on the mammal diversity in the One Tam area of focus. Looking at a suite of native mammals through the MWPIP provides a more complete picture of how terrestrial ecosystems on Mt. Tam are doing compared to looking at a single species, and provides information on non-native species as well.

The **American badger** requires large patches of grasslands and coastal scrub habitats and is therefore a good indicator of the health and extent of these ecosystems. A voracious predator of small rodents, the American badger may be considered a keystone species, and their burrows also provide important habitat for other wildlife including reptiles, amphibians, small mammals, and burrowing owls. The badgers on Mt. Tam are part of a larger population that includes coastal grasslands in Point Reyes and Petaluma, and extends north to the Jenner Headlands (Headlands (Bay Area Open Space Council [BAOSPC], 2011). Maintaining the health and connectivity of this broader northern San Francisco Bay Area badger population is important because it appears to be isolated from other California badgers by large forested tracts to the north and east.

The charisma of **North American river otters** makes them excellent ambassadors for watershed conservation and wetland restoration. Historically extirpated from the San Francisco Bay Area, their return after a decades-long absence is remarkable. These apex predators play an important role in ecosystem health, and their use of both terrestrial and aquatic habitats make them good indicators of multiple habitat types.

Birds are another charismatic and inspiring group, which are also excellent indicators of the condition of a wide range of habitats. Agencies within the One Tam area of focus have a relatively long history of bird monitoring, enabling estimates of population trends for multiple species in a number of different vegetation communities. In addition to looking at the condition and trend of birds as a whole, several specific bird communities were included in this assessment, including oak woodland, conifer and mixed hardwood forests, grassland, scrub and chaparral, riparian areas, and climate-vulnerable species.

Threatened **Northern Spotted Owls** are important upper-level predators and are good indicators of forest health, as their success in the One Tam area of focus depends on the presence of forest ecosystems with sufficient food sources. Marin County is home to the southernmost populations of this species, and One Tam land management agencies have a wealth of data for most of Marin County. Data on long-term trends in Northern Spotted Owl territory occupancy, reproductive success, and nesting habitat preferences help managers track population trends, avoid nesting season disturbances, and evaluate the impacts of potential threats including competition from Barred Owls (*S. varia*), Sudden Oak Death, and climate change.

Visitors to Mt. Tam's lakes and reservoirs are often treated to the sight of nesting **Osprey** (*Pandion haliaetus*). Because Osprey are sensitive to toxins and feed almost exclusively on fish, their breeding success is a good indicator of water quality and fish abundance. The Osprey colony at Kent Lake has been continuously monitored since 1981, making it one of the longest-running Osprey nesting studies in the Pacific region.

Spending part of their lives in freshwater streams and part in the ocean, **anadromous fish** are good indicators of riparian habitat and hydrological conditions as well as ocean health, and are an important food source for many other species. Threespine stickleback (*Gasterosteus aculeatus*), endangered coho salmon (*Oncorhynchus kisutch*), and threatened steelhead trout (*O. mykiss*) live in Redwood and Lagunitas creeks in the One Tam area of focus. Mt. Tam's land managers and their partners have been monitoring coho salmon and steelhead trout in these creeks for many years.

Western pond turtles (*Actinemys marmorata*) are good indicators of freshwater aquatic conditions and are also considered vulnerable to climate change and invasive aquatic predators. Their population has declined dramatically throughout the state in recent decades, spurring the California Department of Fish and Wildlife to list them as a species special concern. The Marin Municipal Water District (MMWD) has been monitoring western pond turtles since 2004.

Amphibians are sensitive to changes in hydrology and precipitation, as well as to pollutants and toxins, making them excellent indicators of freshwater ecosystem health. Threatened **California red-legged frogs** (*Rana draytonii*) were once common from Mendocino County to Baja California, but their numbers have plummeted as a result of human harvesting, habitat loss, and invasive species. Within the One Tam area of focus, they are known to live in the ponds and wetlands at Muir Beach and in the Olema Creek Watershed. **Foothill yellow-legged frogs** (*Rana boylii*) have also declined over half of their historical range, including a severe drop in numbers in the San Francisco Bay Area. There are currently two populations on MMWD lands: Little Carson Creek and Big Carson Creek.

EXTIRPATED SPECIES

Changing land use, development, hunting, wildlife persecution, collecting, and the introduction of non-native species since the time of European settlement have resulted in the loss of some native wildlife from Mt. Tam. Although this section only discusses extirpated wildlife, widespread regional landscape changes have dramatically affected wildlife abundance. For example, the loss of wetlands near San Francisco Bay and the outer coast, in conjunction with hunting pressures, has likely dramatically reduced the abundance of waterbirds and many other species that depend on these habitats.

One Tam land management agencies have fairly good historic and current information on birds and medium to large size mammals (those greater than one kilogram), while smaller mammals are less well documented. The Likely Extirpated Wildlife Species of Mt. Tam (Table 11.1) has three different categories for historical and current status:

Historical Status:

- **Present:** Species with verified, documented historical occurrences on Mt. Tam
- **Likely Present:** Species that were known to be present in nearby areas and/or similar habitats, but for which we do not have definitive evidence that they were present on Mt. Tam
- **Unknown:** Species that may have been present, but not enough verifiable evidence exists to say if they were likely to have been on Mt. Tam or in adjacent areas

Current Status:

- **Extirpated:** We believe the species was once present, but know that it is no longer on Mt. Tam
- **Not Present:** We suspect, but are not sure, that the species was historically present, and we know that it is not on Mt. Tam now
- **Unknown:** There is insufficient evidence to determine if the species is definitely no longer on Mt. Tam

TABLE 11.1 LIKELY EXTIRPATED WILDLIFE SPECIES OF MT. TAM

Common Name	Scientific Name	Historic Status	Current Status
Mammals			
American black bear	*Ursus americanus*	Present	Extirpated
California ground squirrel	*Otospermophilus beecheyi*	Likely Present	Extirpated
Fisher	*Martes pennanti*	Unknown	Not Present
Gray wolf	*Canis lupus*	Unknown	Not Present
Grizzly bear	*Ursus arctos* ssp.	Likely Present	Extirpated
Mountain beaver	*Aplodontia rufa*	Likely Present	Unknown
North American beaver	*Castor canadensis*	Unknown	Not Present
North American porcupine	*Erethizon dorsatum*	Likely Present	Extirpated
Pronghorn antelope	*Antilocapra americana*	Unknown	Not Present
Ringtail cat	*Bassariscus astutus*	Likely Present	Unknown
Salt marsh harvest mouse	*Reithrodontomys raviventris*	Likely Present	Unknown
Tule elk	*Cervus canadensis nannodes*	Likely Present	Extirpated
Birds			
California Condor	*Gymnogyps californianus*	Likely Present	Extirpated
Greater Roadrunner	*Geococcyx californianus*	Likely Present	Extirpated

This list represents current information compiled by One Tam partner agencies at this time, and will be updated in the future through further review of additional technical reports, inventories, and validation of other data sources.

Restoring some of these species to Mt. Tam today would be extremely challenging due to their need for large, connected habitats; existing development, roads, and other infrastructure; incompatible adjacent land uses; and, in some cases, potential public safety issues. Having already lost many mammalian species from the mountain, it is important to provide the opportunities for extant species to persist, and especially to make sure that key ecological roles and functions are not lost. In addition, it would be important to document the presence and location of rarer species, and those that have not been confirmed as present on Mt. Tam.

BIRDS

The only record for **California Condors** (*Gymnogyps californianus*) near Mt. Tam is of "at least a dozen birds from the mountains near Fairfax in July of 1847." (Shuford, 1993). Koford (1953) attributes this sighting to the ornithologist-painter Andrew Jackson Grayson. An egg record from "prior to 1869" (Grinnell & Miller, 1944) was corrected by Koford (1953) as being from the San Rafael Mountains in Santa Barbara County, not San Rafael in Marin County (Koford, 1953). Koford noted that with condors ranging from Napa County to Humboldt County in the mid-1800s, it is likely that they were in Marin County up to that time. Mt. Tam's rugged landscape and its proximity to the Pacific coastline would have made it an appropriate region for condors.

The **Greater Roadrunner** (*Geococcyx californianu*s) was once a year-round resident of Marin County (Stephens & Pringle, 1933), but was likely extirpated by at least 1960 (Shuford, 1993). Because they prefer arid, spacious shrubland, often adjacent to open oak savannah, northern California roadrunners would have benefitted from regular fires to keep these habitats intact (Shuford, 1993). Shuford notes that of the last three reported Marin County sightings, two came from Golden Gate Audubon Society field trips (published in *The Gull*), one at Homestead, Locust Station, Mill Valley on April 22, 1939, and another at San Rafael Hill on February 24, 1941. An additional sighting was reported on Mt. Tam "sometime in the 1950s" (Shuford, 1993). Shuford also cites Bryant (1916) in the observation that "roadrunners were widely persecuted at one time because, based on limited evidence, they were thought to prey heavily on the eggs and young of quail."

MAMMALS

The **grizzly bear** (*Ursus arctos*) was fairly common in the San Francisco Bay Area at the time of the Gold Rush in 1848, but was gone from northern California by 1902 and extirpated statewide by 1924 (Carroll et al., 2001). Some anecdotal information suggests that **American black bears** (*Ursus americanus*) benefited from rapid removal of grizzly bears after the start of the Gold Rush. The species was documented on Mt. Tam, but Marin County's last black bear was removed from Redwood Creek Canyon in 1880 (Auwaeter & Sears, 2006).

Historic records on the distribution and abundance of **gray wolves** (*Canis lupus*) in California are less certain (Carroll et al., 2001; California Department of Fish and Game [CDFG], 2011). However, no substantive evidence exists to document wolves in California's lowlands, including Marin County, in historic times (Evens, 2008). However, Marin County clearly had suitable habitat and prey species to support wolves. Wolves were likely to have occurred at low abundances in California's Coast Ranges until the early 1800s, and were probably more abundant along the northern coast where elk were more numerous (Carroll et al., 2001; CDFG, 2011). Wolves were rapidly extirpated from north coastal California after during the Gold Rush (Carroll et al., 2001).

The loss of top-level predators such as grizzly bears, black bears, and gray wolves affects prey species levels (Carroll et al., 2001), which can have cascading ecosystem effects (Miller et al., 2001).

Fishers (*Martes pennanti*) have not been documented as historically present on Mt. Tam, though historic range maps extend from the north along the east side of Tomales Bay in Marin County (Tucker et al., 2012).

Tule elk (*Cervus canadensis nannodes*) were once abundant in coastal grasslands, but were quickly extirpated through hunting and competition with cattle during the 1850s (Evens, 2008). This species was reintroduced to Point Reyes National Seashore in 1978, but are not currently present on Mt. Tam. **Pronghorn antelope** (*Antilocapra americana*) were also noted in historic reports from early European exploration and settlement of Marin County. However, it is uncertain whether these observations were accurate. The grazing of elk, and potentially pronghorn antelope, likely helped maintain coastal grasslands in this region.

North American beavers (*Castor canadensis*) are keystone species because they modify streams and create wetlands (Occidental Arts and Ecology Center, 2013). Although beavers were recently documented as historically present in central California coastal watersheds, there is not substantive evidence documenting their presence specifically on Mt. Tam (Occidental Arts and Ecology Center, 2013). Beavers are currently not present in Marin County.

California ground squirrels (*Otospermophilus beecheyi*) were likely historically present on Mt. Tam, as there are museum specimens from adjacent Tennessee Valley. Evens (2008) describes ground squirrels as few and localized at nearby Point Reyes. However, Grinnell & Dixon (1918) reported that ground squirrels were rare in the majority of southern Marin County. California ground squirrels are a key prey species and their burrows provide habitat for many other animals.

North American porcupines (*Erethizon dorsatum*) were not historically documented on Mt. Tam, though there is a species record from just outside Point Reyes National Seashore. Wildlife habitat relationship modeling indicates most of Marin County is suitable porcupine habitat (CDFG, 2012), though they are not currently known to be present.

Ringtail cats (*Bassariscus astutus*), **mountain beavers** (*Aplodontia rufa*), and the **salt marsh harvest mouse** (*Reithrodontomys raviventris*) at Bothin Marsh have not been confirmed in One Tam area of focus, and currently have an unknown status. Although all these species have been documented in adjacent areas, they are rare.

INFORMATION GAPS

One Tam land managers lack the data necessary to assess the condition and trends of some proposed wildlife indicators. While there are many information gaps related to the health of Mt. Tam, **Invertebrates, California giant salamanders (*Dicamptodon ensatus*), bats, and small mammals** remain as important taxonomic groups that were considered for this health assessment process, but were not included due to a lack of information.

While there have been some limited inventory efforts for bats and small mammals on Mt. Tam, they did not provide enough information to include them here as indicators. Outside of some work on butterflies, invertebrates have not been well studied on Mt. Tam at all. One Tam agencies are planning to develop inventory and monitoring plans for these taxa in the near future. See Chapter 22, Wildlife Indicator Needs Statements, for more details on these data gaps and what might be done to fill them.

MANAGEMENT AND MONITORING

Although there are a few programs that cross agency boundaries, each One Tam agency partner has conducted their own wildlife inventories, monitoring programs, surveys, and management programs over the years. A number of academic and non-profit partners have also contributed to this work.

Data used to inform the wildlife condition and trend assessments in the following chapters likewise came from a large number of sources. Each chapter describes in detail where the information used to assess indicator health came from and the methodology used to reach the conclusions within. The chapters also include past and current management, monitoring, restoration, and other efforts that benefit specific wildlife species or communities.

FUTURE ACTIONABLE ITEMS

Below is a preliminary summary of management and monitoring needs identified by agency and local scientists as a part of the technical paper development. These are actions not currently funded as a part of agency programs, but are high priority and will be further evaluated and prioritized for future funding and implementation.

Inventory and Monitoring:

- **Complete Historical Conditions Analysis for Priority Taxa:** Many of the condition statements made about health indicators on Mt. Tam are based on comparison to historic range or population statuses. For some species, especially rare ones, historic information is available electronically and has been incorporated. Often though, not all available museum collection information has been collected or can be readily accessed. Historic field notes and notebooks are rarely searchable online, and old reports are often on shelves, not servers. Partnering with natural history museums to get collections data computer-searchable for taxa such as plants and insects, and tracking down historic notes and reports, will allow us to compare the past to the present and paint a more complete picture as we look to the future.

- **Conduct a Mt. Tam Wildlife Vulnerability Analysis Specific to Climate Change:** The San Francisco Bay Area's climate is changing in ways that will likely impact the spatial patterns or distributions of native plant communities. Several recent studies and predictive modeling efforts (Ackerly et. al., 2012; Thorne et. al., 2016) provide insights into the future distribution and associated levels of vulnerability for vegetation communities under various climate futures.

  These changes to community composition and landscape-scale habitat connectivity may have effects on wildlife presence, movement, and population viability. Gaining a better understanding of species' vulnerability is critical to sustaining healthy wildlife communities. Undertaking a vulnerability assessment or modelling for wildlife shifts as a result of climate change would help identify important actions that could be undertaken to reduce anticipated climate-related stressors. Findings from this assessment could also provide guidance on where to focus limited resources to help reduce non-climate stressors that are within our control, and how to facilitate habitat connectivity to allow for species movement.

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CHAPTER 12. ANADROMOUS FISH

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

COHO SALMON (*ONCORHYNCHUS KISUTCH*) IN LAGUNITAS CREEK

Condition: Significant Concern

Trend: No Change

Confidence: Moderate

COHO SALMON IN REDWOOD CREEK

Condition: Significant Concern

Trend: Declining

Confidence: Moderate

STEELHEAD TROUT (*O. MYKISS*)

Condition: Significant Concern

Trend: No Change

Confidence: Moderate

THREESPINE STICKLEBACK (*GASTEROSTEUS ACULEATUS*)

Condition: Good

Trend: No Change

Confidence: Low

WHY IS THIS RESOURCE INCLUDED?

Spending part of their lives in freshwater streams and part in the ocean, anadromous fish are good indicators of riparian habitat and watershed hydrology as well as ocean health (Quinn, 2005). Anadromous fish are also an important food source for many species, as well as a source of marine-derived nutrients for aquatic and riparian communities (Quinn, 2005). Endangered coho salmon and threatened steelhead trout live in Redwood and Lagunitas creeks in the One Tam area of focus. These iconic and charismatic species are compelling tools for public engagement and environmental education. Threespine stickleback, found in most of the streams in the One Tam area of focus, are also a charismatic native species, easy to recognize, and conducive to citizen science monitoring.

The land management agencies on Mt. Tam and their partners have been monitoring coho salmon and steelhead populations for decades, counting adult spawners, estimating summer fry, and (since 2006) monitoring smolts heading to the ocean. Steelhead have proved to be more difficult to monitor than coho, primarily because they tend to migrate to and from the ocean in late winter, when stream flows can be high. As a result, there remains a fair amount of uncertainty about the condition and trends of our local steelhead populations. Even less is known about the tiny threespine stickleback, which is caught incidentally during salmonid surveys and has not been the object of monitoring efforts. For stickleback, at least, there's an opportunity for the public to help increase our understanding of this local native fish.

OVERALL CONDITION

Coho Salmon (Lagunitas Creek): Listed as a federally threatened species in 1996 and as endangered in 2005, the Lagunitas Creek coho population reached a low point in 2008 when fewer than 60 adult fish returned from the ocean. Coho numbers have rebounded in recent years, but remain far below the 1,300 adults considered necessary to keep the population safe from extinction. Lagunitas Creek is now home to the southernmost stable population of wild coho salmon in the world, while remnant populations as far south as Santa Cruz are being augmented with hatchery fish.

Coho Salmon (Redwood Creek): Currently coho salmon are in steep decline and are at risk of being lost from the Redwood Creek Watershed. As in Lagunitas Creek, Redwood Creek coho salmon reached a low point in 2007–2008 when only four adult fish were observed. However, unlike their northern neighbors, Redwood Creek coho have not rebounded. In an effort to save the population, the California Department of Fish and Wildlife (CDFW) collected juvenile coho in 2014 and 2015 to be raised at the Warm Springs Hatchery and returned as adults starting in 2016–2017. Four mature males and three mature females from nearby Olema Creek were also planted in Redwood Creek in 2015–2016. Additional fish rescues are planned for 2016 (California Department of Fish and Wildlife [CDFW], 2016).

Steelhead Trout: Far more resilient than coho, and with more flexible habitat needs and lifecycles, steelhead trout appear to be relatively widespread in the streams of the One Tam area of focus. They have suffered, however, from the same anthropogenic impacts that have plagued coho, namely dam construction, stream channel alteration, and development. Steelhead trout along the central California coast were listed by the federal government as a threatened species in 2005.

Stickleback: Found throughout coastal drainages in North America, Europe, and northern Asia, the threespine stickleback appears to be abundant and widespread in the One Tam area of focus.

DESIRED CONDITIONS

Coho Salmon (Lagunitas and Redwood Creeks): Pacific salmon have evolved many mechanisms to persist in highly variable freshwater and marine environments, including high fecundity and recolonization of nearby streams should those populations be extirpated. Unfortunately, adjacent coho populations are too small to repopulate Lagunitas Creek in the event of a local catastrophe, so the Lagunitas Creek population will need to be large enough to persist indefinitely on its own. The creek's aquatic habitats will also need to support the diverse life histories of coho salmon (sometimes called "the portfolio effect"), which can provide resilience in a highly variable environment (Schindler et al., 2010). The desired conditions for the Lagunitas Creek and Redwood Creek coho populations are therefore described below in terms of numerical targets for each coho life stage, as well as critical habitat conditions that support those life stages.

Steelhead Trout: Living in both estuarine and stream habitats that vary in depth, velocity, temperature, and shelter, steelhead are not as dependent on stream habitat conditions for survival as coho are. To persist indefinitely, steelhead should occupy more locations in the Mt. Tam area of focus and should migrate to the ocean in numbers sufficient to allow a viable number of adult steelhead to return each year and spawn.

Stickleback: A lack of stickleback in suitable, accessible stream habitats may be evidence of water quality or other problems. For example, sticklebacks are currently being used as indicators of both hydrocarbon and hormone-disrupting chemical pollution (Ostlund-Nilsson et al., 2007). Locating places lacking stickleback can assist in identifying areas of past or ongoing environmental degradation. The desired condition for threespine stickleback is therefore their presence in suitable, accessible water bodies in the One Tam area of focus.

STRESSORS

Historic Hydrological Changes and Habitat Loss: Dam construction and loss of hydrologic connectivity between estuarine and stream habitats, and between creeks and floodplains, have affected the ability of anadromous fish to migrate between freshwater habitats and the ocean. Historic logging increased the amount of fine sediment that entered local streams, which smothered fish eggs and gravel nest sites (also known as “redds”). Removal of large woody debris and the reduction and modification of riparian and stream areas have all reduced the amount of habitat available to these species (Moyle et al., 2008).

Current Hydrological Changes and Habitat Loss: Loss of spawning and rearing habitat continues to be a challenge to anadromous fish in the One Tam area of focus (Stillwater Sciences, 2008). Although much of their stream habitat in this area is on protected, open space lands, water withdrawals and extreme hydrologic and climatic events may still take a toll. Additionally, coarse sediment is being retained in reservoirs, which results in a finer, more mobile streambed that is not replenished. This, in turn, leads to channel incision and a loss of floodplain connectivity downstream. Reservoirs may also retain large woody debris and affect hydrological and geomorphic processes needed to support downstream salmonid habitat.

Ocean and Estuarine-related Factors: Anthropogenic changes are not limited to freshwater environments. Marine overharvesting of salmonids as well as their prey (e.g., sardines) reduces salmonid survival. Changes to ocean food webs related to climate change are also increasing threats to these species (Moyle et al., 2008). Quality and quantity of estuarine habitats are also likely affecting Redwood Creek coho salmon, though recent restoration at Muir Beach has been aimed at improving habitat conditions there.

Invasive Species: The potential invasion of exotic mollusks such as the New Zealand mud snail (*Potamopyrgus antipodarum*) could cause changes to benthic macroinvertebrate communities and impact the salmonids’ diet (Vinson & Baker, 2008). The spread of invasive Japanese knotweed (*Fallopia japonica*), periwinkle (*Vinca* spp.), and invasive ivy species could suppress native riparian vegetation and insect production, and could also alter streambank dynamics (Urgenson, 2006).

Climate Change: Coho salmon in the One Tam area of focus are at the southern edge of their global distribution and are highly vulnerable to increases in water temperatures resulting from climate change. Longer droughts and more intense rainfall, as predicted by climate change models, would negatively impact all the species considered here. For example, longer or more intense droughts mean lower baseflows to sustain creek spawning and rearing habitats. Increased frequency, intensity, and/or duration of flood events can increase sedimentation of spawning gravel and wash salmonids downstream in the absence of suitable refugia. Finally, as described above, disruptions in the ocean food web could impact all anadromous fish species.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

COHO SALMON (LAGUNITAS CREEK)

METRIC 1: COHO SALMON ADULT ESCAPEMENT (ADULT SPAWNERS AND REDDS)

Baseline: Over the last nine years, the numbers of adult coho returning to Lagunitas Creek has averaged just over 300 fish. Biologists track adult abundance by counting redds and assume that each redd represents two adult fish. Three generations provide the minimum period for determining an upward trend in the population.

Condition Goal: The number of adult coho salmon spawners in Lagunitas Creek must be 1,300 to be considered for downlisting from federally endangered to federally threatened, and 2,600 for delisting as defined by National Marine Fisheries Service (NMFS) recovery goals ((National Marine Fisheries Service [NMFS], 2012). The target numbers must be sustained for nine consecutive years to meet the standard per the NMFS 2012 recovery plan. Lagunitas Creek is one of 28 populations that would need to achieve specific population goals before coho in the Central California Coast Ecologically Significant Unit could be downlisted or delisted.

Condition Thresholds:

- **Good:** Nine consecutive years (three generations of each of the three year classes) of at least 1,300 redds
- **Caution:** Nine consecutive years of between 650 and 1,300 redds
- **Significant Concern:** Less than nine consecutive years of at least 650 redds

Current Condition: Significant Concern

The 20-year average is only approximately 20% of the downlisting goal (Figure 12.1).

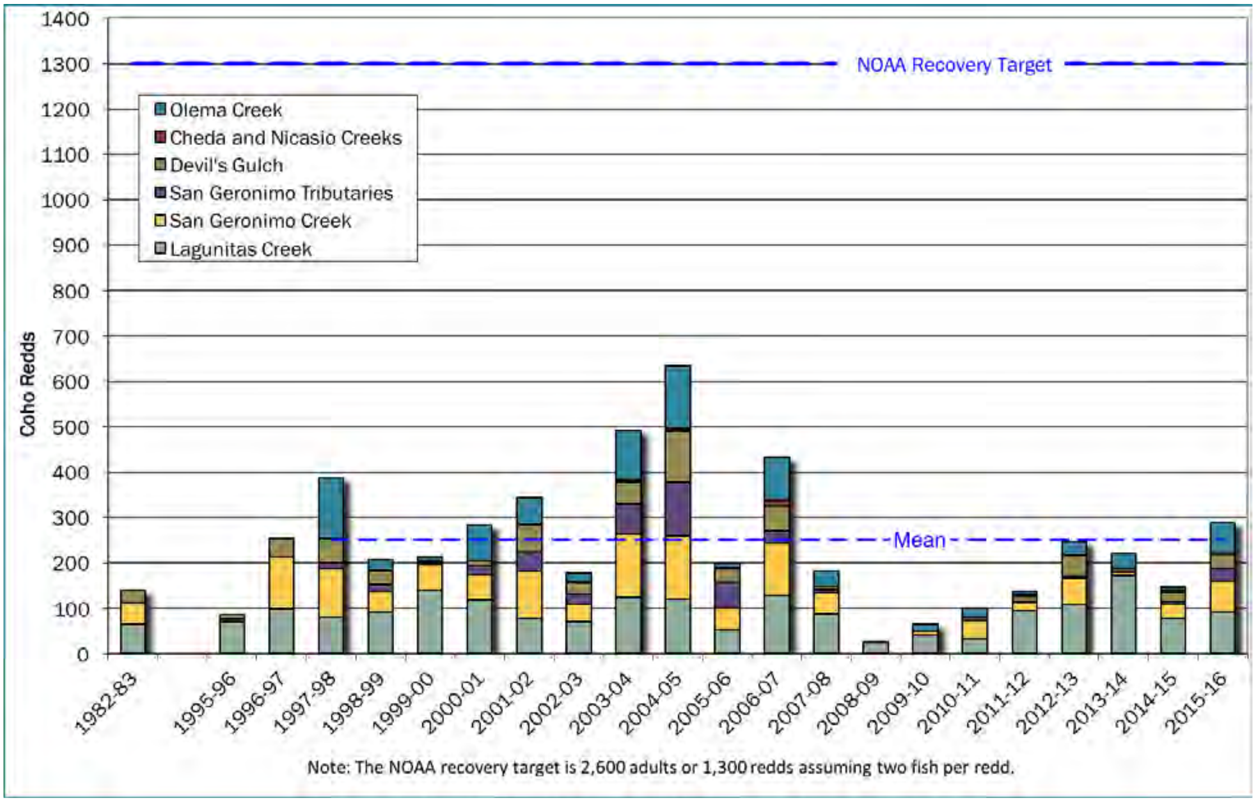
Confidence: High

Surveyors cover all creek reaches where anadromous fish are found weekly when flows allow.

Trend: No Change

Two of three coho year classes have shown increases over two generations, while the third year class (represented most recently by the 2013–2014 adult run) increased over one generation. If the run in 2016–2017 is larger than its parent generation, the trend will be confidently assessed as increasing.

FIGURE 12.1 COHO REDDS IN THE LAGUNITAS CREEK WATERSHED (ETTLINGER ET AL., 2015A)



METRIC 2: OUTMIGRANT COHO SALMON SMOLTS

Baseline: Coho smolt outmigration estimates over the last nine years have averaged 9,600 fish.

Condition Goal: An average of 52,000 coho salmon smolts in Lagunitas Creek over nine years (three generations), with 5% marine survival based on nine years of data. This number of coho salmon smolts and marine survival rate would result in 2,600 adults and meet the adult recovery goal (NMFS, 2012). This metric is also a useful way to look at overwintering survival of juvenile coho salmon and provide an indicator of watershed health.

Condition Thresholds:

- **Good:** A nine-year average of 26,000 smolts
- **Caution:** A nine-year average of 13,000 smolts
- **Significant Concern:** A nine-year average of less than 13,000 smolts

Current Condition: Significant Concern

Current average smolt numbers for Lagunitas Creek are at approximately 18% of the recovery goal (Figure 12.2).

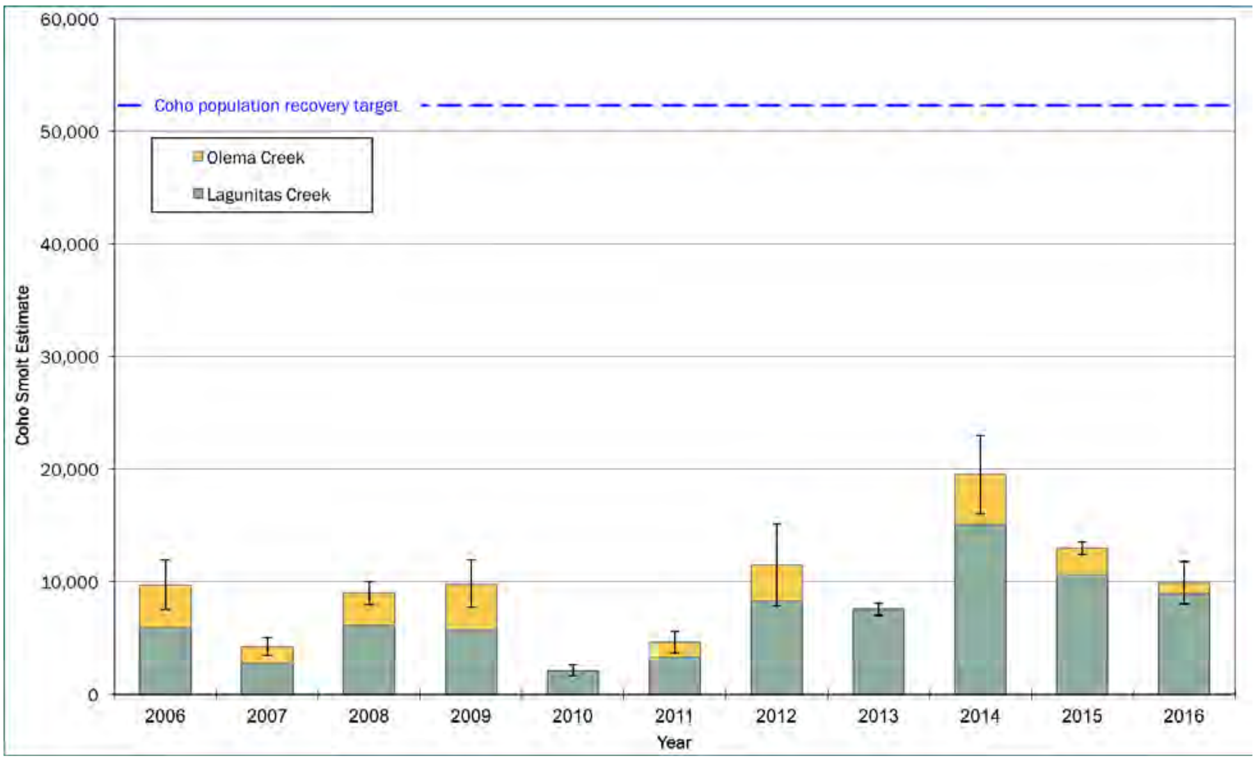
Confidence: High

Smolt estimates are the most accurate of any of the coho life stage estimates. Generally, the entire migration period is monitored and the efficiency of smolt traps can be accurately estimated.

Trend: Improving

Two of the three year classes have shown increases over two generations. The third year class, while only increasing over one generation, reached the highest numbers yet seen (Figure 12.2).

FIGURE 12.2 COHO SMOLTS IN THE LAGUNITAS CREEK WATERSHED (ETTLINGER ET AL., 2015C)



METRIC 3: JUVENILE COHO SALMON COUNTS

Baseline: Over the last nine years an estimated 22,000 juvenile coho (also known as "fry") were present in the Lagunitas Creek Watershed (Ettlinger et al., 2015b).

Condition Goal: An estimated 120,000 individual coho salmon fry in the Lagunitas Creek watershed based on a maximum density of three coho per meter and accessible habitat of 40 kilometers of stream (Ettlinger et al., 2015b).

Condition Thresholds:

- **Good:** A nine-year average of at least 60,000 juvenile coho
- **Caution:** A nine-year average of at least 30,000 juvenile coho

- **Significant Concern:** A nine-year average of less than 30,000 juvenile coho

Current Condition: Significant Concern

The current nine-year average is approximately 25,000 coho fry. Just as importantly, fry populations are highly volatile (ranging from 69,000 fry in 2007 to below 2,000 in 2009) and could drop below a depensation threshold (Figure 12.3).

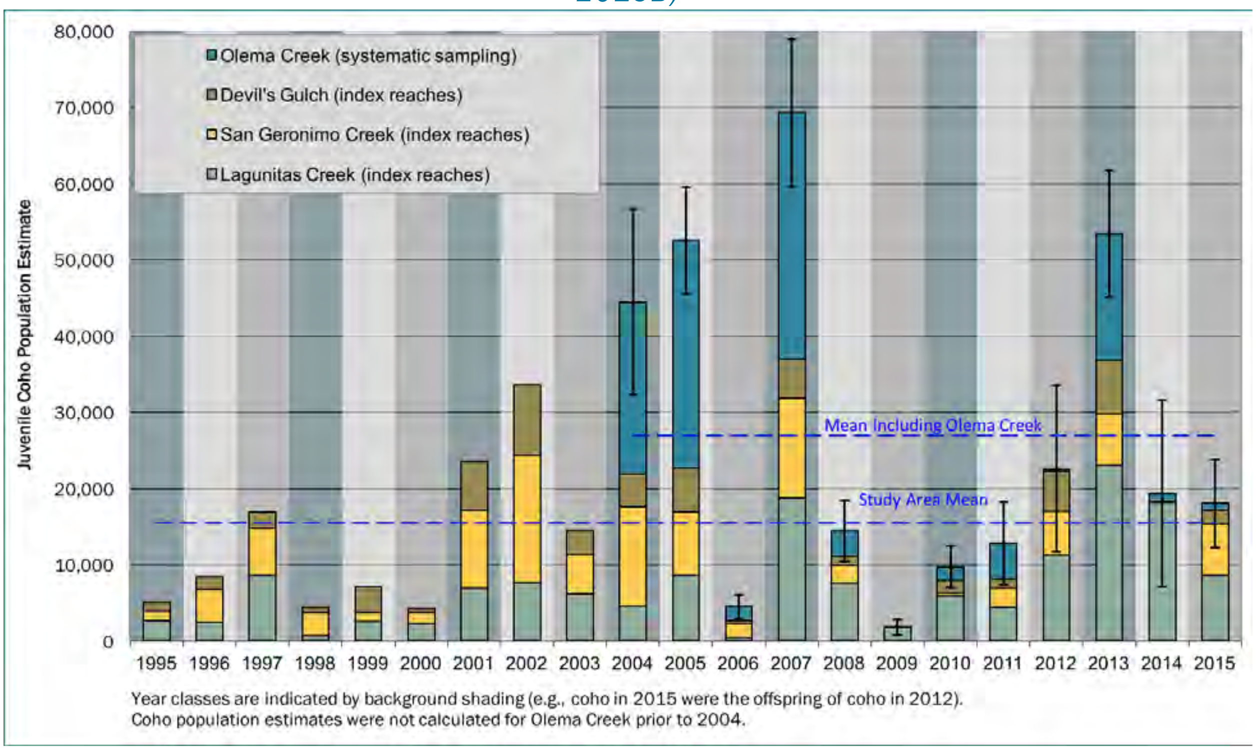
Confidence: Moderate

Marin Municipal Water District (MMWD) and National Park Service (NPS) biologists only survey a small fraction of the watershed, so the confidence intervals around these estimates are very large.

Trend: No Change

The juvenile coho population in Lagunitas Creek has fluctuated widely with no trend since 2006 (three generations). However, because biologists survey only small parts of the watershed, only very large population changes can be detected.

FIGURE 12.3 JUVENILE COHO IN THE LAGUNITAS CREEK WATERSHED (ETTLINGER ET AL., 2015B)



METRIC 4: WOOD LOADING

Baseline: Wood volume in the Lagunitas Creek Watershed has never been measured in detail, but counts of individual logs indicate that it is far below the levels that are beneficial for juvenile coho. In 2011, 520 logs were counted in pools in Lagunitas Creek and two tributaries (Ettlinger et al., 2013).

Condition Goal: Wood loading will meet established criteria for the forest type: 300 cubic meters per hectare in redwood channels, and 100 cubic meters per hectare in hardwood channels (California Regional Water Quality Control Board [CRWQCB], 2014).

Condition Thresholds:

- **Good:** At least 300 cubic meters of wood per hectare in redwood channels and 100 cubic meters per hectare in hardwood channels
- **Caution:** At least 150 cubic meters of wood per hectare in redwood channels, and 50 cubic meters per hectare in hardwood channels
- **Significant Concern:** Less than 150 cubic meters of wood per hectare in redwood channels, or less than 50 cubic meters per hectare in hardwood channels

Current Condition: Significant Concern

Based on the 520 logs counted in 2011, an estimate of 23 hectares of channel surveyed, and an extremely rough estimate of four cubic meters of wood per log, wood loading was approximately 90 cubic meters per hectare. Wood loading appeared to be lower in redwood channels than in hardwood channels, so the redwood channel loading was less than 150 cubic meters per hectare.

Confidence: Moderate

Many assumptions went into the above wood loading estimate, but the estimate represents a reasonable assessment of current conditions. A thorough survey of wood loading is currently underway.

Trend: No Change

Log counts in Lagunitas Creek have not been conducted consistently and have not measured wood volume. Higher numbers of logs counted since 2003 may not accurately represent an increase in wood volume (Table 12.1).

TABLE 12.1 LOG COUNTS IN SURVEYED STREAMS (ETTLINGER ET AL., 2013)

Stream	Reach	2003	2006	2011
Lagunitas Creek	Nicasio Cr.–Tocaloma	70	81	115
	Toc.–Devil's Gulch	54	113	107
	D.G.–Shafter Bridge	56	130	93
	Shafter–Peters Dam	15	42	28
San Geronimo Creek	Mouth–Larsen Cr.	~30	27	40
	Larsen Cr.–Dixon Weir	~90	91	80
Devils Gulch		36	65	57
Total		**351**	**549**	**520**

COHO SALMON (REDWOOD CREEK)

METRIC 1: COHO ADULT ESCAPEMENT (ADULT SPAWNERS AND REDDS)

Baseline: Over the last nine years, average coho escapement has been 32 adults (based on average counts of 16 redds). Biologists track adult abundance by counting redds and assume that each redd represents two adult fish.

Condition Goal: The number of adult coho salmon spawners in Redwood Creek must be 136 for downlisting from federally endangered to federally threatened, and 272 for delisting as defined by recovery goals (NMFS, 2012). The target numbers must be sustained for nine consecutive years to meet the standard per the NMFS 2012 recovery plan. Redwood Creek is one of 28 populations that would need to achieve specific population goals before coho in the Central California Coast Ecologically Significant Unit could be downlisted or delisted.

Condition Thresholds:

- **Good:** Nine consecutive years (three generations of each of the three year classes) of at least 136 adult coho
- **Caution:** Nine consecutive years (three generations of each of the three year classes) of at least 65 adult coho
- **Significant Concern:** Nine consecutive years (three generations of each of the three year classes) of fewer than 65 adult coho

Current Condition: Significant Concern

The nine-year average is only approximately 12% of the delisting goal (Figure 12.5).

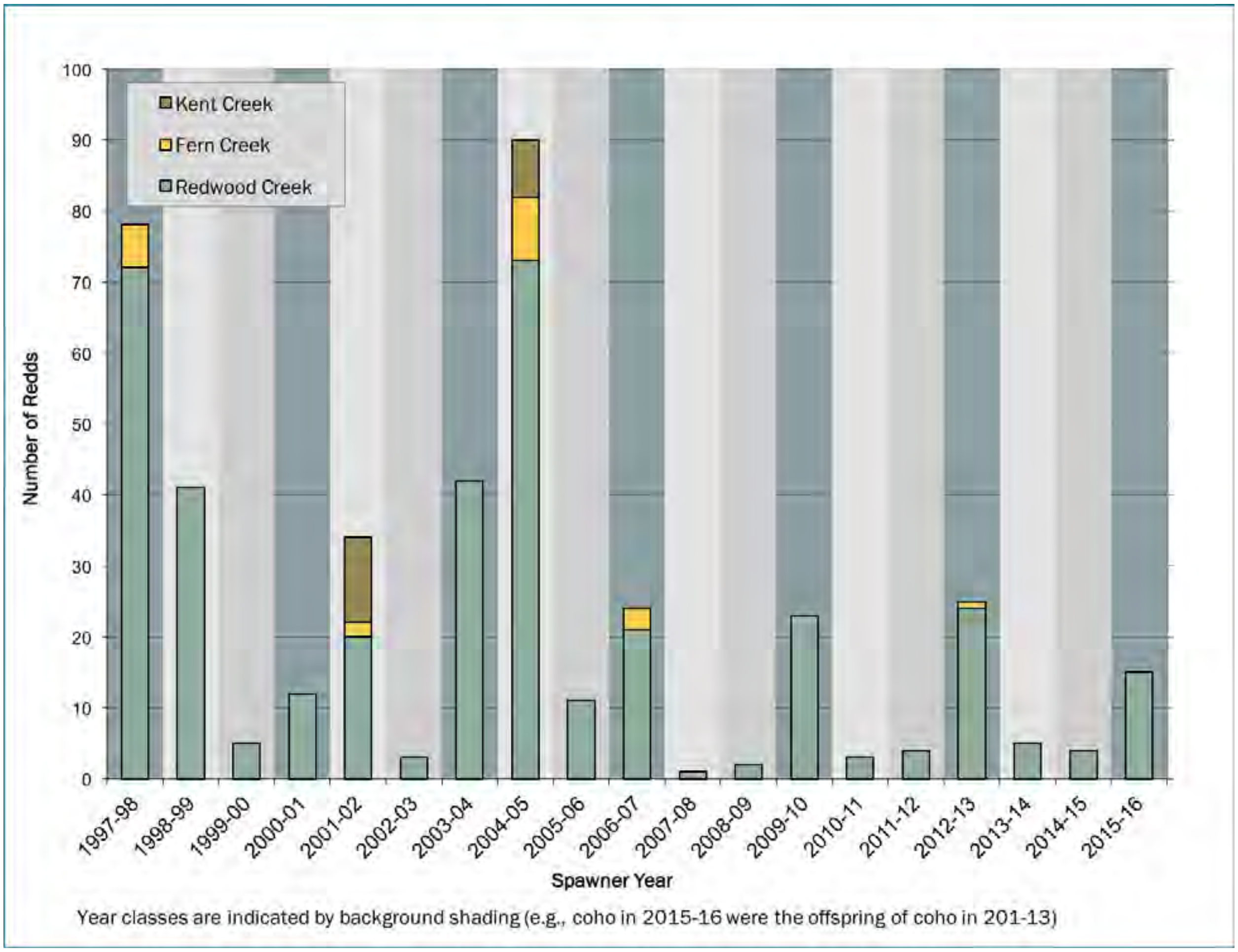
Confidence: High

Surveyors cover all anadromous reaches weekly when flows allow.

Trend: Declining

Over the last nine years (three generations) two of three year classes have remained at dangerously low levels in Redwood Creek, while the third year class recently declined.

FIGURE 12.5 COHO REDDS IN REDWOOD CREEK (CARLISLE & REICHMUTH, 2015)



METRIC 2: OUTMIGRANT COHO SALMON SMOLTS

Baseline: During the last nine years, coho smolt production in Redwood Creek has averaged approximately 1,250 fish.

Condition Goal: An average of 14,000 coho salmon smolts in Redwood Creek over nine years (three generations), with 2% marine survival based on 10 years of data (Carlisle et al., 2016). This is the number of coho salmon smolts needed to meet the adult recovery goal for delisting (NMFS, 2012). This metric is also a useful way to look at overwintering survival of juvenile coho salmon and provide an indicator of watershed health.

Condition Thresholds:

- **Good:** An average of 7,000 coho salmon smolts over nine years
- **Caution:** An average of 3,500 coho salmon smolts over nine years
- **Significant Concern:** A nine-year average of less than 3,500 coho salmon smolts

Current Condition: Significant Concern

Current average smolt numbers for Redwood Creek are approximately 9% of the delisting target.

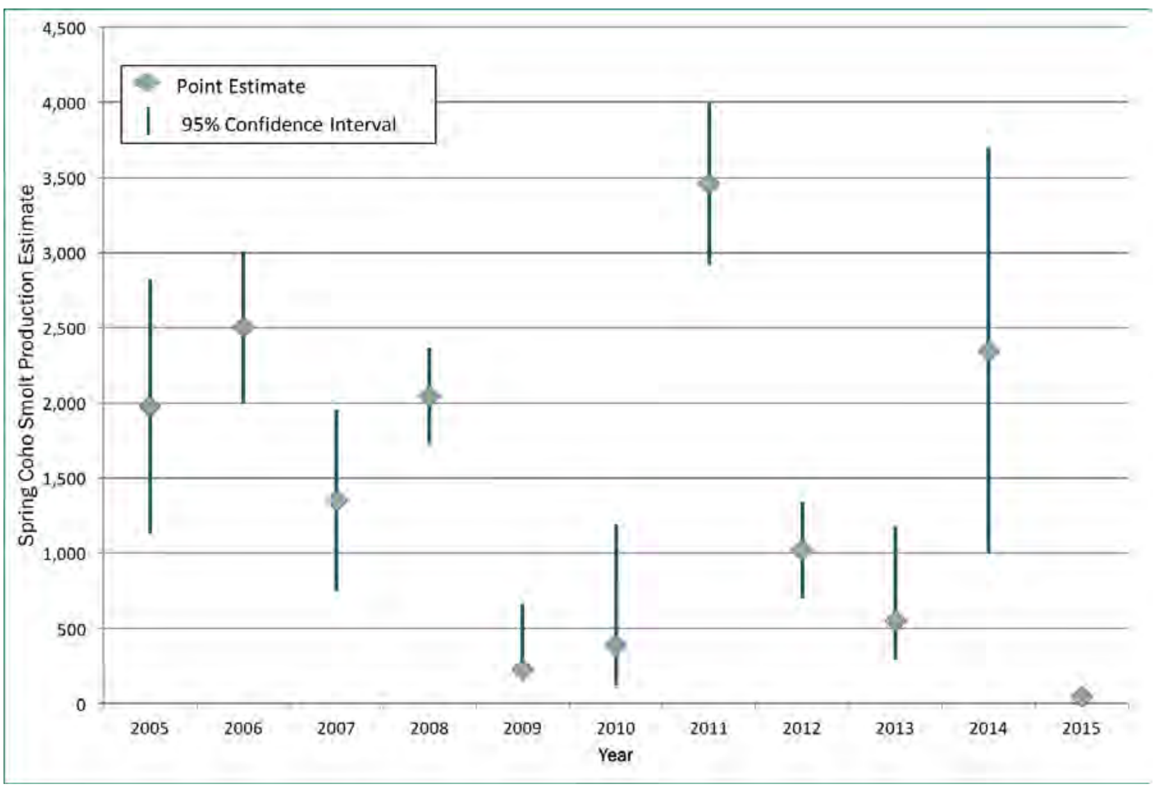
Confidence: Moderate

Smolt estimates are the most accurate of any of the coho life stage estimates, although the fyke trap in Redwood Creek is more easily avoided by coho smolts than the rotary screw trap used in Lagunitas Creek. This results in a greater degree of uncertainty around the Redwood Creek smolt estimates (Carlisle et al., 2016).

Trend: Declining

Two of three Redwood Creek year classes have declined and the third does not show a significant trend (Figure 12.6).

FIGURE 12.6 REDWOOD CREEK SMOLT ESTIMATES (CARLISLE ET AL., 2016)



METRIC 3: JUVENILE COHO SALMON COUNTS

Baseline: Over the last nine years the average number of juvenile coho in Redwood Creek was estimated at 1,900 fish (Carlisle et al., 2016).

Condition Goal: An estimated 27,000 juvenile coho salmon fry in Redwood Creek based on a maximum density of three coho per meter and accessible habitat of 9 kilometers of stream (Carlisle et al., 2016).

Condition Thresholds:

- **Good:** A nine-year average of at least 13,500 juvenile coho
- **Caution:** A nine-year average of at least 7,000 juvenile coho
- **Significant Concern:** A nine-year average of less than 7,000 juvenile coho

Current Condition: Significant Concern

Two of three year classes have been hovering near extirpation since 2008 (Figure 12.7). Since 2014, CDFW has removed juvenile coho from Redwood Creek to raise them at the Warm Springs Hatchery.

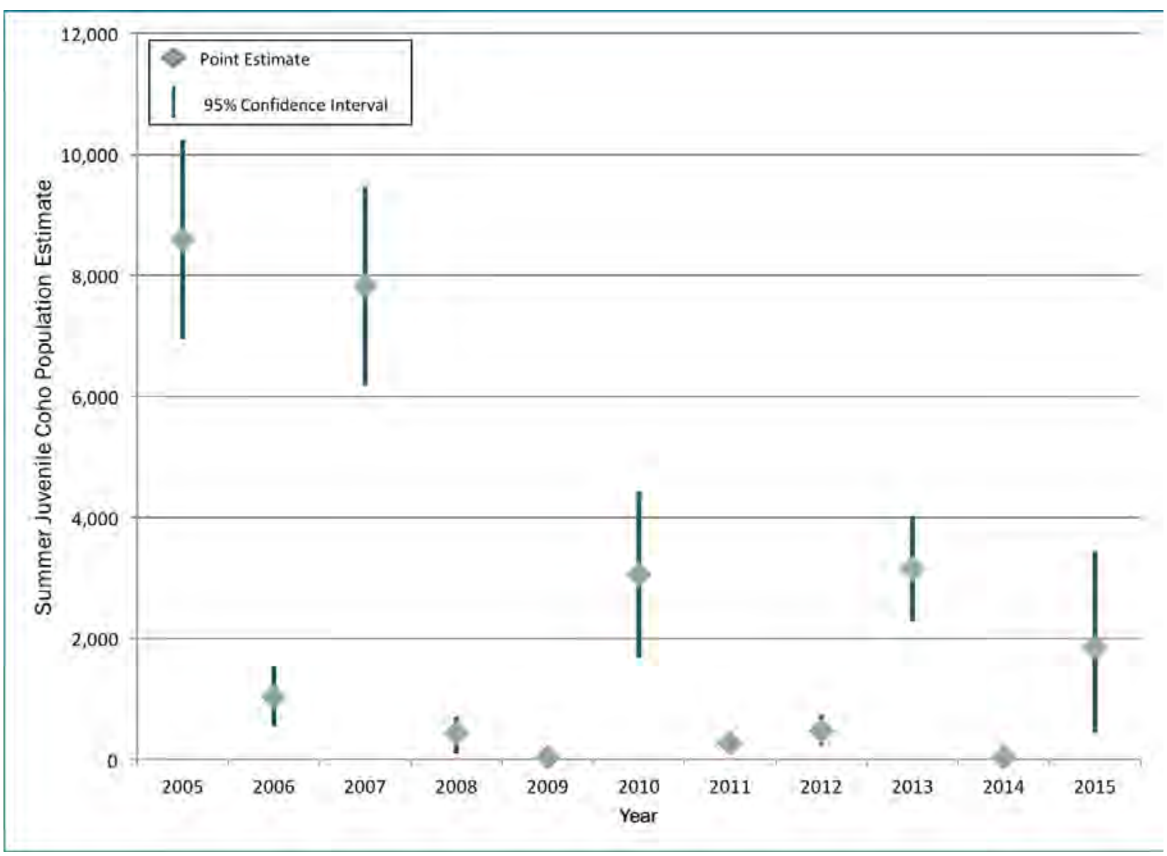
Confidence: Moderate

National Park Service biologists survey a small fraction of the watershed, so confidence intervals around the population estimates are very large.

Trend: Declining

The population of juvenile coho salmon in Redwood Creek has dropped drastically since 2006 (three generations) (Figure 12.7).

FIGURE 12.7 JUVENILE COHO POPULATION ESTIMATES IN REDWOOD CREEK (CARLISLE ET AL., 2016)



METRIC 4: WOOD LOADING

Baseline: Several years of log counts have been conducted during habitat surveys. Over the last 11 years, the average number of "key pieces" of wood has been 5.3 pieces per 100 meters (M. Reichmuth, personal communication).

Condition Goal: The 2012 coho recovery plan identifies wood frequency recovery actions in Redwood Creek. For stream sections with bankfull widths less than 10 meters, wood loading should be 6–11 key pieces per 100 meters, while for sections with bankfull widths greater than 10 meters, wood loading would be 1.3–4 key pieces per 100 meters (NMFS, 2012). This wood loading goal differs from the goal in Lagunitas Creek because Lagunitas Creek has its own wood loading target (CRWQCB, 2014).

Condition Thresholds:

- **Good:** At least six key pieces per 100 meters for sections with bankfull width less than 10 meters wide and at least 1.3 key pieces per 100 meters for sections with bankfull widths greater than 10 meters

- **Caution:** At least three key pieces per 100 meters for sections with bankfull width less than 10 meters wide and at least 0.7 key pieces per 100 meters for sections with bankfull widths greater than 10 meters (half of NMFS criteria)

- **Significant Concern:** Less than three key pieces per 100 meters for sections with bankfull width less than 10 meters wide, or less than 0.7 key pieces per 100 meters for sections with bankfull widths greater than 10 meters

Current Condition: Caution

The number of key pieces is just below the threshold of six pieces recommended by NMFS (2012).

Confidence: High

Annual surveys count each log and log jam, yielding a "High" level of confidence in the condition assessment above.

Trend: Improving

The highest number of key pieces was counted in 2015 (M. Reichmuth, personal communication).

STEELHEAD TROUT

METRIC 1: STEELHEAD ADULT ESCAPEMENT (SPAWNERS AND REDDS)

Baseline:

Over the last eight years (roughly two generations) the numbers of adult steelhead returning to Lagunitas Creek has averaged 300 fish (based on an average of 145 redds). In Redwood Creek, the number of steelhead has averaged less than 20 fish (based on an average of seven redds).

Condition Goal: The number of adult steelhead spawners must be 38–78 in Redwood Creek and 2,600 in Lagunitas Creek in order for them to be taken off the endangered species list. The target numbers must be sustained for eight consecutive years (typically two generations) to meet the standard per the NMFS draft recovery plan (NMFS, 2015).

Condition Thresholds:

- **Good:** Eight consecutive years (two generations) of at least 325 redds (1,300 fish, a quarter of the delisting target) in Lagunitas Creek, and at least 29 redds (78 fish, the full delisting target) in Redwood Creek

- **Caution:** Eight consecutive years of at least 100 redds in Lagunitas Creek (approximately 7.5% of the delisting target) and 15 redds in Redwood Creek (half the delisting target)

- **Significant Concern:** Less than eight consecutive years of at least 100 redds in Lagunitas Creek, or less than eight consecutive years of at least 15 redds in Redwood Creek

Current Condition: Significant Concern

The eight-year average is only approximately 11% of the delisting goal for Lagunitas Creek and 36% for Redwood Creek. However, local biologists (S. Carlisle, E. Ettlinger, D. Fong, and M. Reichmuth) believe the Lagunitas Creek target is too high given the high fecundity of steelhead, their life history flexibility, and general resiliency. In their professional opinion, steelhead are likely to persist in Lagunitas Creek at population levels far below the current recovery threshold, and the threshold should be eight years of at least 100 redds (200 fish) to be considered out of the "Significant Concern" condition.

Steelhead runs in Lagunitas Creek have exceeded that threshold for five consecutive years now. In Redwood Creek, more than 15 steelhead redds were observed in only one year out of five years of steelhead spawner surveys. This may be the result of ending monitoring seasons before spawning was completed, but it may also indicate a very small population. The condition of the Redwood Creek steelhead population is therefore conservatively considered to be at high risk of extirpation.

Confidence: Moderate

Steelhead spawner surveys do not continue through the latter months of the steelhead run, so large numbers of fish and redds may be missed (Ettlinger et al. 2015b; M. Reichmuth, personal communication). The available data, however, is adequate to roughly assess run sizes and trends.

Trend: No Change

Steelhead redd counts since 2008 in Lagunitas Creek show no strong trend. In Redwood Creek, steelhead redd counts appear to have declined since 2012, although the survey timeframe is short and there is low confidence in individual run estimates.

METRIC 2: STREAM OCCUPANCY

Baseline: Anadromous steelhead currently occupy 52 miles of stream in the One Tam area of focus (MarinMap GIS, "Anadromous fish" layer, internal MMWD data). Streams above MMWD reservoirs are considered permanently inaccessible and are not included in these stream distances.

Condition Goal: Increased distance of occupied stream habitat over existing conditions (currently approximately 52 miles)

Condition Thresholds:

- **Good:** 83 miles of stream occupied by anadromous steelhead, representing 75% of the 110 miles of stream in the One Tam area of focus (MarinMap GIS, internal MMWD data)

- **Caution:** 55 miles of stream occupied by anadromous steelhead representing 50% of the 110 miles of stream in the One Tam area of focus

- **Significant Concern:** Less than 55 miles of stream in the One Tam area of focus occupied by anadromous steelhead

Current Condition: Significant Concern

Fewer than 55 miles of stream are currently occupied by anadromous steelhead. In addition, a 2003 inventory found numerous migration barriers in the Corte Madera Creek Watershed and Mill Valley creeks (Taylor & Associates, 2003).

Confidence: Moderate

Many streams are not surveyed and baseline surveys are needed.

Trend: No Change

The extent to which the 110 miles of streams identified in the One Tam area of focus was historically accessible to steelhead is unknown. Additionally, the current extent of the One Tam area of focus occupied by steelhead trout—either anadromous or resident forms—has not been accurately determined, nor have the upstream limits of anadromy in many streams. Field surveys would be necessary to fully identify both current occupancy and migration barriers. Finally, there is no evidence to determine whether steelhead occupancy has increased or decreased in recent years.

METRIC 3: OUTMIGRANT STEELHEAD TROUT SMOLTS

Baseline: An average of 2,600 steelhead smolts in Lagunitas Creek over the last eight years.

Condition Goal: An average of 26,000 steelhead smolts in Lagunitas Creek over eight years (two generations), with 10% marine survival based on eight years of data. This number of steelhead smolts and marine survival rate would result in 2,600 adults and meet the draft adult recovery goal (NMFS, 2015). In Redwood Creek, 780 steelhead smolts and 10% marine survival would result in 78 adult steelhead trout and meet the draft recovery goal.

Condition Thresholds:

- **Good:** An eight-year average of 13,000 steelhead smolts in Lagunitas Creek and 390 steelhead smolts in Redwood Creek

- **Caution:** An eight-year average of 6,500 steelhead smolts in Lagunitas Creek and 200 steelhead smolts in Redwood Creek

- **Significant Concern:** An eight-year average of fewer than 6,500 steelhead smolts in Lagunitas Creek and 200 steelhead smolts in Redwood Creek

Current Condition: Significant Concern

The average steelhead smolt estimate is 2,600 for Lagunitas Creek (Figure 12.8). While the adult recovery target and related smolt target are likely too high, current steelhead smolt numbers appear to be low. Few data exist on steelhead smolt abundance in Redwood Creek.

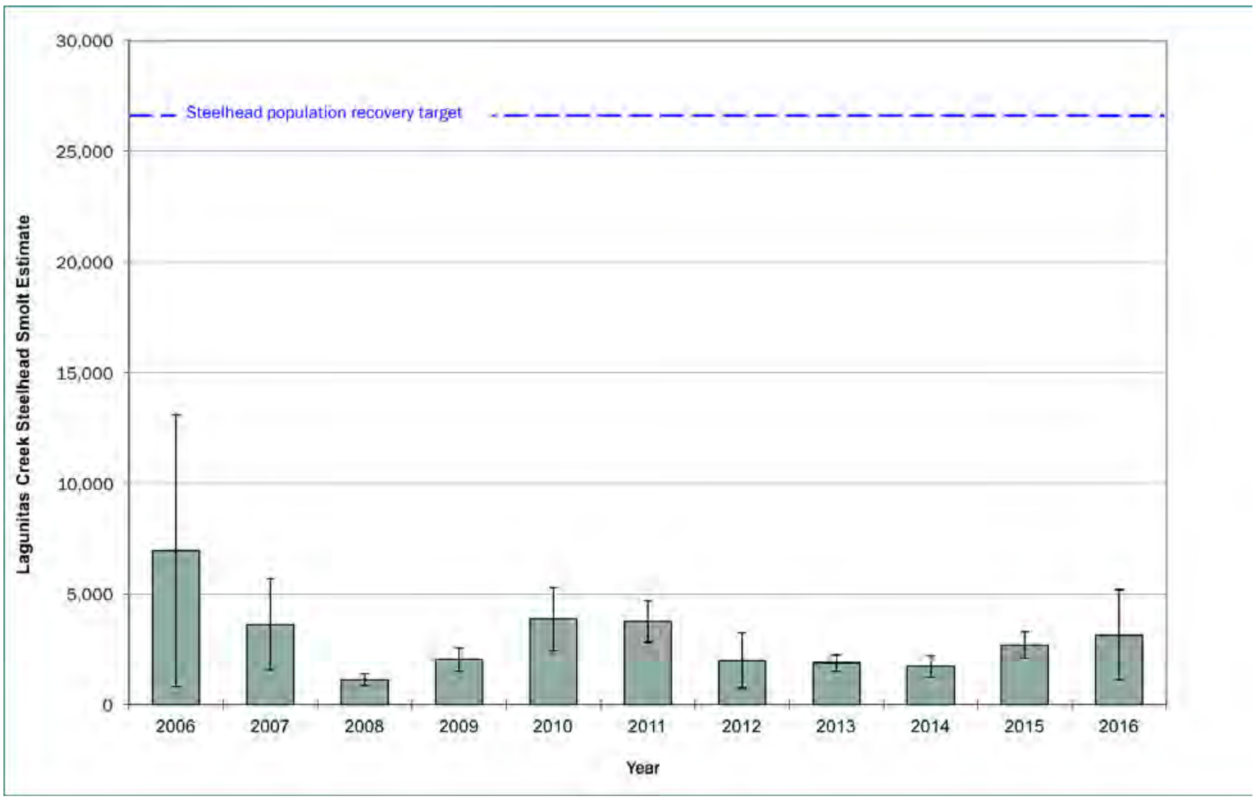
Confidence: Moderate

The steelhead smolt monitoring period misses unknown but possibly significant number of early smolts (Ettlinger et al., 2015c).

Trend: No Change

Steelhead smolt estimates since 2008 (two generations) show no strong trend.

FIGURE 12.8 STEELHEAD SMOLT ESTIMATES FOR THE LAGUNITAS CREEK WATERSHED

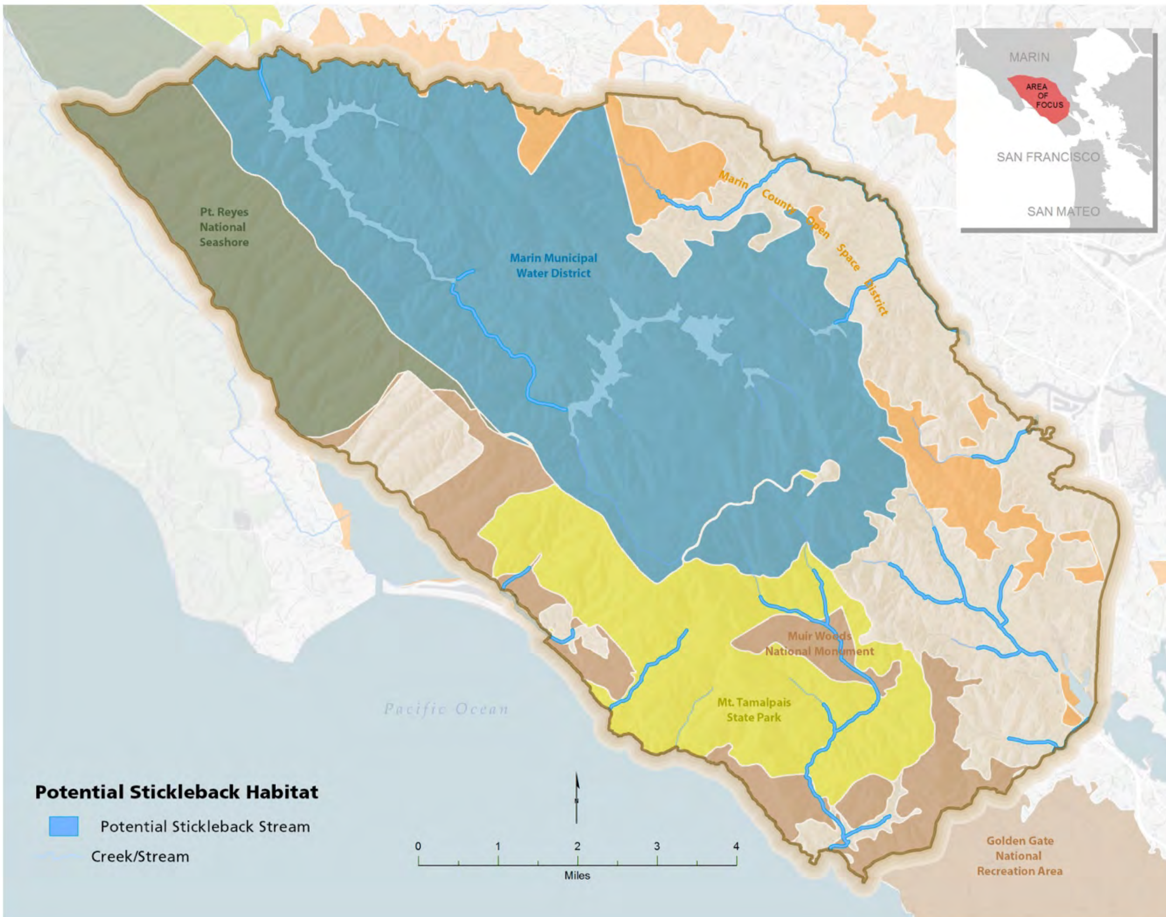


THREESPINE STICKLEBACK

METRIC 1: PRESENCE IN SUITABLE WATER BODIES

Baseline: The current and historical extent of stickleback in the One Tam area is unknown, but stickleback are less widespread than steelhead. Stickleback prefer slow, relatively low-gradient streams. Of the 110 miles of stream in the One Tam area of focus (MarinMap GIS, internal MMWD data), approximately 40 miles could be characterized as slow and low gradient. These 40 miles, along with the MMWD reservoirs, are currently our best guess at the baseline distribution of stickleback in the One Tam area of focus (Figure 12.9).

FIGURE 12.9 POTENTIAL STICKLEBACK HABITAT (INTERNAL MMWD DATA)



Condition Goal: Stickleback should occupy all suitable habitats within the One Tam area of focus.

Condition Thresholds:

- **Good:** At least 40 miles of stream occupied by stickleback, representing all suitable stream habitat in the One Tam area of focus (MarinMap GIS, internal MMWD data)
- **Caution:** 30 miles of stream occupied by stickleback
- **Significant Concern:** Less than 30 miles of stream in the One Tam area of focus occupied by stickleback

Current Condition: Good

We believe that stickleback currently occupy all suitable stream habitat, plus Lake Lagunitas. Stickleback do not appear to occupy other MMWD reservoirs due to non-native piscivorous fish (MMWD internal data, 2006).

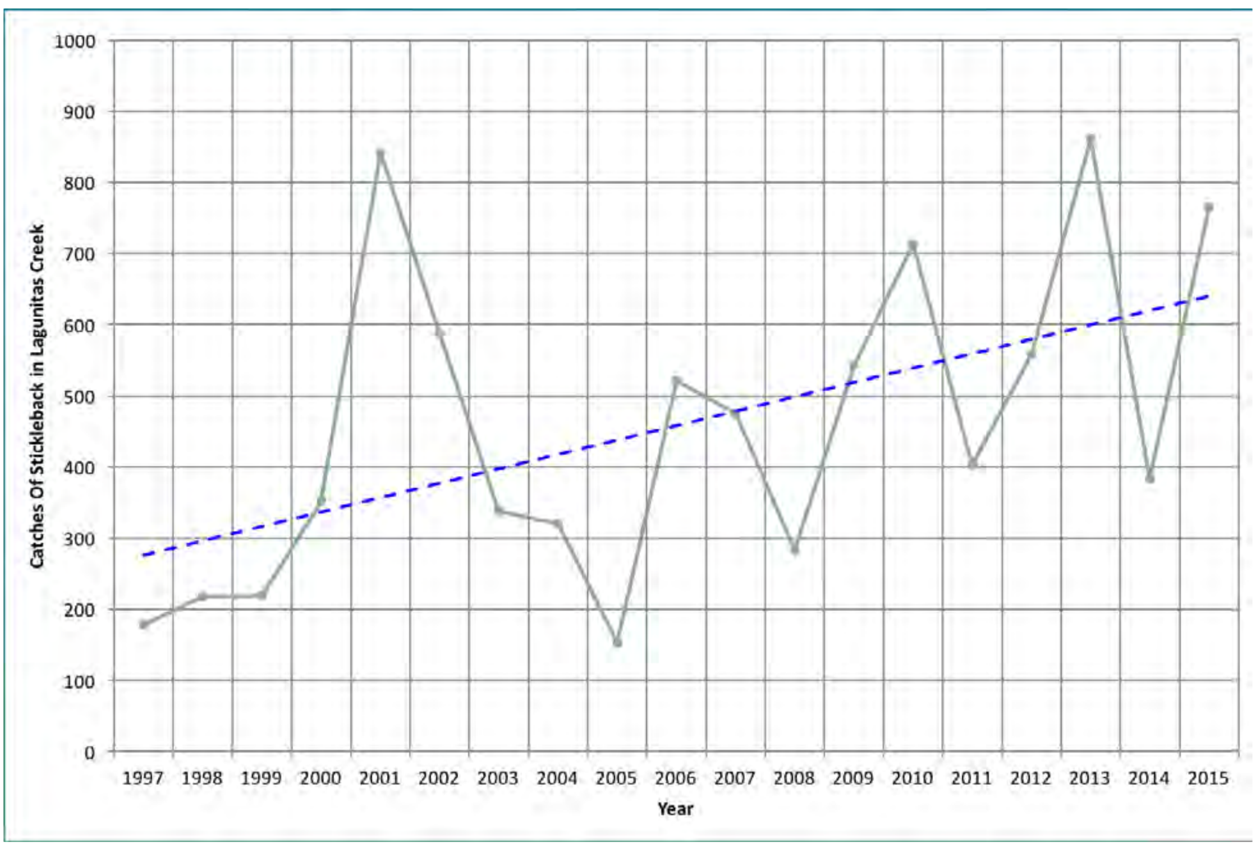
Confidence: Low

The only surveys that have recorded stickleback have been electrofishing surveys outside the One Tam area of focus and a survey of lake fish in 2006. Additional surveys of potential habitats are needed before their distribution can be accurately estimated.

Trend: No Change

There is no data indicating a change in the distribution of stickleback in the One Tam area of focus. Electrofishing surveys in Lagunitas Creek have documented an increase in stickleback since the late 1990s (Figure 12.10), although this may not reflect population dynamics in the broader One Tam area of focus.

FIGURE 12.10 CATCHES OF STICKLEBACK IN LAGUNITAS CREEK (INTERNAL MMWD INTERNAL DATA)



SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

The following monitoring, research, and assessments have been used to inform the data and conclusions presented in this chapter:

- NMFS Federal Register documents (NMFS 2012 and 2015)
- NPS inventory and annual monitoring (Carlisle et al., 2016)
- MMWD annual monitoring reports (*marinwater.org/177/Lagunitas-Creek-Watershed*)
- Redwood Creek Watershed Assessment (Stillwater Sciences, 2011)

A summary of key monitoring programs is below. More information about each program can be found in the accompanying citations.

ANNUAL ADULT SALMONID MONITORING

Marin Municipal Water District fisheries staff walk Lagunitas Creek and two of its tributaries weekly between November and mid-March. Salmonid redds are counted and classified to species. Live fish and carcasses are also counted. Run sizes for each species are conservatively estimated by assuming each redd represents two adult fish. These surveys have been conducted annually since 1995–1996 (MMWD, 2015b). National Park Service staff monitor adult salmonids in Olema Creek and Redwood Creek using similar methods (Carlisle et al., 2016).

ANNUAL SUMMER JUVENILE SALMONID MONITORING

Marin Municipal Water District fisheries staff conduct electrofishing and snorkel surveys at established index reaches in Lagunitas Creek. These surveys were first conducted in 1970 and then annually starting in 1993. Other fish and amphibians are also captured, and these incidental observations provide some trend information for other native fish such as threespine stickleback (Ettlinger et al., 2015b). The National Park Service monitors juvenile salmonids in Olema Creek and Redwood Creek using a basinwide estimation procedure that uses snorkel surveys calibrated by electrofishing. In addition, index sections are electrofished (Carlisle et al., 2016).

ANNUAL SMOLT MONITORING

Since 2006, MMWD has operated a rotary screw trap near Point Reyes Station to estimate coho salmon and steelhead smolts migrating from Lagunitas Creek to the ocean. The trap catches a portion of the migrating fish, and that proportion is estimated by marking a small number of fish each day, releasing them upstream, and counting the number recaptured (Ettlinger et al., 2015c). Salmonids are also counted by NPS and the Salmon Protection and Watershed Network (SPAWN) using fyke net traps on Olema, Redwood, and San Geronimo creeks (Carlisle et al., 2016; SPAWN internal data).

SALMONID HABITAT MONITORING

Every five years, or more frequently if floods alter the stream channel, MMWD staff measure salmonid habitat in the Lagunitas Creek study area. Habitats are classified (as pool, riffle, run, or glide), their dimensions measured, and characteristics such as fish shelter, bank characteristics, and canopy are quantified (Ettlinger et al., 2013). The National Park Service measures and classifies stream habitats in Redwood Creek annually (Carlisle et al., 2016).

INFORMATION GAPS

Monitoring Data: Current monitoring targets coho salmon, but surveys could be expanded to build a more robust dataset for steelhead trout and threespine stickleback.

Fish Migration and Habitat: The timing and magnitude of salmonid movements between streams using Passive Integrated Transponder (PIT) tag technology would provide valuable information on habitat needs during multiple life stages. Expanding existing PIT tagging to steelhead trout would provide data on steelhead trout smolt emigration prior to the start of smolt trapping.

Pool Habitat: The availability of pool habitats was identified as an important metric for coho salmon. However, there is not consensus on what defines these habitats, how different kinds of pools are classified, or what the ideal frequency of pools along a stream should be. Developing site-specific criteria for pool frequencies using appropriate data (e.g., geomorphic, sediment loading, pool scour potential, roughness, large woody debris loading, etc.) would allow us to measure this important aspect of salmonid habitat health in the future.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration:

- Extensive habitat restoration in Lagunitas Creek including installing large wood structures and reducing fine sediment inputs (MMWD)

- Redwood Creek habitat restoration including removal of fish passage barriers, installation of habitat structures, native plant restoration, and restoration of natural processes and hydrology at the creek's mouth at Muir Beach (NPS)

- Realigning and reconnecting Green Gulch Creek to Redwood Creek for the first time in many decades and providing valuable off-channel habitat for coho salmon (NPS and San Francisco Zen Center)

- Removal of culvert barriers for adult and juvenile steelhead in Jewel Creek (NPS land, implemented by MMWD)

- Banducci restoration, including large woody debris installation and creek realignment in 2003, removal of levies and fill from floodplain in 2007, and groundwater recharge improvements in 2015 (NPS)

- Identifying high-priority sites for barrier removal on Redwood Creek through the 2003 Marin County Fish Passage Assessment, leading to the installation of a new culvert connecting Kent Canyon and the mainstem of Redwood Creek and replacement of an undersized culvert under Muir Woods Road (NPS)

Management:

- Multi-agency Coho Jumpstart program to rear and release coho salmon back into Redwood Creek starting in 2015

- Water releases into Lagunitas Creek to maintain streamflow for salmonids (MMWD)

- Reduced sedimentation: as a result of the Dias Ridge restoration project (NPS), multiple projects along the Bootjack Trail (NPS and State Parks), Alice Eastwood Road culvert removal (State Parks), fire road and trail sediment reduction projects in San Geronimo/Lagunitas Watershed (MCP), and several significant projects stemming from the implementation of the MMWD's 2005 *Mt. Tamalpais Watershed Road and Trail Management Plan*

Monitoring: Long-term life-cycle (juvenile, smolt, adult spawner/redds) monitoring of salmonids in Lagunitas and Redwood creeks (MMWD and NPS) and annual adult and smolt monitoring in the San Geronimo Valley (SPAWN)

Outreach:

- AmeriCorps-led volunteer salmon enhancement projects and watershed education programs in schools (MMWD)

- Spawner Day Program at Samuel P. Taylor State Park

- Annual Welcome Back Salmon event at Muir Beach, held in partnership with the Federated Indians of Graton Rancheria (NPS)

- Thousands of volunteer hours spent on habitat restoration and stewardship and salmonid monitoring

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Juvenile Coho Winter Habitat Improvements Within Redwood Creek***:* Remove a portion of the rock riprap along the creek within Muir Woods, and move fallen trees on the forest floor into the creek to allow the natural movement of water to form the habitat features needed for juvenile salmon survival

- **Hydrologic Restoration at Roy's Redwoods:** Conduct an assessment of wetland features and hydrologic function within the Roy's Redwoods region to determine the feasibility of the reconnection to Larsen's Creek, a salmonid-bearing stream

- **Visitor Use Infrastructure Improvements on San Anselmo Creek at Cascade Canyon Preserve**: Implement visitor use improvements including social trail management, bridge installation, and subsequent restoration to reduce sedimentation into the creek

- **San Anselmo Creek Downstream of Cascade Canyon Preserve:** Partner with private landowners to remove downstream salmon migration barriers

- **Summer Instream Flows at Redwood Creek:** Leverage funds from the existing California Proposition 1 grant-funded project at the Muir Beach Community Service District to support implementation of the recommendations from a feasibility study on improving groundwater recharge in the Redwood Creek Watershed

- **Muir Beach Restoration***:* Complete the final phase of this project to removal of floodplain connection barriers, including the replacement of the Pacific Way Bridge, and subsequent floodplain and habitat restoration upstream and downstream of the barrier removals

- **Redwood Creek Trail Realignment:** Implement this project to reroute the current trail out of the floodplain, restore the floodplain, eliminate horse fjords, and replace many existing bridges and culverts to reduce sedimentation and visitor use impacts to Redwood Creek

Potential Research:

- **Potential Impacts of Targeted Non-Native Species:** Learn how are weeds impacting vegetation cover and structure necessary for maintaining habitat conditions for fisheries (e.g. shade needed to sustain optimal water temperatures and reduce evaporation

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(the following years are also available through datastore: 1997 1998, 2000, 2001)

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CHAPTER 13. CALIFORNIA RED-LEGGED FROG (*RANA DRAYTONII*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: No Change

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Amphibians are good indicators of freshwater wetland condition because they are relatively long-lived and breed and rear in wetland and aquatic sites. Their sensitivity to changes in hydrology and precipitation, as well as susceptibility to pollutants and toxins makes them excellent indicators of ecosystem health.

The California red-legged frog was federally listed as a threatened species in 1996, and Mt. Tam is part of a core area identified by the U.S. Fish and Wildlife Service for the recovery of the species. The National Park Service (NPS) and their partners have been working to improve trail systems, construct ponds and wetlands for breeding frogs, and restore native vegetation at Muir Beach. The NPS and U.S. Geological Survey (USGS) conduct egg mass surveys and non-breeding season surveys for larvae, juveniles, and adults (Fong et al., 2010). California red-legged frog egg masses are large (fist-sized) and laid attached to vegetation in relatively shallow waters close to shore (Alvarez et al., 2013). Hence, they are relatively easy to find and document, allowing for high confidence in abundance estimates.

OVERALL CONDITION

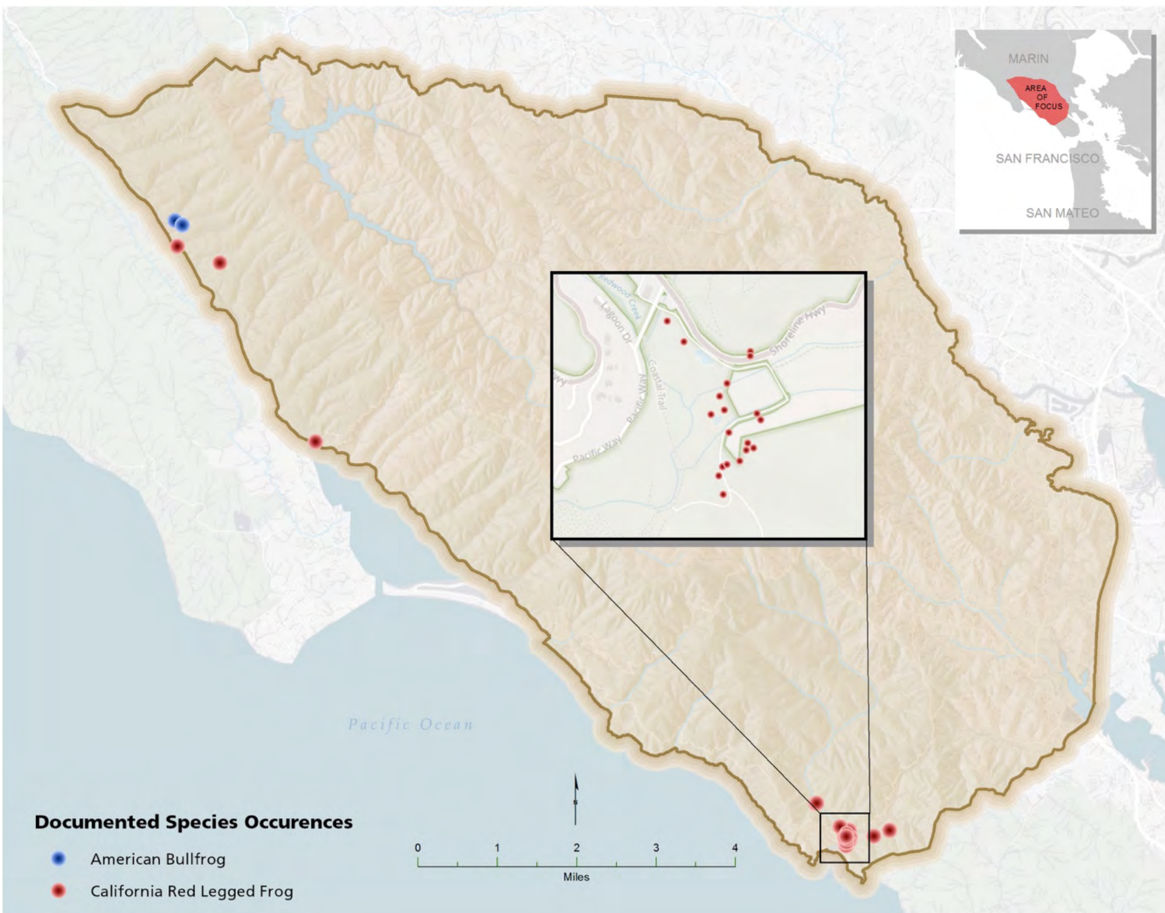
Now eliminated from 70% of their former range, California red-legged frogs are primarily found in coastal drainages from Marin County south to San Simeon. Within the One Tam area of focus, they are known to live at Muir Beach and in the Olema Creek Watershed. We do not have enough data to know the current status of the Olema Creek watershed population. However, the population at Muir Beach has increased thanks to stream restoration, breeding pond creation, and reintroduction of egg masses (Shoulders & Fong, 2015). There are no current observations of a breeding population in the east side of the Bolinas Lagoon Watershed, where California red-legged frogs once lived (NPS, 2016, unpublished data). Little information is available about the status of California red-legged frogs in the eastern and southern portions of the One Tam area of focus.

DESIRED CONDITIONS

As recommended by U.S. Fish and Wildlife Service's recovery plan (U.S. Fish and Wildlife Service [USFWS], 2002) the goal is to have the long-term population trend of California red-legged frogs unchanged or increasing.

Invasive Species: Non-native American bullfrogs (*Lithobates catesbeianus*) and non-native fish prey on California red-legged frogs and compete with them for resources. Bullfrogs are present at several sites within the Olema Creek Watershed but are not found in the Redwood Creek Watershed (Figure 13.1). Historic data indicate presence of non-native crayfish and introduced fish at the ponds in Olema Creek Watershed within One Tam area of focus (Fong, 1996).

FIGURE 13.1 DETECTIONS OF AMERICAN BULLFROGS, CALIFORNIA RED-LEGGED FROGS, AND CALIFORNIA GIANT SALAMANDERS ON NPS LANDS IN MARIN COUNTY 1993–2014 (GOLDEN GATE NATIONAL RECREATION AREA [GGNRA], 2015)



Habitat Loss: A large freshwater/brackish 25-acre lagoon complex once present at Muir Beach in the mid-1850s was lost due to historical land use changes (Jones & Stokes, 2007). Some of this habitat has been replaced by recently created off-channel ponds and backwater areas at the site. In addition to ponds and wetlands, California red-legged frogs also use creek channels as non-breeding rearing habitat. A high frequency of dry creek downstream of diversions was noted in the 1980s, 1990s, and early 2000s (Hofstra & Anderson, 1989; Smith, 1994; Smith, 2003). Water diversions are present in the Redwood Creek Watershed, although the magnitude is likely reduced through the enaction of conservation measures by the Muir Beach Community Services District and cessation of pumping for agriculture.

Disease: Chytrid fungus (*Batrachochytrium dendrobatidis*) causes a potentially lethal disease in amphibians called chytridiomycosis, which has caused worldwide amphibian population declines. Chytrid fungus is present on Mt. Tam, but so far it does not seem to be affecting California red-legged frogs.

Climate Change: Climate change models predict warmer temperatures, more variable rainfall, and rising sea levels. Changes in temperature and precipitation patterns may decrease the distribution of the deep, calm pools California red-legged frogs need for breeding. Such conditions are likely to decrease survival of egg masses and tadpoles, and increase uncertainty in breeding from year to year (Allen & Kleeman, 2015). Increased frequency and elevation of high tides could also raise salinity levels in low-lying breeding habitat (Allen & Kleeman, 2015). The Bolinas Lagoon site is particularly sensitive to this threat.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: PRESENCE IN SUITABLE BREEDING HABITATS

Baseline: This metric is defined as the number and percent occupancy of suitable breeding sites.

Currently, there are three potentially suitable breeding sites within the One Tam portion of the Olema Creek Watershed, and one potentially suitable breeding site within One Tam portion of the Bolinas Lagoon Watershed. There is no current information on California red-legged frog breeding at the Olema Creek Watershed sites. There was no breeding at the Bolinas Lagoon site in breeding year 2016.

There are five potentially suitable breeding sites in the lower Redwood Creek Watershed near Muir Beach, where there was breeding in four of the five sites in breeding year 2015. There are no other reports of current breeding sites in the One Tam area (California Natural Diversity Database [CNDDB], 2016), although it is unclear the level of survey effort in the eastern and southern portions.

Condition Goals: Number and percent occupancy trend is unchanged or increasing for at least a 15-year period, which is approximately four to five generations of the California red-legged frog (USFWS recovery criterion #2) (USFWS, 2002).

Condition Thresholds:

- **Good:** At least 67% of potentially suitable habitat with breeding activity in the Olema and Redwood Creek watersheds in the One Tam area of focus, and some breeding activity within the Bolinas Lagoon site
- **Caution:** At least 33% of potentially suitable habitat with breeding activity in the Olema and Redwood Creek watersheds in the One Tam area of focus
- **Significant Concern:** No breeding activity in the Bolinas, Olema, or Redwood Creek watersheds in the One Tam area of focus

Current Condition: Good for Redwood Creek; Unknown for Olema Creek

Monitoring indicates that California red-legged frogs are stable in the Redwood Creek Watershed (D. Fong, personal communication). However, there is only sparse data for the Olema Creek Watershed within the One Tam area of focus. California red-legged frogs are increasing in the Muir Beach area due to recent efforts by NPS.

Confidence: High for Redwood Creek; Low for Olema Creek

Different levels of available data yield different confidence levels for these two watersheds.

Trend: No Change for Redwood creek; Unknown for Olema Creek

The number and occupancy of breeding sites has been stable in the Redwood Creek Watershed over a 15-year period. The trend for the Olema Creek Watershed is “Unknown” due to a lack of data.

METRIC 2: NUMBER OF EGG MASSES OBSERVED DURING BREEDING SURVEYS

Baseline: This metric would be summarized by watershed rather than on a per site basis. For the Redwood Creek Watershed, the 15-year average is 22 egg masses per year and a positive trend over this period (Figure 13.2). For Bolinas Lagoon, the six-year average is zero egg masses per year. No recent data are available for Olema Valley.

Condition Goal: Annual abundance of egg masses is unchanged or increasing for at least a 15-year period, which is approximately four to five generations of the California red-legged frog (USFWS recovery criterion #2) (USFWS, 2002)

Condition Thresholds:

- **Good:** Both watersheds in the One Tam area of focus with egg masses present and with no significant negative trend in annual abundance of egg masses over 15-year or longer period

- **Caution:** One watershed with significant negative trend in annual abundance of egg masses over 15-year or longer period

- **Significant Concern:** Both watersheds with significant negative trend in annual abundance of egg masses over 15-year or longer period

Current Condition: Good for Redwood Creek; Unknown for Olema Creek

Egg mass counts at breeding sites in the Redwood Creek Watershed show increasing numbers (Figure 13.2).

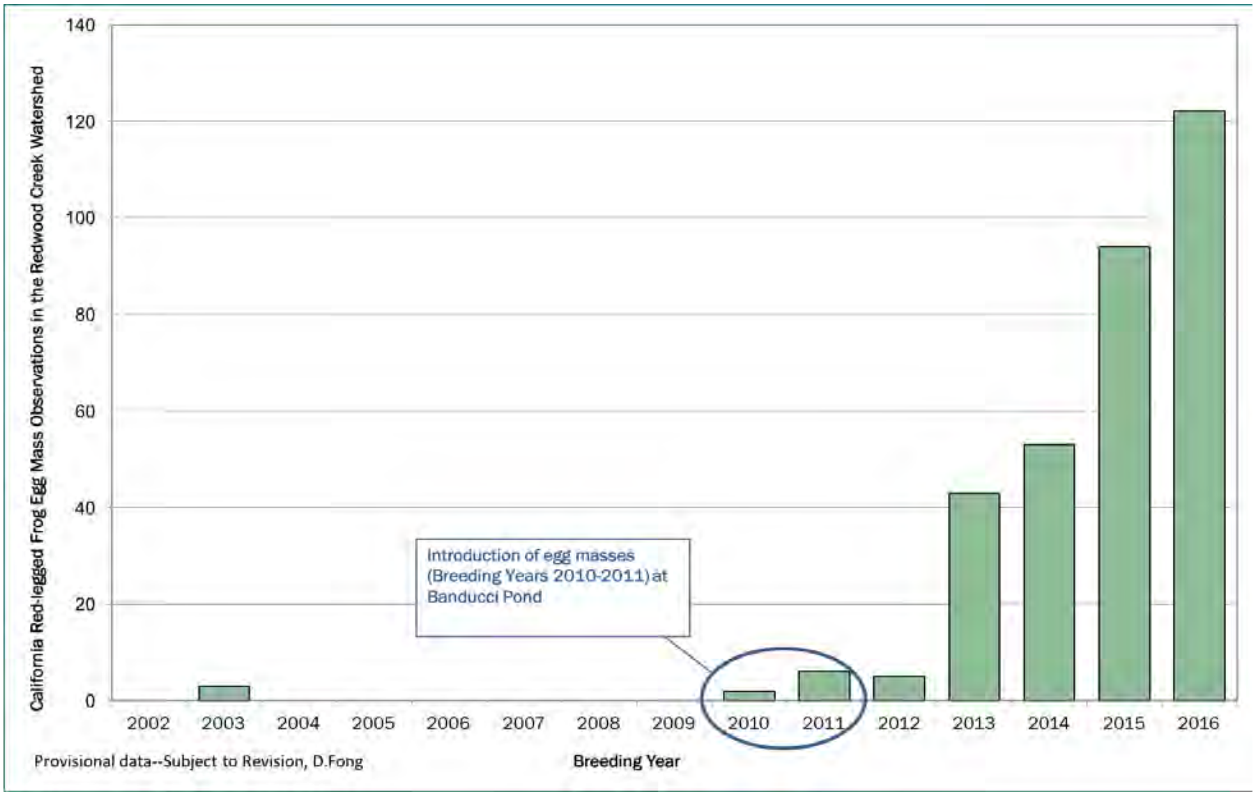
Confidence: High for Redwood Creek; Low for Olema Creek

Different levels of available data yield different confidence levels for these two watersheds.

Trend: Improving for Redwood Creek; Unknown for Olema Creek

Stable over 15-year period despite an initial loss of small population and subsequent re-introduction in breeding years 2010–2011 (Figure 13.2).

FIGURE 13.2 TOTAL COUNTS OF CALIFORNIA RED-LEGGED FROG EGG MASSES IN THE REDWOOD CREEK WATERSHED 2002–2016 (NPS, 2016, UNPUBLISHED DATA)



METRIC 3: NUMBER OF SITES OCCUPIED BY NON-NATIVE PREDATORS

Baseline: No recent data are available for the Olema Creek sites within the One Tam area of focus. Historic data documented the presence of non-native swamp crayfish (*Procambarus clarkia*), American bullfrogs, and non-native fish. Recent fisheries data from Redwood Creek indicates that there are no persistent non-native fish (Carlisle et al., 2016).

Condition Goals:

- No breeding sites occupied by non-native predators
- No non-native predators in wetland and aquatic sites within one mile of California red-legged frog breeding sites

Condition Thresholds:

- **Good:** All breeding sites absent of non-native predators and no non-native predators in wetland and aquatic sites within one mile of breeding sites
- **Caution:** Two of the three watersheds in the One Tam are of focus absent of non-native predators and no non-native predators in wetland and aquatic sites within one mile of breeding sites

- **Significant Concern:** One of the three watersheds in the One Tam area of focus absent of non-native predators and no non-native predators in wetland and aquatic sites within one mile of breeding sites

Current Condition: Caution

We estimate a condition of Caution based on best professional judgement, and the available data on non-native predators in these watersheds.

Confidence: Low

Data are not available for the full suite of watersheds and non-native predator species.

Trend: No Change

California red-legged frog breeding sites within Redwood Creek Watershed are without non-native predators. However, they are present in potential breeding sites in the Olema Creek Watershed. Some sites on the west side of Bolinas Ridge have bullfrogs present (GGNRA, 2015).

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

NATIONAL PARK SERVICE LANDS

The NPS and USGS have collected sporadic data on breeding California red-legged frog populations in the Olema Valley and Bolinas Lagoon. However, consistent annual surveys have occurred in the Redwood Creek Watershed since 2002. Monitoring includes winter egg mass surveys that provide long-term monitoring data to assess trends in abundance of winter-breeding frogs, specifically the California red-legged frog, at sites within Marin and San Mateo Counties. Fong et al. (2010) include a full description of this monitoring program and its methods.

OTHER ONE TAM PARTNER AGENCIES

There are no reported observations of breeding California red-legged frogs in the portion of the One Tam area managed by the Marin Municipal Water District, which are generally too forested and too steep to support breeding habitats for this species. There are no California red-legged frog populations on Marin County Park or California State Parks lands in the One Tam area of focus.

INFORMATION GAPS

Climate Change: It is not known how climate change may affect California red-legged frogs, though higher temperatures and/or changes in precipitation patterns may increase drying of breeding ponds and sea level rise may increase salinity in lower floodplain habitats.

Population Variables: Factors affecting the abundance and vital rates (e.g., survival, recruitment, population) are poorly understood.

Stream Data: Though data about California red-legged frogs in pond breeding habitats are available, similar breeding data for streams is lacking throughout the One Tam area of focus.

Eastern and Southern One Tam Area: There are no current observations of California red-legged frogs within this area. However, low-lying freshwater marshes (e.g., Arroyo Corte Madera del Presidio) and streams may not have been surveyed with sufficient frequency. Bay-fringing marshes in nearby areas of Tiburon and San Rafael have recent sightings of California red-legged frogs. Better inventory data are needed in potentially suitable breeding habitat for the species.

Olema Creek: Consistent monitoring data from Olema Creek California red-legged frog breeding sites is needed to better understand their condition and trends in the One Tam area of focus.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration:

- Creation of breeding pond and backwater habitats at Muir Beach beginning in 2009 and at Banducci in 2007
- Relocation of egg masses and/or adult frogs to help bolster the population at the Banducci farm and Muir Beach restoration sites (NPS)

Monitoring: Annual breeding frog surveys (NPS)

Research:

- Habitat use and movement study at Olema, Bolinas, and Redwood Creek watersheds
- Genetic studies to determine diversity of the Redwood Creek Watershed population (NPS and USGS)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Habitat Protection:**
    - Identify habitat impairments throughout the Mt. Tam region and implement priority wetland and creek restoration actions
    - Minimize the impacts of removing artificial breeding and rearing habitat (also known as stock ponds) through being strategic about pond removal and/or modifications to minimize impacts to California red-legged frog populations

Inventory and Monitoring:

- Implement a more focused inventory effort on California State Parks lands, and a systematic approach to monitoring this species in Olema Valley to detect bullfrogs, emerging diseases, and other population stressors
- Expand hydroperiod monitoring—building off ongoing groundwater monitoring at Muir Beach—to include key wetland and other aquatic breeding sites

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CHAPTER 14. FOOTHILL YELLOW-LEGGED FROG (*RANA BOYLII*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Significant Concern

Trend: No Change

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Foothill yellow-legged frogs are good indicators of both perennial and ephemeral stream conditions because they rely on lotic environments for breeding and post-metamorphic habitat. Early life stages are sensitive to streamflow fluctuations, changes in water temperature, and are vulnerable to both recreational use and invasive aquatic species. This species is also considered vulnerable to climate change because of its sensitivities to temperature and precipitation levels.

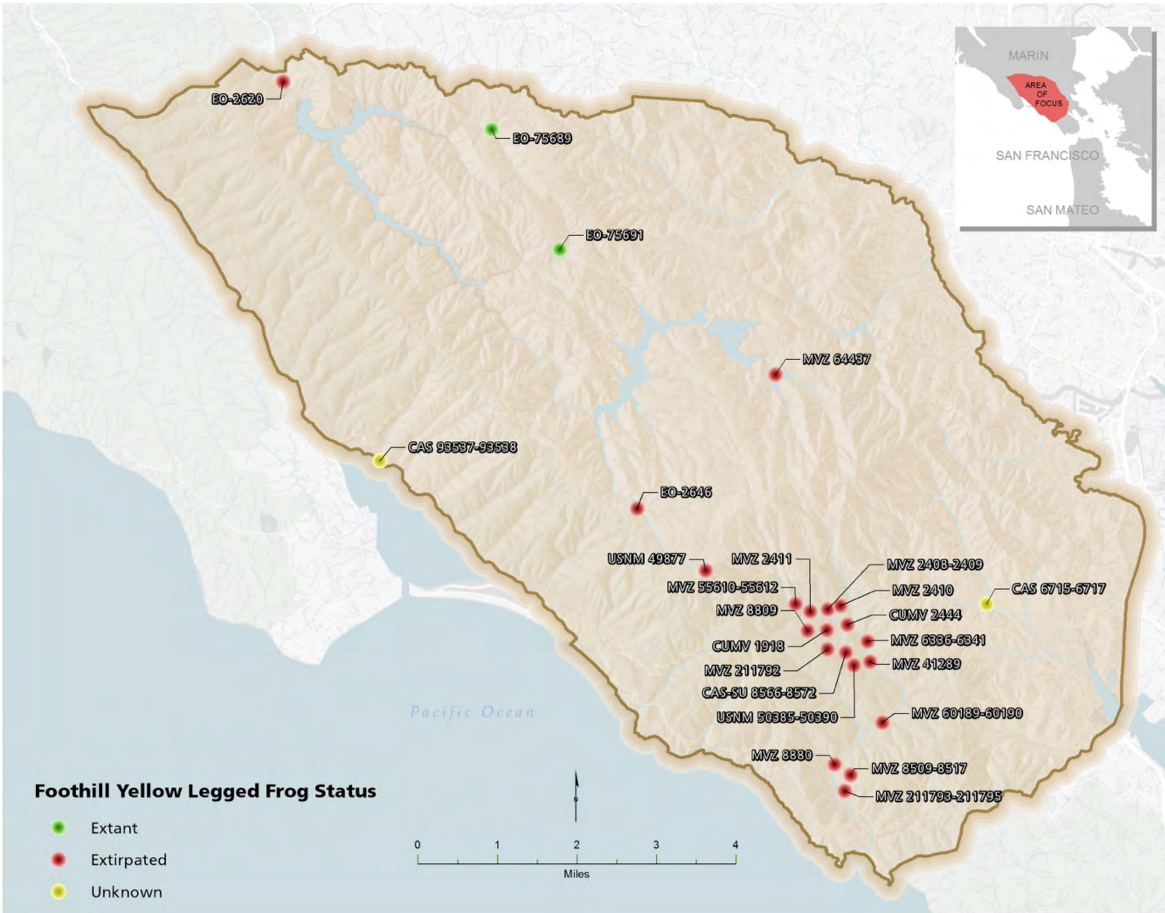
The Marin Municipal Water District (MMWD) has been monitoring this species since 2004, and has implemented restoration and other protection measures to benefit them in the One Tam area of focus.

OVERALL CONDITION

The foothill yellow-legged frog's range includes streams from Oregon to Los Angeles County, California, including at elevations up to 6,300 feet in the Sierra Nevadas. This species has declined over half of their historical range, including a severe drop in numbers in the San Francisco Bay Area (Center for Biological Diversity [CBD], 2016). As a result, the foothill yellow-legged frog is designated as a Federal species of concern, a Forest Service sensitive species, and a California species of special concern. Museum specimens and California Natural Diversity Database (CNDDB) records reveal foothill yellow-legged frogs lived at Rock Spring Meadow, Redwood Creek, and Cataract Creek well into the middle of the twentieth century. There are currently two populations on MMWD lands: Little Carson Creek and Big Carson Creek, both tributaries to Kent Lake (Garcia and Associates [GANDA], 2010).

A review of historic records, museum specimens, and CNDDB records, combined with focused field surveys (GANDA, 2003), indicate that both the foothill yellow-legged frog's range and numbers have declined significantly in Marin County and in the One Tam area of focus over the last 75 years (Figure 14.1). Breeding surveys conducted by MMWD between 2004 and the present indicate the remaining breeding populations have been relatively stable (GANDA, 2016), but they are vulnerable to decline due to their small size and isolation from other foothill yellow-legged frog populations. Although the aggregation of the condition scores for the metrics below yield a borderline Caution/Significant Concern rating, we felt that this high level of vulnerability warranted an overall condition of Significant Concern.

FIGURE 14.1 FOOTHILL YELLOW-LEGGED FROG OCCURRENCES IN MARIN COUNTY (GANDA, 2010)



DESIRED CONDITIONS

- Continued presence of all life stages in currently occupied streams (Big and Little Carson creeks) with stable or increasing number of egg masses and individual adults detected each year
- Re-establishment of breeding populations in historically occupied streams including Cataract and Redwood creeks
- Improved breeding habitat quality, including sunny openings above breeding pools, reduction in human-caused impacts to creek bottoms/cobble in and adjacent to breeding pools, and continued management of non-native predators

STRESSORS

Predation: Foothill yellow-legged frogs are vulnerable to predation by invasive bullfrogs (*R. catesbiana*) and signal crayfish (*Pacifastacus leniusculus*), as well as native rough-skinned newts

(*Taricha granulosa*). Breeding pools are monitored for these species, and any bullfrogs and crayfish that are found are removed.

In-stream Habitat Disturbance: During the breeding season (February through May), foothill yellow-legged frogs congregate in sunny pools where the water is warm and well aerated to deposit egg masses among cobbles and gravel. Eggs and tadpoles are highly vulnerable to in-stream disturbances that shift or compact both large and small rocks. Disturbance and loss of egg masses and breeding habitat can occur as a result of very high flow events as well as in-stream recreational and maintenance activities. Since 2008, MMWD has placed docents to help protect sensitive habitats at Little Carson Creek during the breeding season. At Big Carson Creek, MMWD translocates egg masses out of the Pine Mountain Road wet crossing to prevent crushing by authorized vehicle traffic and recreationists (GANDA, 2016).

Shading: The absence of gaps in the riparian canopy can deprive frogs of the sunny areas they prefer. MMWD actively manages vegetation along the banks of creeks where this species is found to maintain or create sunny openings. Potential frog breeding areas should be assessed to quantify canopy cover, stream substrate, slope, and other factors. Areas that could benefit from canopy opening should be identified.

Disease: Chytrid fungus (*Batrachochytrium dendrobatidis*) causes a potentially lethal disease in amphibians called chytridiomycosis, which has caused amphibian population declines worldwide. Chytrid fungus is present on Mt. Tam, but so far it does not seem to be affecting foothill yellow-legged frogs (GANDA, 2013b).

Potential Inbreeding: Small, isolated populations of foothill yellow-legged frogs may be vulnerable inbreeding, which could negatively affect their health. While the Big Carson and Little Carson populations have sufficiently suitable upland habitat to allow them to interbreed with each other, the next nearest historic populations have been extirpated. The introduction of new genetic material from populations elsewhere in Marin County or beyond is likely to be a rare event (GANDA, 2013b).

Climate Change: Foothill yellow-legged frogs are vulnerable to extreme temperature and flow fluctuations, both of which may occur under future climate change scenarios.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: SPECIES PRESENCE IN SUITABLE STREAMS OR HISTORICALLY OCCUPIED STREAMS (PROPORTION OF SITES OCCUPIED)

Baseline: Museum specimens and CNDDB records establish the presence of foothill yellow-legged frogs in Rock Spring Meadow, Redwood Creek, and Cataract Creek well into the middle of the last century. However, protocol-level surveys conducted by both the National Park Service (NPS) and MMWD have not detected foothill yellow-legged frogs in these locations this century. The species is presumed to have been extirpated from everywhere within One Tam area of focus except Big Carson and Little Carson creeks and their tributaries.

Condition Goal: Re-establish breeding populations within 100% of streams with suitable habitat

Condition Thresholds:

- **Good:** Three consecutive years of egg mass or tadpole detection in two additional streams

- **Caution:** Three consecutive years of egg mass or tadpole detection in one additional stream

- **Significant Concern:** No egg masses or tadpoles detected outside of Big Carson and Little Carson creeks

Current Condition: Significant Concern

Monitoring results indicate that the only populations in the One Tam area of focus are at Big Carson and Little Carson creeks.

Confidence: Moderate

While there are no other populations known in the One Tam area of focus, a full survey of suitable habitat has not been conducted since 2003.

Trend: No Change

Annual surveys conducted in both Little Carson and Big Carson creeks since 2004 show that the persistence of the species in these drainages appears to be stable (Table 14.2). However, these populations are vulnerable to decline due to their small size and isolation from other populations that could act as a source of additional frogs. The threshold for changing this trend assessment would be the detection of egg masses, tadpoles, or frogs in Redwood Creek, Cataract Creek, or Rock Spring Meadows and its streams.

TABLE 14.2 ADULT RECAPTURE DATA FOR BIG AND LITTLE CARSON CREEKS (GANDA, 2016)

	Females			Males			TOTALS (Females and Males)		
Subsite	Little Carson Creek	Big Carson Creek	Total Females	Little Carson Creek	Big Carson Creek	Total Males	Total- Little Carson Creek	Total- Big Carson Creek	Total Individuals
Total 2008	17	8	25	33	33	66	50	41	91
Total New 2009	8	17	25	4	11	15	12	28	40
Total New 2010	4	9	13	4	12	16	8	21	29
Total New 2011	12	11	23	8	9	17	20	20	40
Total New 2012	4	6	10	2	3	5	6	9	15
Total New 2013	18	1	19	26	6	32	44	7	51
Total New 2014	1	1	2	17	9	26	18	10	28
Total New 2015	6	5	11	21	37	58	27	42	69
Totals 2008-2015	70	58	128	115	120	235	185	178	363
Total Recaps 2009	5	2	7	13	18	31	18	20	38
Total Recaps 2010	7	5	12	10	21	31	17	26	43
Total Recaps 2011	8	4	12	8	14	22	16	18	34
Total Recaps 2012	10	9	19	12	17	29	22	26	48
Total Recaps 2013	9	7	16	7	15	22	16	22	38
Total Recaps 2014	5	4	9	17	15	32	22	19	41
Total Recaps 2015	3	1	4	12	14	26	15	15	30
Total Recaptures 2008-2015	47	32	79	79	114	193	126	146	272

METRIC 2: NUMBER OF EGG MASSES OBSERVED DURING BREEDING SURVEYS

Baseline: The total number of egg masses observed at Little Carson Creek and Big Carson creeks combined has remained relatively stable with a 12-year overall average of 24 egg masses per year and a five-year running average at or above this level since 2011 (Figure 14.3). No egg masses or tadpoles have been reported in Redwood Creek or Cataract Creek in recent years.

Condition Goals:

- Maintain a five-year running average of no less than 24 egg masses observed in Big Carson Creek, its tributaries, and little Carson Creek combined
- Establish self-sustaining breeding populations of foothill yellow-legged frogs, as evidenced by observations of 10 or more egg masses per creek per year for a minimum of three years in a row, in habitat deemed suitable based on past occurrences and current and projected habitat conditions

Condition Thresholds:

- **Good:** Five-year running average of 24 egg masses combined for Little Carson and Big Carson with tributaries, as well as five-year running average of 10 or more egg masses per creek in Redwood or Cataract Creek
- **Caution:** Five-year running average of 18–24 egg masses combined for Little Carson and Big Carson with tributaries, as well as observed egg masses in Redwood and Cataract creeks remaining under 10 per year
- **Significant Concern:** Five-year running average below 18 egg masses observed at Little Carson and Big Carson creeks with tributaries as well as the continued absence of egg masses in Redwood and Cataract creeks

Current Condition: Significant Concern

The five-year running average is below 18 egg masses (Figure 14.3) and no egg masses have been detected in Redwood or Cataract Creek.

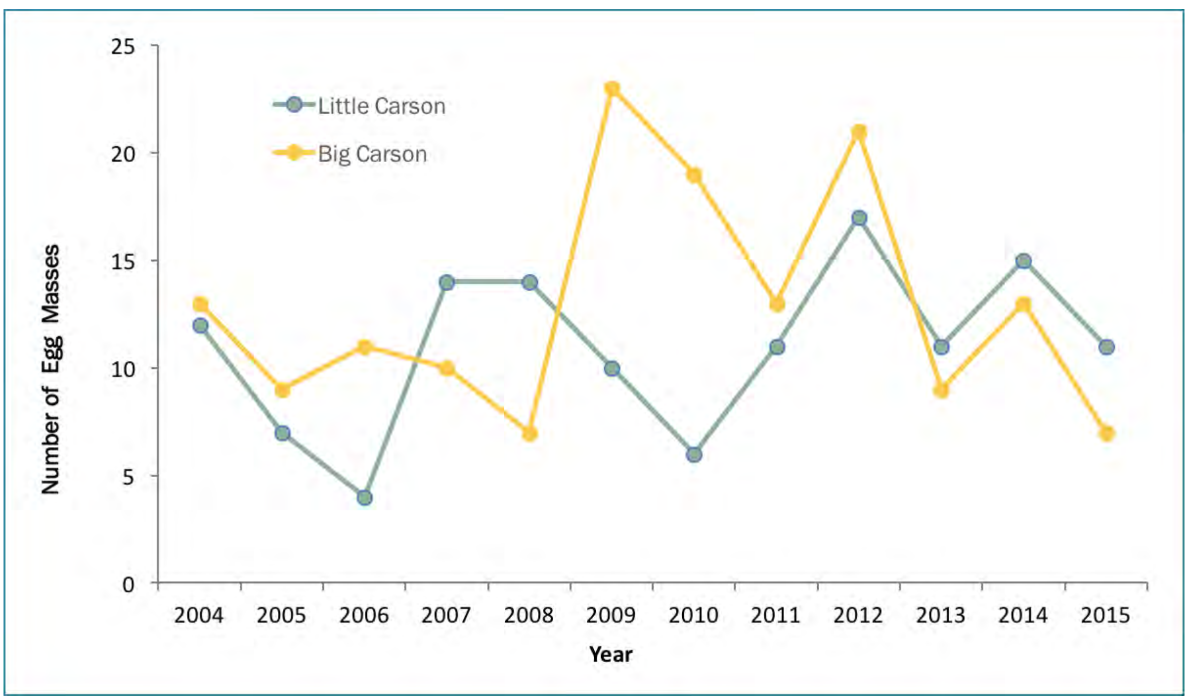
Confidence: High

Egg mass surveys conducted between 2003 and the present have used a consistent technique, trained biologists, and a consistent level of effort within known breeding pools.

Trend: No Change

Monitoring data since 2004 reveal the numbers of foothill yellow-legged frog egg masses are stable (Figure 14.3).

FIGURE 14.3 ANNUAL EGG MASS COUNTS FOR THE LITTLE CARSON AND BIG CARSON CREEKS FOOTHILL YELLOW-LEGGED FROG POPULATIONS, 2004–2015 (GANDA, 2016)



METRIC 3: PERCENT OF EGG MASSES OBSERVED TO SUCCESSFULLY INCUBATE

Baseline: The 12-year average for egg mass maturation in Little Carson and Big Carson creeks is estimated to be greater than 94% (GANDA 2005, 2006, 2007, 2009, 2011, 2013a, 2013b, and 2016). Egg mass maturation rates are indicative of in-stream conditions. Prior to the emergence of tadpoles, foothill yellow-legged frog egg masses are vulnerable to scouring caused by high flow events, predation by both native and non-native species, and human-caused disturbance to the in-stream cobble and gravel substrate on which the egg masses are anchored.

Condition Goals:

- More than 94% of egg masses reach maturation each year
- No egg masses are lost due to in-stream disturbance caused by maintenance work or recreational activities

Condition Thresholds:

- **Good:** Five-year running average maturation rate >90% and no egg masses lost due to human activity
- **Caution:** Five-year running average maturation rate between 80–90% and/or more than two egg masses lost due to human activity for two consecutive years
- **Significant Concern:** Five-year running average maturation rate <80% and/or consecutive years of four or more crushed egg masses

Current Condition: Good

The 12-year average for egg mass maturation is estimated to be greater than 94%.

Confidence: High

Surveys use a consistent technique and trained biologists so our confidence in these estimates is high.

Trend: No Change

The trend for this metric would switch from “No Change” to “Improving” with three consecutive years of no crushing, and from “No Change” to “Declining” with two consecutive years of two or more crushed egg masses.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

MMWD COMPREHENSIVE SURVEY OF MT. TAMALPAIS WATERSHED, 2003

In 2003, Garcia and Associates (GANDA) conducted foothill yellow-legged frog surveys on behalf of MMWD from April 7–23, 2003 at a number of sites according to the protocol outlined in Fellers & Freel (1985). They used binoculars to scan for frogs, and by slowly walking in the water or on adjacent banks to search for eggs, larvae, and adults. All detections of sensitive, listed, and common herpetofauna observed during surveys were recorded. Weather conditions (air temperature and wind speed) and water temperature were recorded. Fish presence was also recorded because of their potential indirect or direct effects on foothill yellow-legged frog populations. See GANDA (2003) for additional details about this monitoring project.

MMWD ANNUAL BREEDING SUCCESS MONITORING, 2004–PRESENT

GANDA conduct foothill yellow-legged frog surveys on behalf of MMWD at Big Carson Creek and two of its unnamed tributaries near Pine Mountain Road, and at Little Carson Creek near Kent Lake following methods described in Seltenrich & Pool (2002). They survey tributaries from the downstream end to the upstream end during all survey rounds. For each egg mass observed, a standard list of parameters are measured and recorded, including location; attachment substrate; distance from shore; depth of egg mass and maximum depth at the egg mass; velocity at the egg mass; surface velocity; microhabitat; stream substrate; water temperature; egg mass shape; egg mass color; egg mass size, and Gosner developmental stage (Gosner, 1960).

Although surveys focus on locating egg masses, they document all life stages of frogs (i.e., egg masses, tadpoles, juveniles and adults) encountered. Data collected for captured frogs included location; sex; snout-urostyle length (milimeters); weight (grams); condition (gravid or spent); activity; habitat and microhabitat type; and dominant substrate. A photograph of the chin taken of each frog captured from 2008–2015 was used to identify individual frogs by matching their unique patterns of mottling. They also record notes for any frogs with injuries or deformities. Uncaptured frogs are also noted and data collected to the extent possible. Surveyors attempt to remove any bullfrogs or crayfish encountered during these surveys. See GANDA (2013) for a complete description of this monitoring program and its findings.

NATIONAL PARK SERVICE AND CALIFORNIA STATE PARKS DETECTION SURVEYS, MUIR WOODS, 2013

An amphibian survey conducted in 2013 covered approximately 700 meters of creek near a planned project to replace the bridge on Bootjack Trail that spans Rattlesnake Creek, but did not find any foothill yellow-legged frogs. See Kleeman (2013) for a full project summary.

INFORMATION GAPS

Population Viability Analysis: Twelve years of consistent surveys in Big Carson Creek, its tributaries, and Little Carson Creek now provide time series data pertaining to foothill yellow-legged frogs at life stages from egg mass through breeding adult. There is sufficient data available for the development of a simplistic population model and viability analysis which would help land managers better refine recovery targets for reintroduction efforts in Redwood and Cataract creeks.

Range: Individual frogs can be identified by the unique pattern of markings on each frog's chin, enabling researchers to maintain annual records on individual frog's vigor, reproductive state, and location. Chin pattern analysis combined with mark and recapture studies indicate that there is very little movement between frogs at Big Carson and Little Carson creeks, suggesting that dispersal and gene flow between the two locations is limited (Marlow et al., 2016). However, the potential range for individual frogs is not known, which limits land managers' ability to identify steps to enhance gene flow and dispersal.

Habitat Requirements: While the habitat conditions in breeding pools needed for successful egg laying and tadpole maturation are reasonably well understood, less is known about foothill yellow-legged frog requirements at other life stages or for movement from one breeding site to another.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Management:

- A trail reroute and informational signs at Carson Falls in 2007 to reduce recreational impacts to breeding pools while increasing visitor safety and opportunities to observe frogs from a designated viewing area

- Annual removal of signal cray fish and bullfrogs in Little and Big Carson creeks during breeding session surveys

- Thinning the tree canopy at the Big Carson Creek road crossing in 2013 to promote breeding outside road crossings and minimize trampling potential

Outreach: A seasonal public education program at Carson Falls begun in 2005 to increase visitor awareness of the frogs and the need to stay out of breeding pools between February–June

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Reintroductions:**
    - Implement the priority actions identified within the completed feasibility study (GANDA, 2010) for reintroduction at Cataract Creek and White's Hill
    - Reintroduce into Cataract Creek while source populations in Big and Little Carson creeks are considered stable and eggs could be translocated to reintroduction sites or captive breeding facilities
    - Investigate Ink Wells at White Hill as potential additional reintroduction site

- **Predator Management:** Continue efforts to manage numbers of non-native predators, and consider expanding efforts to manage signal crayfish and bullfrogs known to occur in potentially suitable habitat in Cataract Creek (GANDA, 2010)

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CHAPTER 15. WESTERN POND TURTLE (*ACTINEMYS MARMORATA*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: No Change

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Western pond turtles are good indicators of freshwater aquatic conditions and, to some extent, terrestrial grassland conditions. In their aquatic habitat, they are vulnerable to predation and competition with invasive species. On land, breeding adults, nests, and hatchlings are vulnerable to habitat degradation and predation by overly abundant ravens, crows, skunks, and raccoons.

The western pond turtle is a California Department of Fish and Wildlife (CDFW) species of special concern and is considered vulnerable to climate change. The Marin Municipal Water District (MMWD) has been monitoring this species since 2004, and has implemented restoration and other protection measures for it in the One Tam area of focus. The National Park Service (NPS) also has western pond turtle inventory data from the One Tam area of focus from 1996 (Fong, 2002) and 2014–2015.

OVERALL CONDITION

Western pond turtle populations have declined dramatically throughout the State of California in recent decades. Historic population records and museum specimen collections have not been systematically reviewed for the One Tam area of focus, with the exception of Museum of Vertebrate Zoology (MVZ) and records compiled by Barbara Stein and also by Mark Jennings covering NPS lands (Museum of Vertebrate Zoology, 1999).

Anecdotal accounts from long-time residents report turtles from a large backdune pond at Stinson Beach that has since been filled and converted to a parking lot. The small numbers of western pond turtles at Muir Beach observed by consultants and researchers in the early 1990s (Philip Williams and Associates, Moss Landing Marine Laboratory, Smith, Northmore, Roberts and Associates, & Hornor, 1994; Ely, 1993 have disappeared (D. Fong, 2015, unpublished data). A 2003 survey conducted by Garcia and Associates on behalf of MMWD was not comprehensive. However, combined with several years of turtle trapping and five years of volunteer observations, there is some information for this species on MMWD lands.

Volunteer and biologists' observations between 2003–2016 were consistently low, regardless of the level of effort. The majority of western pond turtles observed were mature adults. Non-native turtles were observed far more frequently and these observations include more hatchlings and juveniles (Rogers & Ettlinger, 2015).

DESIRED CONDITIONS

The western pond turtle population in the One Tam area of focus should be stable or increasing with an age distribution that indicates successful reproduction and recruitment.

STRESSORS

Non-native and Unnaturally Abundant Predators: Non-native American bullfrogs (*Lithobates catesbeianus*) and bass (*Micropterus* spp.) prey on western pond turtles. Certain native predators such as skunks (*Spilogale* spp.), raccoons (*Procyon lotor*), ravens (*Corvus corax*), and crows (*Corvus brachyrhynchos*) thrive near human development and can reach higher than normal numbers in places like Marin County and the One Tam area of focus.

Competition: Red-eared sliders (*Trachemys scripta elegans*) and other non-native turtles in Mt. Tam's ponds and reservoirs may compete with western pond turtles for basking habitat or food (Garcia and Associates [GANDA], 2003. Large numbers of non-native turtle nests may also attract predators to western pond turtle nesting areas.

Habitat Modification: Western pond turtles can be killed when crossing roads as they travel between aquatic habitats or when migrating to nesting sites.

Climate Change: Temperature increases and/or changes in precipitation patterns as a result of climate change could affect the streams and small ponds that this species depends upon.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: HABITAT OCCUPANCY (LAKES, PONDS, STREAMS, FRESHWATER MARSHES) IN CURRENT VERSUS HISTORICALLY OCCUPIED WATER BODIES

Baseline: A 2003 survey of MMWD lands found western pond turtles in Phoenix, Lagunitas, and Alpine lakes and in Bon Tempe Creek (GANDA, 2003). One of three Olema Valley ponds has an extant record (NPS, 2015, unpublished data). There are anecdotal historic observations at Stinson Beach, and both historic observations and archeological remains at Redwood Creek at Muir Beach, but no current observations (NPS, 2015, unpublished data). A California Academy of Sciences museum specimen from an undefined San Anselmo locality was lost in the 1906 earthquake and fire.

Condition Goal: Proportion of sites occupied by western pond turtles is similar or higher than historic conditions

Condition Thresholds:

- **Good:** All sites in the One Tam area of focus with historic pond turtle occupancy continue to be occupied

- **Caution:** Pond turtles are no longer present at one previously occupied site, or at multiple sites separated by less than two miles

- **Significant Concern:** Pond turtles are no longer present at multiple, distant, previously occupied sites

Current Condition: Caution

Occupancy of the lone Olema Valley pond within the One Tam area of focus is unchanged. Occupancy of MMWD lakes appears stable, while the Redwood Creek population has disappeared (D. Fong, personal communication).

Confidence: High

Multiple data sources support the above habitat occupancy assessments.

Trend: No Change

Sites on MMWD lands occupied in 2003 and in Olema Valley continue to be occupied, but western pond turtles have disappeared from the Redwood Creek Watershed (D. Fong, personal communication).

METRIC 2: ABUNDANCE

Baseline: A 2003 MMWD survey captured, marked, and released 30 western pond turtles (GANDA, 2003).

Condition Goal: Population numbers increasing or stable against the baseline

Condition Thresholds:

- **Good:** Three-year average number of pond turtles observed at the sites surveyed in 2003 is at least 30
- **Caution:** Three-year average number of pond turtles observed at the sites surveyed in 2003 is between 20–29
- **Significant Concern:** Three-year average number of pond turtles observed at the sites surveyed in 2003 is below 20

Current Condition: Good

Where present, western pond turtle captures and observations have remained low but fairly consistent between 2003–2015, regardless of the level of effort (Figure 15.1). The age structure of the MMWD population appears stable and indicates ongoing recruitment (internal MMWD data).

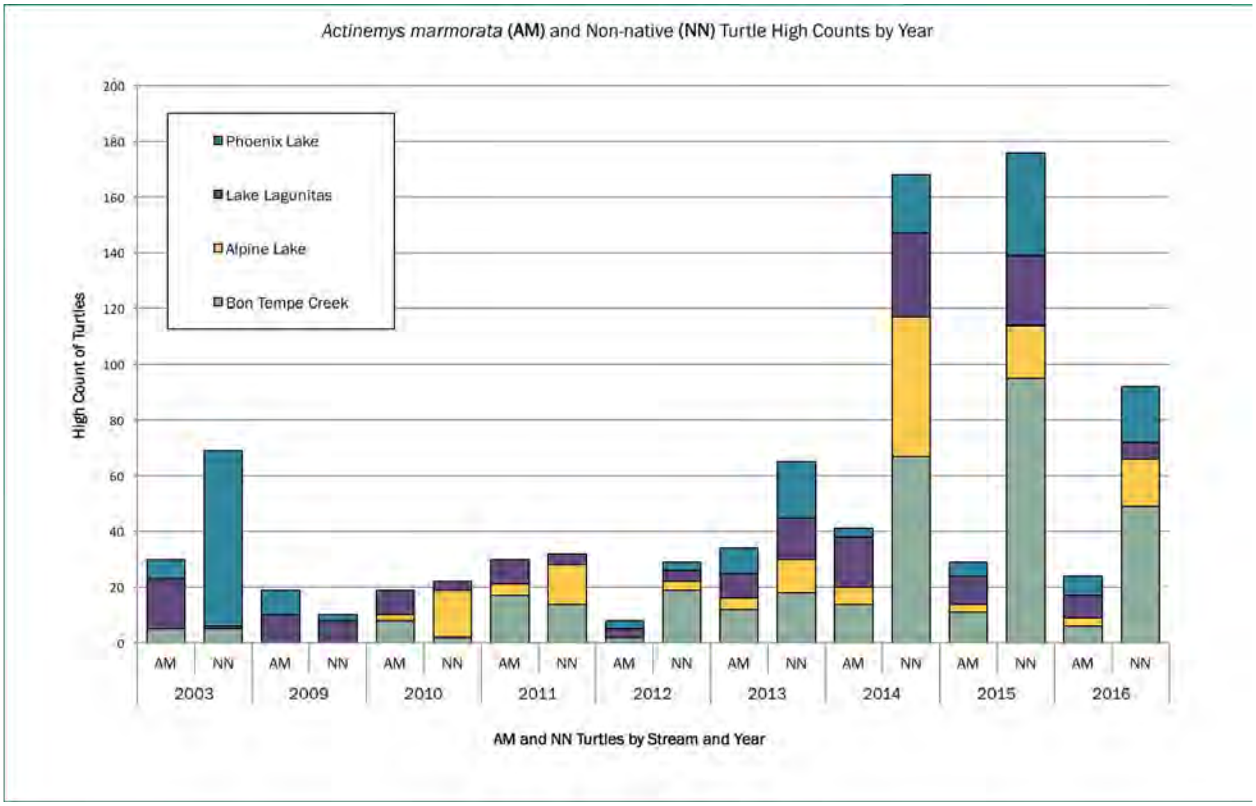
Confidence: High

Long-term monitoring has yielded consistent counts between 2003–2015, regardless of the level of effort.

Trend: No Change

Western pond turtle captures and observations have remained low but fairly consistent between 2003–2015 regardless of the level of effort (Hossfeld & Ettlinger, 2016).

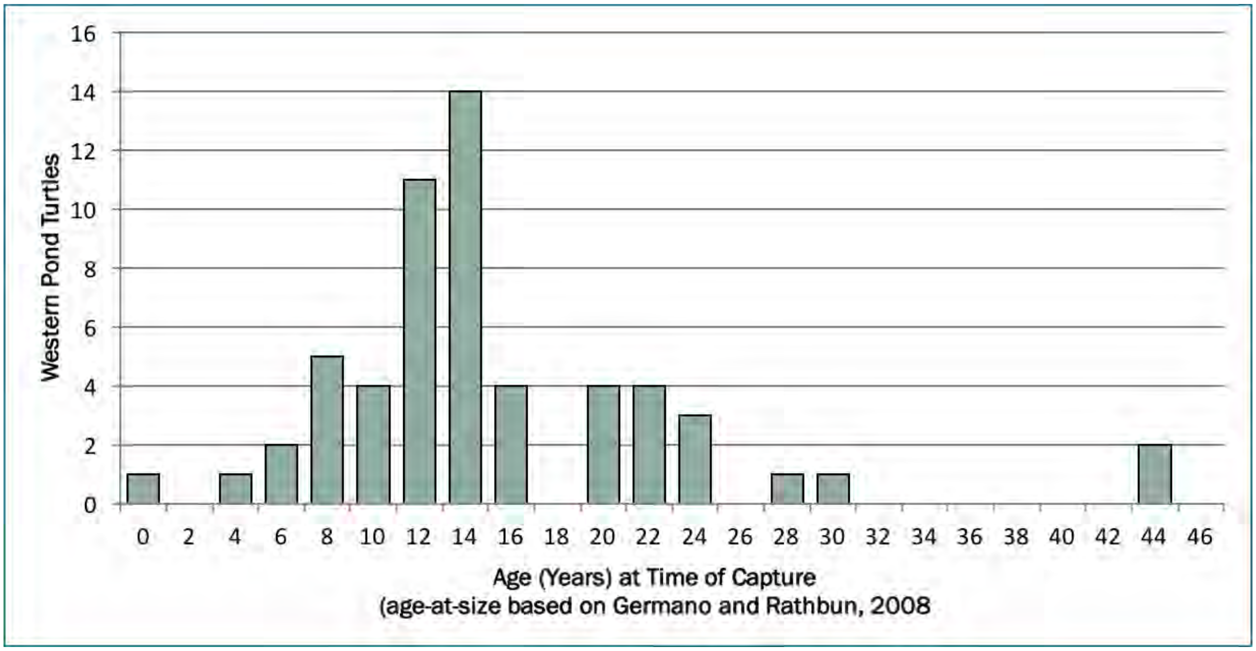
FIGURE 15.1 WESTERN POND TURTLE AND NON-NATIVE TURTLE COUNTS AT MMWD SITES (HOSSFELD & ETTLINGER, 2016)



METRIC 3: AGE STRUCTURE

Baseline: The age structure for western pond turtles in MMWD reservoirs was assessed in 2016 based on size data collected between 2003–2016 (Hossfeld & Ettlinger, 2016). Ages were estimated based on published age and size data for western pond turtles in central California (Germano & Rathbun, 2008). Low numbers of turtles less than 10 years old have been documented in most years.

FIGURE 15.2 WESTERN POND TURTLE AGE DISTRIBUTION IN MMWD RESERVOIRS (HOSSFELD & ETTLINGER, 2016)



Condition Goals:

- Conduct research into the reproductive success and early life stage survival of western pond turtles in MMWD reservoirs
- Determine whether management action is needed to increase the rate of recruitment

Condition Thresholds:

- **Good:** Western pond turtles less than 10 years old have been documented in MMWD reservoirs in the last five years
- **Caution:** Western pond turtles less than 10 years old have been documented in MMWD reservoirs in the last ten years
- **Significant Concern:** Western pond turtles less than 10 years old have not been documented in MMWD reservoirs in the last 10 years

Current Condition: Good

The youngest western pond turtle captured in MMWD reservoirs in 2016 was estimated to be five years old (Hossfeld & Ettlinger, 2016).

Confidence: Moderate

Trapping methods may under-sample small pond turtles and be ineffective at sampling hatchlings.

Trend: No Change

Young turtles less than 10 years old have been captured in most survey years. The MMWD western pond turtle population appears stable, indicating some level of recruitment (Hossfeld & Ettlinger, 2016).

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

MMWD SURVEY OF MT. TAMALPAIS WATERSHED IN 2003

We conducted a habitat characterization in April and August 2003 at the Alpine Lake, Bon Tempe Creek, Bon Tempe Reservoir, Lake Lagunitas, and Phoenix Lake study sites. The project included:

- Documenting key characteristics of the western pond turtle habitat to create a map showing essential habitat areas for hatchlings, juveniles, and adults (e.g., aquatic habitat, basking areas, and potential nesting areas)
- An assessment of known western pond turtle population size and distribution within the region
- A population study of western pond turtles and non-native turtle species using collected mark-recapture data through repeated trapping and release of marked turtles

See GANDA (2003) for a full description of study methodology and results.

MMWD IRREGULAR MARK AND RELEASE EFFORTS BETWEEN 2004–2016

Turtle trapping has been conducted irregularly in MMWD reservoirs with the primary objective of removing non-native turtles. Western pond turtles were also captured, measured, marked, and released. These surveys provide some indication of population sizes in each reservoir, age estimates, and sex ratios (Ettlinger, 2016).

MMWD VOLUNTEER TURTLE OBSERVER PROGRAM

Since 2010, trained volunteers have visited the dam and shoreline of Lake Lagunitas, the shoreline of Alpine Lake along Bullfrog Trail, Alpine Lake below Bon Tempe Dam, and the shoreline of Phoenix Lake. The volunteers observe turtles anywhere from 30 minutes to three-and-a-half hours at a given location and record age, date, time interval, weather, and a series of qualitative observations about each turtle’s appearance and behavior.

See Rogers & Ettlinger (2015) for a full description of volunteer monitoring methodology and results.

TURTLE INVENTORIES CONDUCTED ON NPS LANDS (1996, 2014–PRESENT)

The first systematic surveys were conducted as part of a general herpetological inventory of the Golden Gate National Recreation Area using visual encounter methods by contract herpetologist Ed Ely in 1993. Turtle surveys were also conducted in 1996 using baited traps and visual encounter methods. More recently, visual surveys have been repeated in 2015–2016 in Olema and Redwood Creek watersheds within the One Tam area of focus (NPS, 2016, unpublished data).

INFORMATION GAPS

Population Drivers: We do not know enough about factors such as egg and hatchling predation rates that affect western pond turtle abundance, survival, and recruitment. The root cause of the decline and loss of western pond turtles from Muir Beach area is also not known. Additional research on the influence of local coastal climatic conditions on breeding ecology is also needed.

Demographics: Data are lacking on age and size structure composition of sustainable western pond turtle populations in coastal California.

Surveys: Some presence/absence surveys of historic populations were not covered by the 2003 MMWD surveys.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration: Stream and wetland restoration and enhancement activities in the Muir Beach vicinity from 2006–present

Management:

- Red-eared slider removal in 2004, 2005, 2014, 2015, and 2016
- Nest site protection measures and exclusion fencing in the Phoenix Lake area in 2009 and 2010
- Basking habitat enhancements (log installations) in Phoenix Lake and Lake Lagunitas (multiple years between 2004–present)

Monitoring and Surveys:

- Habitat and population survey in 2003
- Irregular mark and release efforts between 2004–2016
- Periodic turtle trapping to remove non-native turtles and to provide some data on western pond turtle population sizes, age estimates, and sex ratios in each reservoir
- Volunteer turtle observer program to collect age, date, time interval, weather, and a series of qualitative observations about each turtle's appearance and behavior
- Turtle inventories in 1996 and 2014–present (NPS)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and

will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Western Pond Turtle Nursery Areas:** Create a nursery area where non-native fish are excluded to prevent them from eating young turtles (MMWD)

- **Reintroduction:** Reintroduce western pond turtles at appropriate sites at Muir Beach (NPS)

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CHAPTER 16. BIRDS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

ALL BIRDS

Condition: Good

Trend: No Change

Confidence: High

OAK WOODLAND BIRDS

Condition: Good

Trend: No Change

Confidence: High

CONIFER FOREST–MIXED HARDWOOD FOREST BIRDS

Condition: Good

Trend: Improving

Confidence: High

GRASSLAND BIRDS

Condition: Unknown

Trend: Unknown

Confidence: Unknown

SCRUB AND CHAPARRAL BIRDS

Condition: Good

Trend: No Change

Confidence: High

RIPARIAN BIRDS

Condition: Good

Trend: No Change

Confidence: High

CLIMATE CHANGE VULNERABLE BIRDS

Condition: Good

Trend: No Change

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Birds are recognized as indicators of ecological change (Carignan & Villard, 2002). They provide a wide variety of ecosystem services including devouring pests, pollinating flowers, dispersing seeds, scavenging carrion, cycling nutrients, and modifying the environment in ways that benefit other species (Whelan et al., 2015).

Agencies within the One Tam area of focus have a relatively long history of bird monitoring, enabling estimates of population trends for multiple species in multiple vegetation communities (see Bird Species of Mt. Tam in Appendix 9). Birds are also a highly visible resource with a great deal of public interest attracting many bird watchers to the One Tam region and delighting regular visitors and residents. Their songs and behavior (e.g., long distance migration) also inspire great interest. Bird watching can also have significant positive impacts on local to national economies (Carver, 2013).

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: TREND IN ABUNDANCE

Baseline: Baselines are the abundance in the year of the initial survey. Hence, for Marin Municipal Water District (MMWD) lands, the year is 1996 (Cormier et al., 2014). For National Park Service (NPS) Golden Gate National Recreation Area lands, it is 1997 (Gardali & Geupel, 1997), and 2001 for just riparian areas (Humple & Porzig, 2012). For the Marin County Parks (MCP), it is 2009 (Gardali et al., 2010), and for the Northern Spotted Owl, it is 1999 (Ellis et al., 2013; Cormier, 2015). Baselines will need to be established for species not well sampled by these efforts (e.g., raptors, waterbirds).

Condition Goal: Stable or increasing populations over the next five years

We acknowledge that environmental change, and in particular climate change, complicates setting static long-term goals. Hence, we judged a short-term goal of five years to be reasonable. Species will likely be moving in response to climate change (Stralberg et al., 2009), and as such, expectations that abundance for all species should be stable or increasing is not realistic. However, maintaining conditions with the goal of stable or increasing populations may benefit species with distributions that are likely to be reduced. For example, sufficient population size and fitness are likely to be important components of a species' ability to track environmental change (Williams et al., 2008).

Current Condition: Bird species were aggregated to reach a summarized current status for individuals sharing similar traits, as well as overall.

Individual species condition statuses were summarized from the species traits-status database (see below). A subset of bird species was selected, such as birds that had scored "yes" on climate vulnerability. To determine the combined condition, each "Good" scored 100, each "Caution" scored 50, and each "Significant Concern" scored 0. Any species with an "Unknown" condition were omitted from the summary. The combined score was averaged, and then set against the following scale:

- **Significant Concern:** 0–25
- **Caution:** 26–74
- **Good:** 75–100

Confidence: Bird species were aggregated to reach a summarized confidence level for individuals sharing similar traits, as well as overall.

Individual species confidence levels were summarized from the species traits-status database (see below). A desired subset of bird species was selected. To determine the combined confidence level of the combined condition, each "High" scored 100, each "Moderate" scored 50, and each "Low" scored 0. Any species with an "Unknown" condition were omitted from the summary. It was assumed that if a bird had been given a condition status, that the confidence level in that status would at least be Low, (i.e., it could not be "Unknown"). The combined score was averaged, and then set against the following scale:

- **Low:** 0–25
- **Moderate:** 26–74
- **High:** 75–100

Trend: Bird species were aggregated to reach a summarized trend for the condition of individuals sharing similar traits, as well as overall.

Individual species condition statuses were summarized from the species traits-status database (see below). A desired subset of bird species was selected. To determine the overall trend, the number of species with a "Declining" trend was subtracted from the number of species with an "Improving" trend. The resultant score was set against the following scale:

- **Improving:** +2 or higher
- **No Change (stable):** -2 to +2
- **Declining:** -2 or lower

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

DATABASE APPROACH

We developed a species trait-status database in order to provide a flexible approach to assess the condition and status of bird populations in the One Tam area of focus. For example, all species were evaluated based on the same criteria, ranging from life history characteristics, predicted vulnerability to climate change, and known stressors. We chose to use a flexible approach given the many useful ways data on multiple species of birds could be summarized. For example, the database allows users to summarize information for groups of birds depending on their affiliation to vegetation communities, or by their vulnerability to climate change.

How We Identified Species to Include: Based on his local knowledge and expertise in avian conservation planning in California (e.g., Shuford & Gardali, 2008), Thomas Gardali of Point Blue Conservation Science (Point Blue) developed the first draft of species for inclusion in this assessment. This draft was vetted and improved during the workshop held on February 5, 2016 (see end of this chapter for list of participants).

The 57 species were ultimately included and the full database can be viewed here: *docs.google.com/spreadsheets/d/1LzdDeDBdiodylxThUBKkZEMbuBfJ9FcjZS-dyct7eus/edit?usp=sharing*

What We Included in the Database: The Health of Mt. Tam's Natural Resources Advisory Committee discussed the different types of information that would be desirable to capture in the species trait-status database and ultimately ended up with 27 fields (Table 16.1). These fields captured general life history information (e.g., habitat affinity), regulatory status, whether the species is iconic, threat and risk factors (e.g., climate vulnerability, sensitivity to disturbance), the condition, confidence, and trend, and finally the types of data available (e.g., abundance) and how many agencies have those data in-hand (Table 16.1).

For each field a specific data description was drafted and a standard set of data options were provided as a menu choice (Table 16.1).

Populating the Database: Four biologists with local expertise on bird ecology and conservation populated the database. These biologists were Thomas Gardali and Renée Cormier (Point Blue Conservation Science), Allen Fish (Golden Gate Raptor Observatory), and Bill Merkle (NPS).

Life History data: The primary sources used included Shuford (1993), Rodewald (2015), and expert opinion.

Regulatory Status: State and federal threatened and endangered status lists were consulted as well as the California Department of Fish and Wildlife's Bird species of special concern (Shuford & Gardali, 2008).

Iconic: We used the definition developed by Gardali et al. (2011). Although the definition provides guidance, this category was subjective and hence reflected the opinion of the scoring biologist.

Threats and Risk Factors: The primary sources used included Shuford (1993), Rodewald (2015), and expert opinion. Biologists attempted to identify the top imminent or likely threats to each species, rather than selecting the full suite of threats and risk factors for every species. For climate change vulnerability we used Gardali et al. (2012) and the online probability of occurrence models (*data.prbo.org/cadc/tools/ccweb2/index.php*). We visually compared contemporary occurrence with two climate change futures, based on two different climate models, and when the probability was predicted to decline, we considered the species vulnerable.

Condition, Confidence, and Trend: Information for the majority of assessed species came from one source which only covered lands owned and managed by MMWD (Cormier et al., 2014). We also consulted Humple & Porzig (2012) for some riparian associated species within the One Tam area of focus. These two sources evaluated trends in abundance for individual species. For wider-ranging species such as diurnal raptors, we also consulted migration counts from the Marin Headlands

(Golden Gate Raptor Observatory, unpublished data), and Christmas Bird Count data (National Audubon Society) for southern Marin County (*netapp.audubon.org/CBCObservation/Historical/ResultsByCount.aspx*).

A “Good” designation was given if a species was stable or increasing, “Caution” when trends were mixed, “Significant Concern” when there were clear declines indicated, and “Unknown” when trend data were not available. When Cormier et al. (2014) or Humple and Porzig (2012) could estimate a trend, we considered the confidence “High,” when they both estimate a trend but the results were mixed the confidence was “Moderate,” and when no trend was estimated confidence was “Unknown.” A “Low” confidence designation was given if any useful regional trend data were lacking. Trend was simply the direction of the data as “Improving,” “No Change,” “Declining,” or “Unknown.”

Data Availability: For three types of data, the scoring biologist simply listed the number of agencies where data have been collected and are available based on their knowledge of work in the One Tam area of focus. In many cases, data exist for multiple agencies but the time series of data, which is needed for this assessment, is not noted.

TABLE 16.1 DATA DICTIONARY OUTLINING THE FIELD HEADINGS, FIELD DESCRIPTIONS, AND VALID VALUES FOR THE BIRD SPECIES TRAITS-STATUS DATABASE

Data Type	Description	Menu Options
Life History		
Primary affiliation	This is the vegetation affiliation most strongly associated with the focal species	Open-canopy oak woodland, Closed canopy forest (mixed), Conifers, Grassland, Riparian, Tidal marsh, Scrub/chaparral, Serpentine barrens, Sargent cypress, Lakes, Springs/seeps and wet meadows
Secondary affiliation	This is a vegetation affiliation associated with the focal species	
Does species use three or more vegetation types?	If the species associates with three or more vegetation types it is regarded as a generalist	Yes, No
Trophic level/diet	What main role does the species play within its ecosystem	Carnivore, Insectivore, Omnivore, Piscivore, Granivore, Detritivore/decomposer, Herbivore, Primary producer
Reproduction-specific or habitat requirement	Only the most important to a species should be chosen	Tree/snag cavity, Wetland/aquatic, Ground nester, Shrub nester, Canopy nester, Subterranean nest/den/burrow, Fire
Landscape requirement	What size home range does the species require to carry out all necessary life functions	Small area required, Large area required, Beyond Mt. Tam
Regulatory Status		
Current regulatory or other special status	Which conservation list does the species currently appear on	Federal Threatened and Endangered, State Threatened and Endangered, California Rare Plant Ranks list, Global Natural Conservation (NatureServe) rank, California Department of Fish and Wildlife Species of Special Concern, Other, None

Data Type	Description	Menu Options
Iconic		
Iconic	Does the species fit one of the following categories: ▪ Charismatic to local cultural perspectives ▪ Current status is likely to draw broad attention or concern ▪ Emblematic of a local habitat or region ▪ Widely-recognized by the public, and/or its name refers to a locality within the One Tam area of focus	Yes, No
Threats and Risk Factors		
Climate change vulnerable?	Is the local species population particularly vulnerable to likely changes in the climate within the Mt. Tam area of focus? Vulnerability is a measure of the susceptibility or amount of risk of a population to negative impacts. We define climate vulnerability as the amount of evidence that climate change will negatively impact a population. Consideration should be given to intrinsic traits (such as physiological tolerances) of species that make them vulnerable and extrinsic factors (such as increasing temperatures or habitat loss) that will result from climate change. For example, a species that is highly sensitive to increasing temperature would be more vulnerable if the magnitude of climate change is larger within that species' geographic range than the same species would be if the magnitude of climate change for its range was smaller.	Yes, No, Unlikely, Unknown
Highly restricted distribution	The level of endemism for species with a restricted distribution (or select Not restricted)	Mt. Tam only, Marin Only, Regional only, Locally rare, Not restricted
Mechanical disturbance	Is the local species population particularly sensitive to disturbance from mechanical processes, such as grass cutting, brush cutting, fuelbreak maintenance, etc.	Yes, No
Invasive species	Is the local species population particularly vulnerable to threats from invasive species	Yes, No
Disease	Is the species particularly sensitive to threats from disease	Yes, No
Fire regime change	Is the species particularly vulnerable to threats from a significant change in fire regime than what is considered natural (including increase and decrease in fire)	Yes, No
Pollution (air, water, noise)	Is the species particularly sensitive to threats from pollutants such as noise, water pollution, air pollution, etc.	Yes, No
Compaction or trampling	Is the species particularly sensitive to threats from trampling/disturbance or ground compaction	Yes, No
Human presence	Is the local species population particularly	Yes, No

Data Type	Description	Menu Options
	sensitive by its proximity to human presence	
Drought	Is the local species population particularly sensitive to threats caused by drought-related issues	Yes, No
Pesticides or rodenticides	Is the local species population particularly sensitive to the threats caused by pesticides, herbicides or rodenticides	Yes, No
Habitat loss and fragmentation	Is the local species population particularly sensitive to the effects of reduced habitat or reduced habitat connectivity	Yes, No
Trophic level disruptions	Is the local species population particularly sensitive to changes in its ecosystem trophic levels, beyond what is considered natural, such as changes in availability of preferred prey or increased predation by natural predators	Yes, No
Condition, Confidence, and Trend		
Condition	The current condition of the focal species based on its metric: Good - stable or increasing. Caution - mixed trends. Significant Concern - declining. Unknown - not enough information to state condition	Good, Caution, Significant Concern, Unknown
Confidence	The level of confidence when returning the confidence and trend statement	High, Moderate, Low, Unknown
Trend	The change in condition of the focal species based on current versus previous measure(s); independent of status (e.g., a resource may be Declining but still be in Good condition). Improving - The condition is getting better. No Change - The condition is unchanging. Declining - The condition is deteriorating/getting worse. Unknown - Not enough information to state trend.	Improving, No Change, Declining, Unknown
Data Availability		
Presence/absence	How many One Tam agencies have presence/absence data for this species	1 Agency, 2 agencies, 3 agencies, All agencies, Not available
Abundance	How many One Tam agencies have abundance data for this species	
Reproductive success	How many One Tam agencies have reproductive success data for this species	

INFORMATION GAPS

By Vegetation Community: We were unable to estimate trends for grassland associated birds. This is likely because the data are primarily from MMWD lands of which grassland acreage is low, and because grassland birds naturally occur in relatively low densities.

By Land Ownership: While inventory surveys (a single year) exist for MCP (Gardali et al., 2010) and the National Park Service (e.g., Gardali & Geupel, 1997; Gardali et al., 1999; Humple & Gardali, 2006), only MMWD has time series data sufficient for trend assessment. Hence, trends from the NPS (aside from riparian associated species in Humple & Porzig, 2012) and MCP are unknown.

By Season: The One Tam area of focus has a diverse wintering bird community, many species of which are present for six or more months. The winter season is a critical part of their annual cycle and conditions on the wintering grounds impact population trends. Minimal information exists for wintering bird populations (but see Audubon's Christmas Bird Count; *audubon.org/conservation/science/christmas-bird-count*). Additionally, the One Tam area of focus provides important resources for migrating birds that stopover briefly during spring and fall seasons. Currently, trends for birds during migration are only available from riparian areas on NPS lands (Humple & Porzig, 2012).

Demography: Understanding trends in abundance is crucial to conserving birds. However, population demographic data (e.g., survival, reproductive success) provide additional insight into observed trends in abundance. We have indices for reproduction from banding data on NPS lands in riparian habitat (Humple & Porzig, 2012), but data for most species and other lands is lacking.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration: Over 15 years of invasive plant removal and revegetation in the Redwood Creek Watershed

Monitoring: Ongoing monitoring to periodically assess population trends (NPS [Redwood Creek Watershed] and MMWD/Point Blue)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Inventory and Monitoring:

- **Time-Series Bird Monitoring Throughout the One Tam Area of Focus:** Expand the MMWD monitoring program onto NPS, State Parks, and MCP to better assess trends in health on a mountain-wide scale, regardless of jurisdictional differences regarding approaches to vegetation management or recreational access; Special attention should be given to grasslands and coast scrub, which lack adequate data to determine status and trend of associated bird species

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CHAPTER 17. NORTHERN SPOTTED OWLS (*STRIX OCCIDENTALIS CAURINA*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: No Change

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Iconic and charismatic Northern Spotted Owls are good indicators of Marin County's forest health, as their success depends on the presence of diverse, robust evergreen forest ecosystems in this area. Northern Spotted Owls are important upper-level predators that feed on a variety of rodents, especially dusky-footed woodrats (*Neotoma fuscipes*).

One Tam land management agencies have a wealth of inventory and long-term monitoring data on this species covering most of Marin County. Data on long-term trends in Northern Spotted Owl territory occupancy, reproductive success, and nesting habitat preferences help managers track population trends, avoid nesting season disturbances, and evaluate the impacts of potential threats including encroaching Barred Owls (*S. varia*), Sudden Oak Death (SOD), and climate change.

OVERALL CONDITION

The Northern Spotted Owl was listed as federally threatened in 1990 under the Endangered Species Act and also as threatened under the California Endangered Species Act in 2016. Northern Spotted Owl numbers appear to be dramatically decreasing across their range, which extends from southern British Columbia to Marin County, California (Dugger et al., 2016). In contrast, Marin's Northern Spotted Owl population appears stable (Ellis, 2016; Cormier, 2015).

California Northern Spotted Owl demographic monitoring sites, Green Diamond Resource Company, Hoopa Tribe Reservation, and Northwest California, are all located in the northwest coastal portion of the state (Dugger et al., 2016). In general, these sites show patterns of declining territory occupancy, with probability of occupancy dropping from around 0.8–0.9 in the mid-1990s–2000 to closer to 0.6 in 2016. Estimated mean rates of population change were all below 1.0, indicating declines, except for the Green Diamond Reserve site where Barred Owl removal was occurring. Barred Owls were shown to have a dramatic effect on territory extinction rates across all demographic monitoring sites.

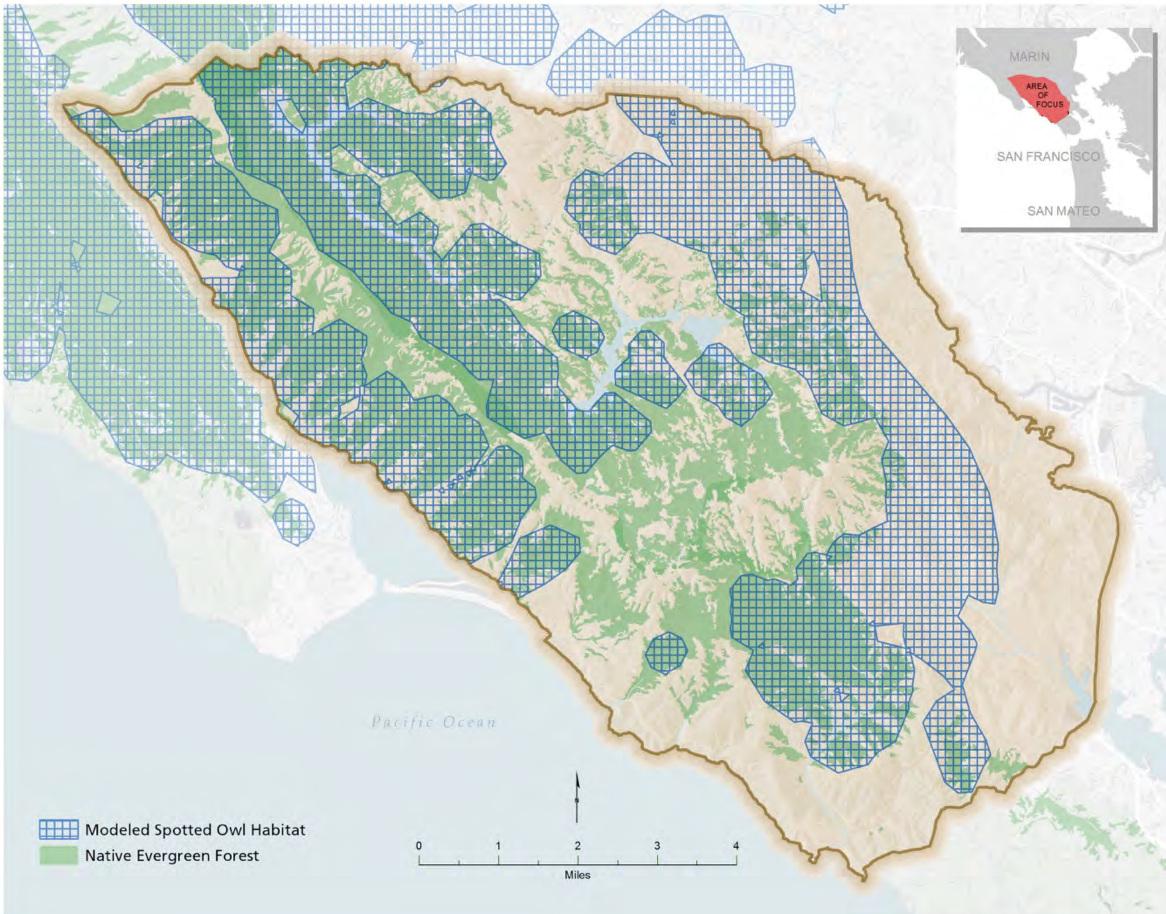
Mendocino Redwood Company (MRC) manages 229,000 acres of forests mainly in Mendocino County, with a small acreage in Sonoma County, encompassing approximately 160 Northern Spotted Owl territories (Mendocino Redwood Company [MRC], 2016). Territory occupancy has ranged from 0.54–0.85 and averaged 0.68 from 2000–2015. Occupancy in 2015 was the lowest during this period at 0.54. However, low territory occupancy was also recorded in 2003 at 0.58 and 2009 at 0.56. Fecundity has been variable, but ranged from about 0.05–0.5 from 1989–2015. There appears to be a slight decline in fecundity over this time period, with the absence of high fecundity years after 2009. Of significant note has been a sharp increase in the number of Northern Spotted Owl territories with Barred Owl detections, which jumped from four sites in 2009 to 22 in 2010 and peaked at 47 in 2013. This does provide evidence of a marked increase in Barred Owl detections in forests only about 120 kilometers north of Mt. Tam.

Marin County's Northern Spotted Owls are unique in their isolation from these Northern Spotted Owl populations to the north (Barrowclough et al., 2005) and by their relatively high density and fecundity. Genetic work indicates that they have some unique haplotypes and that there is more gene flow out of the population than coming in (Henke et al., 2003). They have also only recently been impacted by Barred Owls (Jennings et al., 2011; Ellis, 2016). On Mt. Tam, Northern Spotted Owls occur at high densities in native evergreen forests, most with some conifer component (Figure 17.1; Ellis, 2016; Cormier, 2015).

Annual monitoring of Northern Spotted Owls in Marin County has been conducted since 1999, with the National Park Service (NPS) covering federal and California State Parks (State Parks) lands and Point Blue Conservation Science (Point Blue) monitoring on Marin Municipal Water District (MMWD) and Marin County Park (MCP) property and adjacent land. Long-term NPS monitoring is designed to cover a series of randomly selected sites (Press et al., 2011), 36 of which are currently monitored, with additional management sites added as necessary.

Similarly, Point Blue annually monitors a set of historically occupied territories on behalf of MMWD and MCP, with the episodic addition of other suitable habitat that may be affected by management actions in the foreseeable future. Thirty such sites were monitored in 2015 (Cormier, 2015). Both NPS and Point Blue follow standard U.S. Fish and Wildlife Service (USFWS) protocols for determining nesting status (Press, 2010; USFWS, 2012; Cormier, 2015). The pooled monitoring of Marin County Northern Spotted Owls represents a sample that is not completely randomly determined. However, in some years it covers close to two-thirds of the known Marin County population and we do not see clear differences in the NPS compared to Point Blue data sets, indicating that these pooled data are a good representation of the range of Northern Spotted Owl habitat and landscape conditions for the Mt. Tam area of focus. These current monitoring efforts on and around the mountain indicate that Northern Spotted Owl territory occupancy is high and relatively steady, and that their fecundity is variable (Cormier, 2015; Ellis, 2016).

FIGURE 17.1 POTENTIAL SUITABLE NORTHERN SPOTTED OWL HABITAT IN THE ONE TAM AREA OF FOCUS (BASED ON STRALBERG ET AL., 2009)



DESIRED CONDITIONS

A healthy population of Northern Spotted Owls on Mt. Tam would remain stable or increase over time. Additionally, existing high levels of pair occupancy and fecundity are maintained within the observed normal range of variability, or above long-term average values based on monitoring data. Lastly, the threat from Barred Owls would remain low.

STRESSORS

Barred Owls: This eastern American species has expanded its range westward into the Pacific Northwest, and more recently southward into California, including Muir Woods in 2002 (Jennings et al., 2011). Researchers have found that Barred Owls negatively impact Northern Spotted Owl reproduction and survival, as they are slightly larger, are more aggressive and eat a wider range of prey (USFWS, 2011; Wiens, 2014; Dugger et al., 2016). Although ongoing monitoring has not resulted in any Barred Owl detections in Marin County since 2015, managers will continue to check for their presence (Ellis, 2016).

Habitat Loss: In Marin County, Northern Spotted Owls live in a mix of forest types, including Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), and even hardwoods like California bay (*Umbellularia californica*) and oaks. Though much of their habitat here is on protected lands, Northern Spotted Owls will nest in areas of relatively high recreational use and residential areas, and habitat protections have been important in maintaining habitat quality. Because some Northern Spotted Owl pairs nest adjacent to residential areas, development of private lots can also be a concern.

Sudden Oak Death (SOD): This disease, caused by the water mold *Phytophthora ramorum*, affects many species of native trees in the One Tam area of focus. Widespread die-off of oak trees and understory species such as tan oak as a result of SOD is dramatically changing the structure of forests where Northern Spotted Owls live (Figure 17.1), which could have positive or negative impacts on the birds. Research conducted in Marin County demonstrated a decrease in dusky-footed woodrat abundance with increasing SOD disturbance, likely because the woodrats use oaks for food and shelter (Swei et al., 2011). On the other hand, the opening up of the forest understory may make it easier for Northern Spotted Owls to hunt.

Climate Change: Results from climate change models are mixed for Northern Spotted Owls. Bird distribution models developed by Point Blue show an increase in potential Northern Spotted Owl distribution in the future (Point Blue Conservation Science, 2016). In addition, they were not identified as an at-risk species in a vulnerability assessment of California birds (Gardali et al., 2012). However, Glenn et al. (2011) found that warmer, wetter winters and hotter, drier summers—as some models predict for this area—negatively affect Northern Spotted Owl survival at six study areas in Oregon and Washington. Northern Spotted Owl habitat in Marin County is different than the habitat farther north, and the primary prey species, the dusky-footed woodrat, is different than the prey in Oregon and Washington. Other potential climate impacts to Northern Spotted Owls in Marin County include drought, catastrophic fire, or more frequent large storms.

Noise and Disturbance: Disturbance from recreational use, trail construction and maintenance projects, and other human activities can detrimentally affect Northern Spotted Owls during their February–July breeding season. Ongoing Northern Spotted Owl monitoring tracks nest locations to help managers avoid disruptive activities near nests on public lands. However, public knowledge of Northern Spotted Owl noise regulations in residential areas is sporadic, so owls in these areas are particularly at risk to disturbance.

Rodenticides: Northern Spotted Owls are at risk of potentially deadly rodenticide exposure, especially where they live adjacent to residential areas.

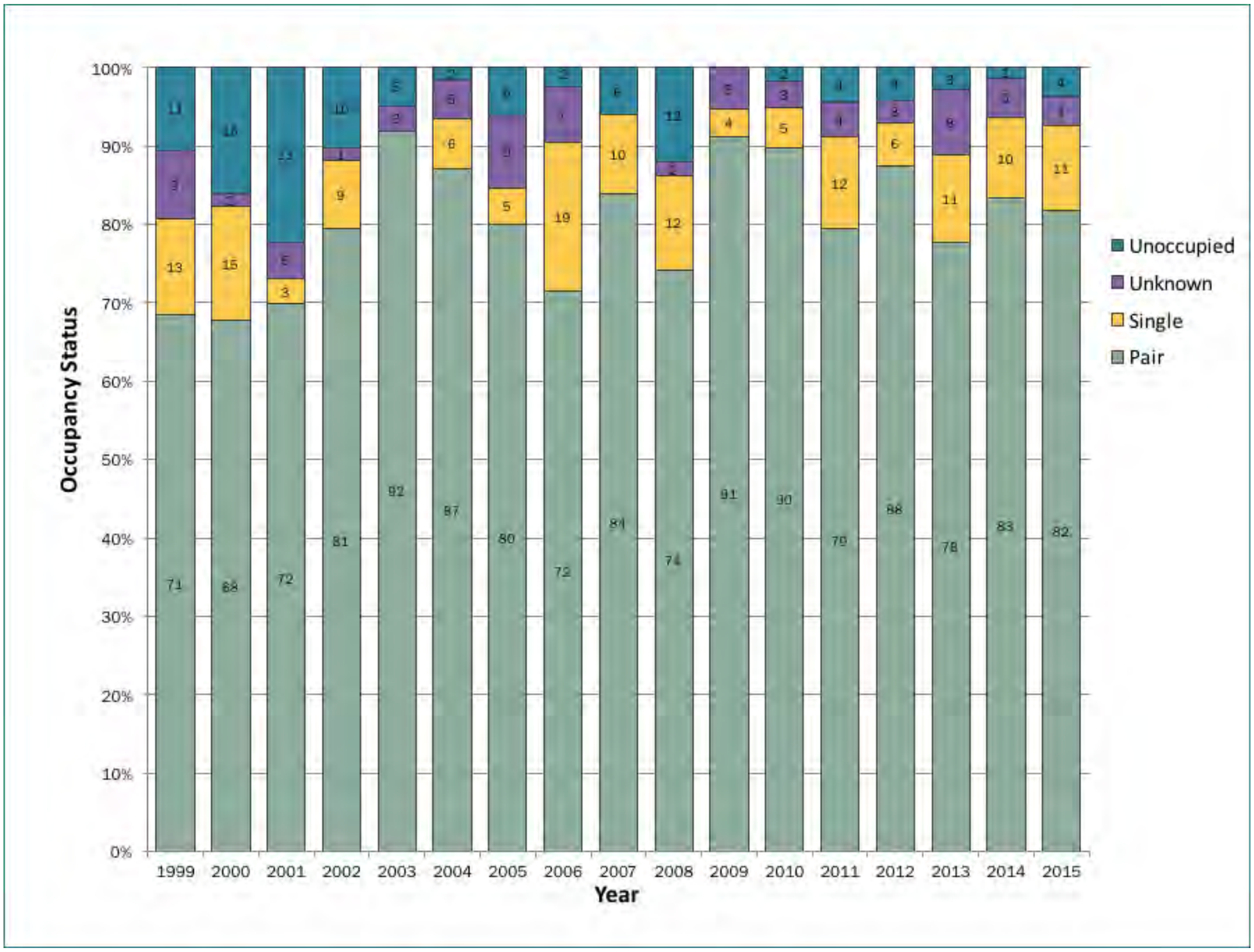
CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: PAIR TERRITORY OCCUPANCY

Baseline: The NPS, State Parks, MCP, and MMWD in partnership with Point Blue Conservation Science have monitored Northern Spotted Owls in Marin County since 1999 using established USFWS protocols. Monitoring has shown average of 81% of potential territories were occupied by Northern Spotted Owl pairs between 1999–2015 (Figure 17.2; Ellis, 2016; Cormier, 2015).

FIGURE 17.2 OCCUPANCY STATUS FOR ALL STUDY SITES (1999–2015) (CORMIER, 2015; ELLIS, 2016)



Condition Goals:

- Pair territory occupancy remains high
- Pair territory occupancy within the range of variability of the long-term average
- Pair territory occupancy in the "Good" range

Condition Thresholds:

- **Good:** Five-year average pair occupancy >=75% and no more than current year with five-year moving average pair occupancy below 75%
- **Caution:** Current year and at least one additional, consecutive year with five-year moving average pair occupancy <75% and >/=65%, or a >50% decline in average pair occupancy between current year and next previous year

- **Significant Concern:** Current year and at least one additional, consecutive year with the five-year moving average <65%

Current Condition: Good

Pooled NPS, MMWD, and MCP monitoring data from 1999–2015 revealed that Northern Spotted Owl pair occupancy of territories ranged from 68–91% of nests surveyed, depending on the year (Table 17.1; Ellis, 2016; Cormier, 2015), with an average pair occupancy of 81%. Five years have had pair occupancy below 75%, including the first three years of monitoring. A five-year moving average was used to smooth the data, and remove the effects of a single bad year.

Thresholds were based on the distribution of the five-year moving average data in comparison with data from other sites. Demographic areas in the Pacific Northwest had occupancy probabilities ranging from 0.6 to close to 1.0 in the mid-1990s (Dugger et al., 2016), while Mendocino Redwood Company had an average occupancy probability of 0.68 for the 2000–2015 period (MRC, 2016). These occupancy estimates are based on detection of a Northern Spotted Owl on a territory, so our estimates of pair occupancy are more conservative (i.e., actual territory occupancy is higher because some sites only have single owls detected).

The NPS monitoring program was designed to be able to detect a 15% decline over five years (Press et al., 2010), while the MMWD and MCP monitoring program is driven by both long-term monitoring goals and environmental compliance requirements for infrastructure projects. In 2015, 82% of territories were occupied by pairs and the five-year moving average value was 82%, well above the “Good” threshold. In the future, the thresholds for the occupancy metric should be reevaluated. Results of an occupancy trend analysis which is underway should also inform this discussion.

TABLE 17.1 NORTHERN SPOTTED OWL PAIR OCCUPANCY AND FIVE-YEAR MOVING AVERAGE BY YEAR FROM NPS MONITORING DATA (ELLIS, 2016; CORMIER, 2015)

Year	Sample Size	Pair Occupancy (%)	Five-year Moving Average
1999	55	71	-
2000	62	68	-
2001	61	72	-
2002	67	81	-
2003	62	92	77
2004	62	87	80
2005	65	80	82
2006	83	72	82
2007	50	84	83
2008	58	74	80
2009	57	91	80
2010	59	90	82
2011	68	79	84
2012	72	88	84
2013	72	78	85
2014	78	83	84
2015	82	82	82
	Average	81	82
	Standard deviation	7	2

Confidence: High

Northern Spotted Owls are monitored on an annual basis within and adjacent to Mt. Tam on both NPS and State Parks lands, as well as by Point Blue on and adjacent to MMWD and MCP lands.

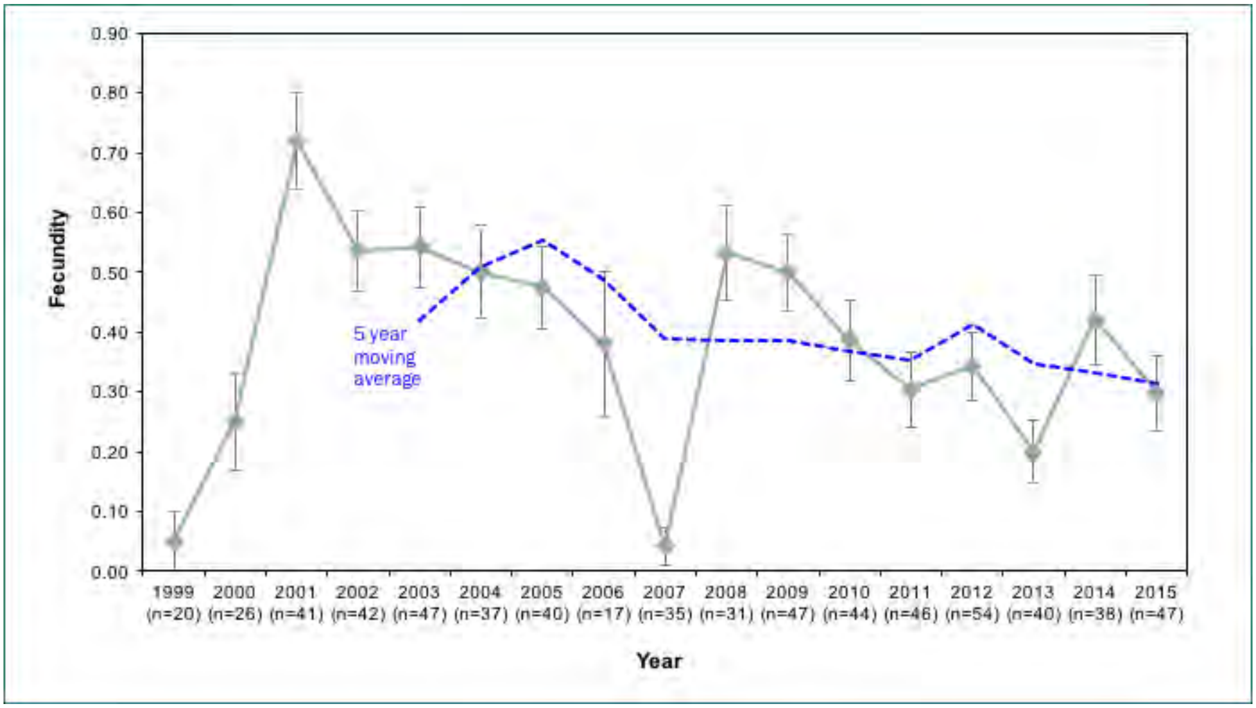
Trend: No Change

Northern Spotted Owl pair occupancy of territories remains high, with some variation (Ellis, 2016; Cormier, 2015). The threshold for “Caution” has not been exceeded in 17 years of monitoring (Table 17.1).

METRIC 2: FECUNDITY

Baseline: Fecundity is defined as the number of female young per territorial female, and is measured by following reproductive status and determining nesting success in terms of the number of young that fledge from each nest during annual monitoring. Data collected between 1999–2015 show an average fecundity of 0.38 (Figure 17.3).

FIGURE 17.3 FECUNDITY FOR 1999–2005 AND 2007–2015 (ELLIS, 2016; CORMIER, 2015)



Fecundity (the number of female young produced per territorial female) for Northern Spotted Owls surveyed in Marin County from 1999-2015. Sample size varies (from n=17 in 1996 to n=54 in 2012), and not all sites were surveyed each year. The five-year moving average is shown as a dashed blue line (Cormier, 2015; Ellis, 2016).

Condition Goals:

- Fecundity remains high
- Fecundity within range of long-term average variability
- Fecundity in the "Good" range

Condition Thresholds:

- **Good:** Five-year average fecundity >/=0.30 and no more than current year with five-year average fecundity <0.30

- **Caution:** Current year and more than one consecutive, previous year with five-year average fecundity <0.30, >50% decline in fecundity between current year and year previous and/or two consecutive years with no breeding; significant declining trend in fecundity

- **Significant Concern:** Current year and next two consecutive, previous years with five-year average fecundity <0.25, or three of the last six years with no breeding

Status: Good

From 1999–2015 fecundity ranged from 0.05–0.72 across all monitored sites, with an average fecundity of 0.38 (Table 17.2). The standard deviation from the mean was 0.18 and the average of the annual standard error was 0.07. Fecundity has been variable over time, with 1999 and 2007 as notably poor years with very few young produced. Although Northern Spotted Owl fecundity remains above the "Good" threshold, the five-year moving average fecundity in 2013–2015 is moving towards the 0.30 cut off for caution. A five-year moving average was used to smooth the data, and remove the effects of a single bad year.

Thresholds were based on the distribution of the five-year moving average data and a comparison with other Northern Spotted Owl monitoring sites. Northern Spotted Owl average adult fecundity ranged from 0.18–0.34 for the demographic monitoring sites of the Pacific Northwest, with the Cle Elum site in the eastern Cascades of Washington an outlier with an average adult fecundity of 0.57 (Duggers et al., 2016). California demographic areas had average adult fecundity of 0.31 (Duggers et al., 2016).

The fecundity numbers presented for Marin County's Northern Spotted Owls are for all age classes, not just adults. Other work has demonstrated that one- and two-year-old females have considerably lower average fecundity than adults (Duggers et al., 2016). Marin Northern Spotted Owl fecundity data which includes sub-adults would be higher if we only looked at adult fecundity. The NPS monitoring program was designed to be able to detect a cumulative 34% decline over five years (Press et al., 2011) while the MMWD and MCP monitoring programs are driven by both long-term monitoring and environmental compliance requirements for infrastructure projects. In the future, the thresholds for condition for the fecundity metric should be reevaluated. Results of a planned fecundity trend analysis should inform this reevaluation.

TABLE 17.2 NORTHERN SPOTTED OWL FECUNDITY AND FIVE-YEAR MOVING AVERAGE (CORMIER, 2015; ELLIS, 2016)

Year	Sample Size	Fecundity	Five-year Moving Average
1999	20	0.05	-
2000	26	0.25	-
2001	41	0.72	-
2002	42	0.54	-
2003	47	0.54	0.42
2004	37	0.50	0.51
2005	40	0.48	0.55
2006	17	0.38	0.49
2007	35	0.04	0.39
2008	31	0.53	0.39
2009	47	0.50	0.39
2010	44	0.39	0.37
2011	46	0.30	0.35
2012	54	0.34	0.41
2013	40	0.20	0.35
2014	38	0.42	0.33
2015	47	0.30	0.31
	Average	0.38	0.40
	Standard deviation	0.18	0.07

Confidence: High

Northern Spotted Owls are monitored on an annual basis within and adjacent to Mt. Tam by NPS on both NPS and State Parks lands, as well as by Point Blue on MMWD and MCP lands.

Trend: No Change

Fecundity appears to be moving within the range of variation. 1999 and 2007 were particularly bad years for fecundity with very few Northern Spotted Owl young fledged. Managers have been concerned that only one of the last five years has had fecundity above the long-term average, and that annual fecundity and the five-year moving average appear to be trending downward (Table 17.2; Figure 17.3; Cormier, 2015; Ellis, 2016). A more extensive trend analysis of fecundity is needed to determine the significance of this trend.

METRIC 3: BARRED OWL PRESENCE

Baseline: Barred Owls were first detected in Marin County in Muir Woods in 2002, and first confirmed breeding in Muir Woods in 2007 (Jennings et al., 2011; Ellis, 2016). Two other confirmed Barred Owls in Olema Valley were also documented over the last several years. In 2015, two Barred Owls were collected from Marin County as part of a research project being led by UC Berkeley in conjunction with the California Academy of Science (Ellis, 2016). Another Barred Owl that had been previously captured and fitted with a radio transmitter was found dead in Muir Woods in 2015. Based on NPS and Point Blue surveys and monitoring of the eBird site (*ebird.org*), no confirmed Barred Owls were present in Marin County as of the end of the 2015 breeding season.

Condition Goal: No Barred Owls present, which is the historic condition for Marin County (Jennings et al., 2011)

Condition Thresholds:

- **Good:** Barred Owls occupy two or fewer areas within monitored areas in Marin County
- **Caution:** Barred Owls occupy three to six areas within monitored areas in Marin County
- **Significant Concern:** Barred Owls occupy more than six areas within monitored areas in Marin County

Status: Good

Currently, there are no confirmed Barred Owls within monitored areas in Marin County (Ellis, 2016). Barred Owls have been demonstrated to strongly negatively impact Northern Spotted Owls, with one of the primary effects being the displacement of Northern Spotted Owls from territories (Duggers et al., 2016). All Northern Spotted Owl demographic monitoring sites have negative population trends, with the only exception being the Green Diamond Reserve in northern California, which has an increasing Northern Spotted Owl population since 2009 when Barred Owl removal treatments began (Duggers et al., 2016). Barred Owl detections in Mendocino County have been increasing considerably since 2009 (MRC, 2016), indicating the potential for more Barred Owls moving into Marin County in the near future.

Confidence: High

Incidental Barred Owl detections are recorded during annual Northern Spotted Owl monitoring by NPS and Point Blue, and NPS conducts annual surveys for Barred Owls in areas outside of Northern Spotted Owl monitoring territories. Staff also monitor Barred Owl reports on eBird.

Trend: Improving

At least three Barred Owls were thought to occur in Marin County at the start of 2015. However, after the management and monitoring efforts described above, Marin County currently has no confirmed Barred Owls.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

As described above in the Overall Condition section of this chapter, Northern Spotted Owls have been well studied in Marin County, and especially within the Mt. Tam area of focus. Monitoring objectives are to determine Northern Spotted Owl site occupancy rates of territories, fecundity, and to evaluate nest site characteristics. In addition, information on Barred Owls is recorded during Northern Spotted Owl surveys.

Inventory work began in the late 1980s (NPS, unpublished data), and continued in the early 1990s, with more complete inventories completed in 1997 and 1998, and again in 2006 for NPS and State Parks lands (Hatch et al., 1999; Jensen et al., 2007).

INFORMATION GAPS

Sudden Oak Death: While this disease has impacted forest habitats where Northern Spotted Owls breed, it is unclear how observed changes in breeding habitat as a result of SOD may affect Northern Spotted Owl foraging or its primary food resource, the dusky-footed woodrat.

Climate Change: It is unknown how climate change may affect Northern Spotted Owl fecundity, survivorship, or their habitat.

Factors Affecting Fecundity: Weather and climate, landscape and habitat factors, and the presence of Barred Owls affect Northern Spotted Owl fecundity across their entire range, but their effects have not been studied specifically in Marin County or Mt. Tam area of focus.

Dispersal: It is not known how juveniles disperse and where they travel to while waiting for opportunities to occupy breeding territories.

Habitat: Habitat was identified as an important metric, but it needs to be further analyzed to be used to assess how it affects the Northern Spotted Owl population. Agencies currently have data on the size of nest trees, information about the area immediately surrounding them, and GIS data on landscape features. Landscape analysis around nest trees has revealed some of the features associated with Northern Spotted Owl habitat (Stralberg et al., 2009).

Dusky-footed Woodrats: Dusky-footed woodrats were considered a potential metric to assess Northern Spotted Owl populations, as they are their primary food resource. However, we do not currently have good data on woodrat abundance across Northern Spotted Owl sites. This metric is being developed as an indicator under mammals, with photo data from the Marin Wildlife Picture Index Project.

Survivorship: Survivorship, or the probability that an owl survives and stays in the study area from one year to the next, is measured by banding and re-sighting Northern Spotted Owls during annual monitoring. Mark-recapture analyses are then used to calculate survivorship estimates. In addition, having marked individuals provides information on territory turnover and shifts in the locations of territories over time. Survivorship is an important metric in assessing Northern Spotted Owls, but is unlikely to be adopted, unless part of a research based project. Due to limited resources, NPS and Point Blue stopped banding Northern Spotted Owls in 2003 after initiating a banding program in 1998 (Ellis, 2016), and focused their efforts on continuing to collect territory occupancy and fecundity data. Incorporating monitoring survivorship would allow us to participate in the periodic demographic reviews of status and trend that are conducted for the Northern Spotted Owl demographic monitoring areas.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Management: Breeding season habitat protections for Northern Spotted Owls

Monitoring:

- Collecting data on occupancy rates of territories, fecundity, and nest site characteristics
- Recording information on Barred Owls during Northern Spotted Owl surveys

Inventories: Northern Spotted Owl surveys in the late 1980s and early 1990s (NPS), with more complete inventories in 1997, 1998, and 2006 (NPS and State Parks)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Targeted Non-native, Invasive Plant Species Control:**
    - Pilot a non-native, invasive species control study (to include brooms) adjacent to or within forests occupied by breeding Northern Spotted Owls to enhance woodrat (prey) habitat
    - Document the effectiveness of increasing woodrat occupancy, including an inventory of existing woodrat nests prior to control treatment and monitoring to document potential increases
    - Expand targeted invasive plant removal program for species known to have impacts on redwood forest richness and structure, and identify priority geographic locations based upon Early Detection and Rapid Response and systematic community assessment work scheduled for 2017
- **Fecundity Analysis**: Conduct a long-term trend analysis including assessing fecundity; analyze factors affecting fecundity specific to Marin County populations

Inventory and Monitoring:

- **Survivorship Monitoring for Northern Spotted Owls:** Add monitoring for key demographic parameters including adult and juvenile survival to existing programs to help assess what lifecycle stage this at-risk species is most limited by
- **Impacts of Sudden Oak Death on Northern Spotted Owls:** Design a study to determine if the disease has impacted or will impact their behavior, breeding success, nest site availability, prey species, or long-term viability, and to improve our ability to protect this iconic species.

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CHAPTER 18. OSPREY (*PANDION HALIAETUS*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: Declining

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

Ospreys are a charismatic and iconic raptor species that breeds in the lakes and reservoirs in the One Tam area of focus. Because Osprey feed almost exclusively on fish, breeding success is a good indicator of water quality and fish abundance. The Kent Lake Osprey colony was first established in the mid-1960s and has been monitored continuously by the Marin Municipal Water District (MMWD) since 1981, making it one of the longest-running Osprey nesting studies in the Pacific region.

OVERALL CONDITION

Osprey were once listed as a California species of special concern as a result of population declines caused by persecution and environmental contamination in the 19th and early 20th centuries. Because of their sensitivity to environmental perturbations, the Osprey is now considered an ideal Worldwide Sentinel Species (Grove et al., 2009). Over the last several decades, the United States' Osprey population has recovered from historic declines, but they are still protected by the Migratory Bird Treaty Act.

After experiencing two decades of growth following its establishment with the filling of Kent Lake, the Osprey colony peaked in the mid-1990s, then entered a period of gradual decline over the subsequent two decades (Figure 18.1)

Recent monitoring suggests the colony is currently about half of its former size. However, west of Kent Lake (Inverness Ridge) and elsewhere in the San Francisco Bay Area (Brake et al., 2014), the number of active Osprey nests have increased over the same period. Therefore, as the local colony has declined, the regional population has grown substantially. In other words, the Kent Lake was the founding colony that likely contributed to the overall growth of the regional population.

The causes of the decline seen at Kent Lake are unknown, but may be multifaceted. Possible explanations include: a shift in regional nesting distribution; response to a pair of nesting Bald Eagles (*Haliaeetus leucocephalus*) at Kent Lake starting in 2008; changing ecological conditions affecting fisheries and foraging success; a response to changes on the Osprey's wintering grounds; and changing patterns of recruitment in the nesting colony.

The current benchmarks for Kent Lake Osprey are (Evens, 2015):

- Average number of active nests from 2003–2015 was 26.7

Note: Occupied nests are defined here as nests that are maintained by the adults up to egg-laying. Active nests are those that persist into the incubation phase. Successful nests are those that fledge at least one young.

- Maximum count of active nests in 1994 was 46
- Average number of occupied nests from 2003–2015 was 37.4
- Maximum count of occupied nests in 1994 was 52

DESIRED CONDITIONS

A healthy nesting population of Osprey on Mt. Tam would remain stable over time. High levels of pair occupancy and annual reproductive success would be maintained within the normal range of variability, or above long-term average values based on recent historical monitoring.

STRESSORS

Climate Change: Ospreys require large, open bodies of water for both nesting and foraging. Extended periods of drought may result in dramatic and sustained drops in lake levels that may negatively impact Osprey fledging success. However, the effects will depend on impacts to fish populations, as an increase in shallow water habitat may actually improve prey availability if fish populations are maintained.

Contaminants: Osprey populations were impacted by contaminants (primarily chlorinated hydrocarbons, but also mercury) in the mid-20th century. Kent Lake Osprey are still potentially threatened by contaminants in nearby areas where they are known to forage. For example, Residues of DDT are still documented in the northern San Francisco Bay Area (U.S. EPA, 2015; Ackerman et al., 2014) also documented above sub-lethal levels of mercury in more than one quarter of 3,000 fish sampled in the San Francisco Bay.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: MEASURES OF REPRODUCTIVE EFFORT

Baseline: Osprey reproductive effort here is broken into two primary measures: number of occupied nests, and nest site occupancy rate (the number of active nests as a percent of occupied nests). Annual monitoring has shown an average of 38 occupied Osprey nests at the Kent Lake colony from 2003–2015. There were an average of 72% of occupied nests persisting to become active (i.e., incubation stage) (Evens, 2015), with one outlier of low active/occupied nests in 2004 (Table 18.1).

Condition Goal: Reproductive effort (number of occupied nests and occupancy rate) remains within the range of values recorded over the last decade

Condition Thresholds:

- **Good:** >25 nests occupied, and average nest site occupancy >/=70%

- **Caution:** >24 nests occupied, and average nest site occupancy <50%, or there is a >25% decline in nest site pair occupancy over three years
- **Significant Concern:** <24 nests occupied, and average nest site occupancy <65%, or there is a >50% decline in nest site pair occupancy over three years

Current Condition: Good

Nest site occupancy has been above 75% for all but four of the past 13 years (Table 18.1).

TABLE 18.1 MEASURES OF KENT LAKE OSPREY REPRODUCTIVE EFFORT, 2003–2015 (EVENS, 2015)

Year	Total Nests	Occupied Nests	Number Active (At Least One Chick)	Nest Site Occupancy Rate (Active/Occupied Nests)
2003	49	42	Unknown	Unknown
2004	53	45	18	0.4
2005	59	50	44	0.88
2006	54	44	37	0.84
2007	52	42	29	0.69
2008	50	52	21	0.5
2009	49	43	27	0.63
2010	42	31	27	0.87
2011	46	34	28	0.82
2012	40	32	27	0.87
2013	40	28	19	0.68
2014	36	25	Unknown	Unknown
2015	33	28	21	0.75
Average	46.4	38.2	27.1	0.72

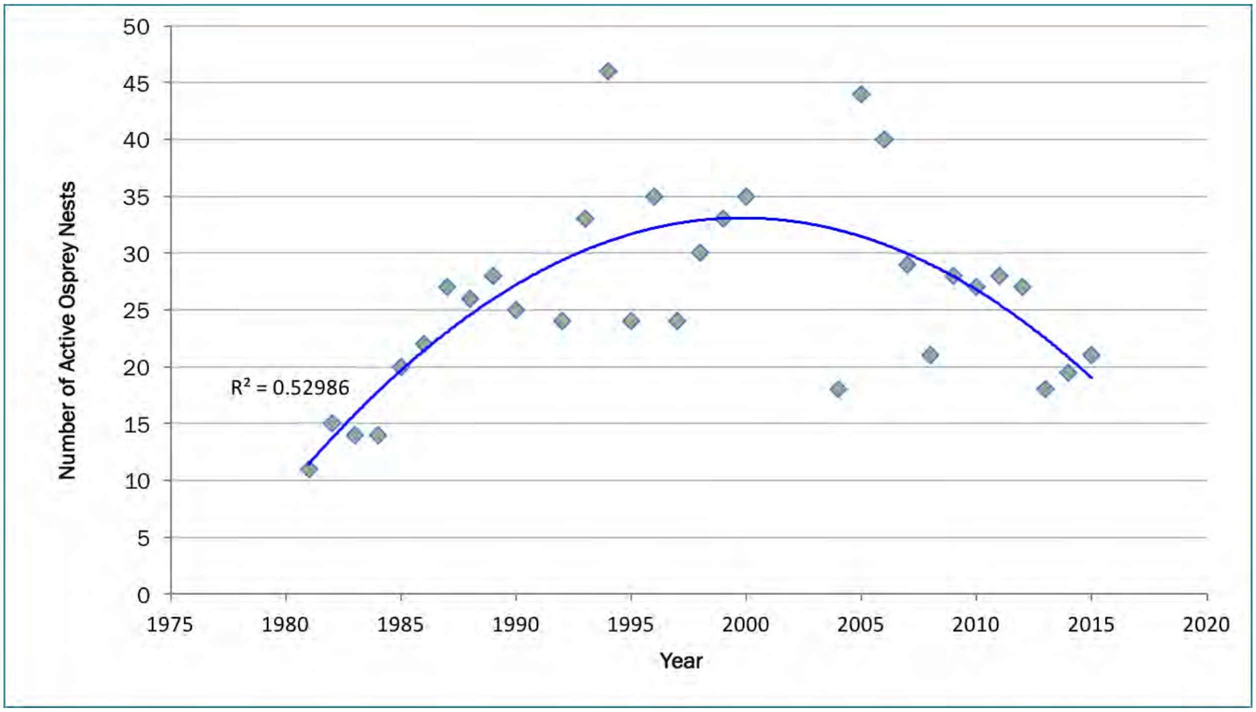
Confidence: High

Jules Evens of Avocet Research has conducted annual nest surveys of the Kent Lake colony during 33 nesting seasons since 1981 (excluding 1991, 2001, and 2002).

Trend: Declining

The Kent Lake Osprey colony was founded sometime after the original filling of Kent Lake, which was built in 1954. The first nest survey in 1981 showed 11 active nests (Evens, 2015). Additional flooding in 1983 killed many of the edge trees, contributing to the number of nest substrates available to Osprey. The number of active nests continued to rise until 1994 when it seemed to plateau (between 35–46 active nests until 2005), then the measure follows a downward trend to 21 in 2015 (Evens, 2015).

FIGURE 18.1 KENT LAKE OSPREY NESTING PAIRS, 1981-2016 (USED WITH PERMISSION BY JULES EVENS)



METRIC 2: ANNUAL REPRODUCTIVE SUCCESS

Baseline: Reproductive success is the number of nestlings fledged from active nests (nests that persist into the incubation stage of the nesting cycle). From 1981–2000, measuring reproductive success was part of Avocet's contract with MMWD. Minimum reproductive success during this time averaged 1.4 chicks per nest (+0.37) (Evens, 2001). Reproductive success of 0.8–1.3 chicks per nest per year is considered the threshold for a viable Osprey nesting population given in the literature (Henny & Wight, 1969; Spitzer & Poole, 1980; Poole, 1989).

Condition Goal: Annual reproductive success is "Good" as defined by the thresholds below

Condition Thresholds:

- **Good:** Annual reproductive success in the range of 0.8–1.3 chicks per nest per year, or higher

- **Caution:** Annual reproductive success <0.8–1.3 chicks per nest per year, or a >30% decline in annual reproductive success over a consecutive three-year period

- **Significant Concern:** Annual reproductive success <50% over a three-year period

Current Condition: Unknown

The reproductive success of the Kent Lake Osprey colony has not been systematically monitored since 2000, and we do not know the actual productivity values (number of fledglings per nest). However, the presence of approximately 20 active nests late in the nesting season over the past several years, often with chicks present, suggests some degree of nesting success.

Confidence: Low

Our confidence in this assessment is "Low" because systematic monitoring has not been conducted since 2000.

Trend: Unknown

The lack of recent observational data makes it impossible for us to state a trend for Osprey annual reproductive success. That said, current monitoring efforts have not detected early abandonment of the nesting effort at occupied nests, an indication that some nests successfully fledge chicks.

METRIC 3: HABITAT

Baseline: The MMWD currently records species and status (i.e., living or dead) of nest trees. Kent Lake Osprey have nested only in trees since the colony's inception, including coast redwood (*Sequoia sempervirens*), and Douglas-fir (*Pseudotsuga menziesii*). In 2015, "dead redwood" was the most common class of nesting tree, hosting nearly 43% of all Kent Lake Osprey nests (Table 18.2; Evens, 2015).

Condition Goal: Continued availability of suitable nesting sites provided by a mix of live and dead standing trees, particularly coast redwood

Condition Thresholds:

- **Good:** Coast redwoods and Douglas-firs, live and dead, at the Kent Lake shoreline available in numbers comparable to Osprey nesting stands from 2006–2015 (Table 18.2)

- **Caution:** Loss of significant number (>50%) of snags and live trees at the Kent Lake shoreline, potentially from high wind events, tree cuts, senescence, or other events

- **Significant Concern:** Loss of significant number (>30%) of snags and live trees at the Kent Lake shoreline

Current Condition: Good

TABLE 18.2 SPECIES AND STATUS (LIVING/DEAD) OF OSPREY NEST TREES AT KENT LAKE IN 2015 (EVENS, 2015)

	Douglas-fir	Redwood	Unknown	Total
Live	3 (10.7)	10 (35.7)	0 (0)	13 (46.4)
Dead	1 (3.4)	12 (42.9)	1 (3.6)	14 (50.0)
Unknown	0 (0)	0 (0)	1 (3.6)	1 (3.6)
Total	4 (14.1)	22 (78.6)	2 (7.1)	28 (100.0)

Confidence: High

Tree counts and conditions have been assessed as recently as 2015 (Evens, 2015).

Trend: No Change

Data on tree species and type going back to 1981 has shown no directional trend.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

Two biologists visit the Kent Lake Osprey colony twice each year to determine location and distribution of occupied and active Osprey and eagle nests in the watershed. These visits are timed to coincide with the height of the nesting cycle (April–June). The entire lake is surveyed by boat and each nest located and recorded. Tree species and class (i.e., living or dead) are also recorded and mapped. Findings are then summarized in an annual report. See Evens (2015) for a full description of this monitoring program and its methods.

INFORMATION GAPS

Reproductive Success: Increasing annual observations to determine productivity

Prey Ecology: Foraging patterns and locations and prey availability are not well known, nor are the local ecological dynamics of prey species (e.g., top smelt). Kent Lake Osprey are known to hunt in adjacent lakes (e.g., Bon Tempe), along the outer coast (e.g., Bolinas Lagoon) and in the San Francisco Bay, but there are few observations of foraging in Kent Lake. California Department of Fish and Wildlife fish stocking is a potential source of data for Bon Tempe Lake, but Kent Lake Osprey forage more broadly than Bon Tempe. No other data are currently available.

Chemical Threats: Sampling for mercury and other contaminants has not been conducted.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Monitoring: Two nesting status surveys throughout Kent Lake each year (MMWD and Avocet) since 1981

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Environmental Contaminants:** Conduct an analysis to determine constituents, specifically mercury and other fish-related contaminants, present in Ospreys to support further understanding of factors contributing to reproductive success

- **Nest Cams:** Record Osprey nesting as a means to build public awareness and interest, and to record behaviors and fish species being consumed

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CHAPTER 19. MAMMALS

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Caution

Trend: Unknown

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

There are currently 40 known native mammal species in the One Tam area of focus (see Mammals Species of Mt. Tam, Appendix 8). Mammals are good indicators of ecological condition because they are responsive to changes in habitat (Andren, 1994) and rely on the health of lower trophic levels due to high energetic requirements as well as connectivity in the landscape. This chapter focuses on terrestrial mammals greater than one kilogram that are likely to be detected by the Marin Wildlife Picture Index Project (MWPIP). North American river otters (*Lontra canadensis*) are covered in a subsequent chapter of this report. The need for future monitoring programs for bats and small mammals is described in Chapter 22.

Obtaining reliable information about abundance and distribution of mammals, understanding community structure, the health of different mammalian trophic levels, and reliably determining trends in mammalian abundance are important metrics in determining overall ecosystem health. In the past, the level of effort to achieve the above was generally beyond the capacity of most land management organizations. Camera trapping at the landscape level provides a non-invasive tool to obtain these metrics and reliably measure change over time. Networks of remote cameras have proven very effective for gaining valuable information on the diversity, distribution, and abundance of the mammalian community (O'Brien et al., 2010; Ahumada et al., 2011). Additionally, photographs can be shared with the public, which provides the community with a chance to see mammals that are all around the One Tam area of focus, but are rarely spotted.

In September 2014, a grid of 128 cameras was established in a variety of habitat types throughout the Lagunitas Creek corridor as a part of Phase I of the MWPIP, using methods first developed by the Wildlife Conservation Society and the Zoological Society of London, and now supported by HP Enterprise Services and Conservation International (Townsend, 2015). Sites across One Tam partner agencies' lands were chosen to help learn more about how mammals are using these interconnected landscapes, and to establish much needed baseline information about mammalian diversity, abundance, and distribution. The proposed MWPIP Phase II would add 100–120 cameras in Redwood Creek Watershed.

The MWPIP targets small to large terrestrial mammals (usually one kilogram or greater) (Townsend, 2015). Analysis of these data provides baseline abundance estimates of the mammalian community, with continued monitoring allowing us to determine if mammalian abundance is stable, increasing, or decreasing over time. By establishing a large grid of cameras evenly spaced across the landscape, these data can also be separated out to measure the abundance of individual species or trophic levels across seasons and years. This approach helps achieve the goal of understanding both the condition (i.e., presence, abundance, and diversity) and trend of the mammalian community as a whole, as well as by guilds or trophic levels (e.g., carnivores or prey) and individual species (e.g., American badger or deer). Additionally, management changes and environmental stressors like drought and the degree of their effects on the mammalian community can be accurately determined through the MWPIP.

OVERALL CONDITION

Mammalian inventories have been completed on portions of lands within and adjacent to Mt. Tam (Howell et al., 1999; Fellers & Pratt, 2001; Semenoff-Irving & Howell., 2005). These inventories were not systematic across Mt. Tam and did not provide information about mammalian abundance. The MWPIP was recently implemented in 2014 in the Lagunitas Creek Watershed (Townsend, 2015), with plans to expand into the Redwood Creek Watershed. This project will provide key information about mammalian community, including distribution and abundance, how the animals move across the landscape, and how they might use different areas over the course of the year.

Results so far suggest most native mammal species—15 of which have been detected—are present in the One Tam area of focus (Townsend, 2015), which is above the “Good” threshold. A few rare species have not been detected within the Mt. Tam area, raising significant concern about this metric. Occupancy results from preliminary data suggest relatively healthy mammal diversity, with an abundance of small mammals (prey species) present. However, more data and analysis is necessary to assess this metric, so this metric is “Unknown”. Opossums and cattle have been the only non-native mammals seen so far, also above the “Good” threshold. Overall, that condition assessment for mammals is “Caution”, with an “Unknown” trend. Further MWPIP data collection and analysis should provide for more robust assessment in the future.

DESIRED CONDITIONS

The desired condition for the mammalian community on Mt. Tam is to maintain native biodiversity at high levels and the habitats that support it. More specifically, this would entail:

- The full suite of native mammals is present
- Native species diversity is high and stable or increasing; mammals are well represented across trophic levels; mammals are distributed across the landscape in appropriate habitats
- Rare species are present in suitable habitat types; where appropriate, actions are taken to increase the abundance and distribution of rare species (e.g., maintaining large grassland patches for rare species like badgers)
- Non-native mammals, especially species like wild boars, that have large ecosystem impacts, are not present
- Wildlife habitat is protected or enhanced through actions such as non-native plant removal and maintaining landscape connectivity (Note: This will differ by species and the habitats they utilize)

STRESSORS

Historical Impacts: Although most of the One Tam area of focus is protected, past land uses still affect habitat quality and quantity. Certain species of mammals were also the targets of hunting and trapping for centuries, the results of which may still be affecting regional mammal numbers and diversity (see Extirpated Species section, Chapter 11).

Habitat Loss and Fragmentation: The contiguous open spaces of One Tam area of focus are threaded with trails and roads, and are surrounded by a mix of agricultural, suburban, and urban areas. Habitat loss and fragmentation caused by these landscape features may have a negative effect on mammal numbers and diversity, and can be particularly detrimental to species like mountain lions that require large home ranges.

Disease: Mammals are subject to a range of diseases, many of which are potentially spread by contact with pets, including canine distemper, canine parvovirus, leptospirosis, and feline leukemia, among others (Riley et al., 2004). A canine distemper outbreak dramatically affected Marin County's gray fox populations in the mid-1990s (B. Merkle, personal communication). Disease is also likely a factor in range-wide declines in spotted skunks.

Rodenticides and Pesticides: Mammals are at risk of potentially deadly rodenticide exposure, especially where they live adjacent to residential areas. Additionally, rodenticide exposure has been linked with susceptibility to mange in bobcats (Riley et al., 2007).

Visitor Use Pressures: Studies have documented recreational use altering the use of protected areas by carnivores (George & Crooks, 2006; Reed & Mehrlander, 2008), and also dogs affecting the abundance and behavior of mammal communities near trails (Lenth et al., 2008).

Invasive Species: Invasive plants and animals can have far-reaching and detrimental effects on Mt. Tam's ecosystems. Invasive plants may dramatically alter wildlife habitat. Some invasive animals can outcompete native species for food, water, nest or burrow sites, and shelter. Other species such as feral pigs can do great damage as they trample foliage and upturn soil while rooting and foraging for food.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: NATIVE SPECIES RICHNESS

Baseline: Currently, there is a good level of native species richness compared to the suite of species we would expect to be present. Fifteen native mammal species have been detected through the MWPIP in the One Tam area of focus to date (Figure 19.1). There are an additional six species that could potentially be detected with camera traps within the study area, including ringtail cat (*Bassariscus astutus*), ermine (*Mustela ermine*), long-tailed weasel (*Mustela frenata*), Point Reyes mountain beaver (*Aplodontia rufa*), American black bear (*Ursus americanus*), and muskrat (*Ondatra zibethicus*). American badgers (*Taxidea taxus*) have also been detected by MWPIP cameras outside of the One Tam area of focus.

At least 12 mammals may have been extirpated from Mt. Tam, with eight of these documented as present or likely present, and four unknown whether they actually occurred on Mt. Tam historically (see Table 11.1 in Chapter 11). Mammalian species that may have been lost from Mt. Tam include top predators such as grizzly bears (*Ursus arctos*), gray wolves (*Canis lupus*), and American black bears (although black bears have occasionally been documented in Marin County as vagrants); ungulates such as tule elk (*Cervus canadensis nannodes*) and pronghorn antelope (*Antilocapra americana*); and rodents such as North American beavers (*Castor canadensis*) and California ground squirrels (*Otospermophilus beecheyi*). The loss of these species represents a considerable ecological loss for Mt. Tam.

Condition Goals:

- Maintain the full suite of expected native mammal species
- No additional mammal species are lost from Mt. Tam

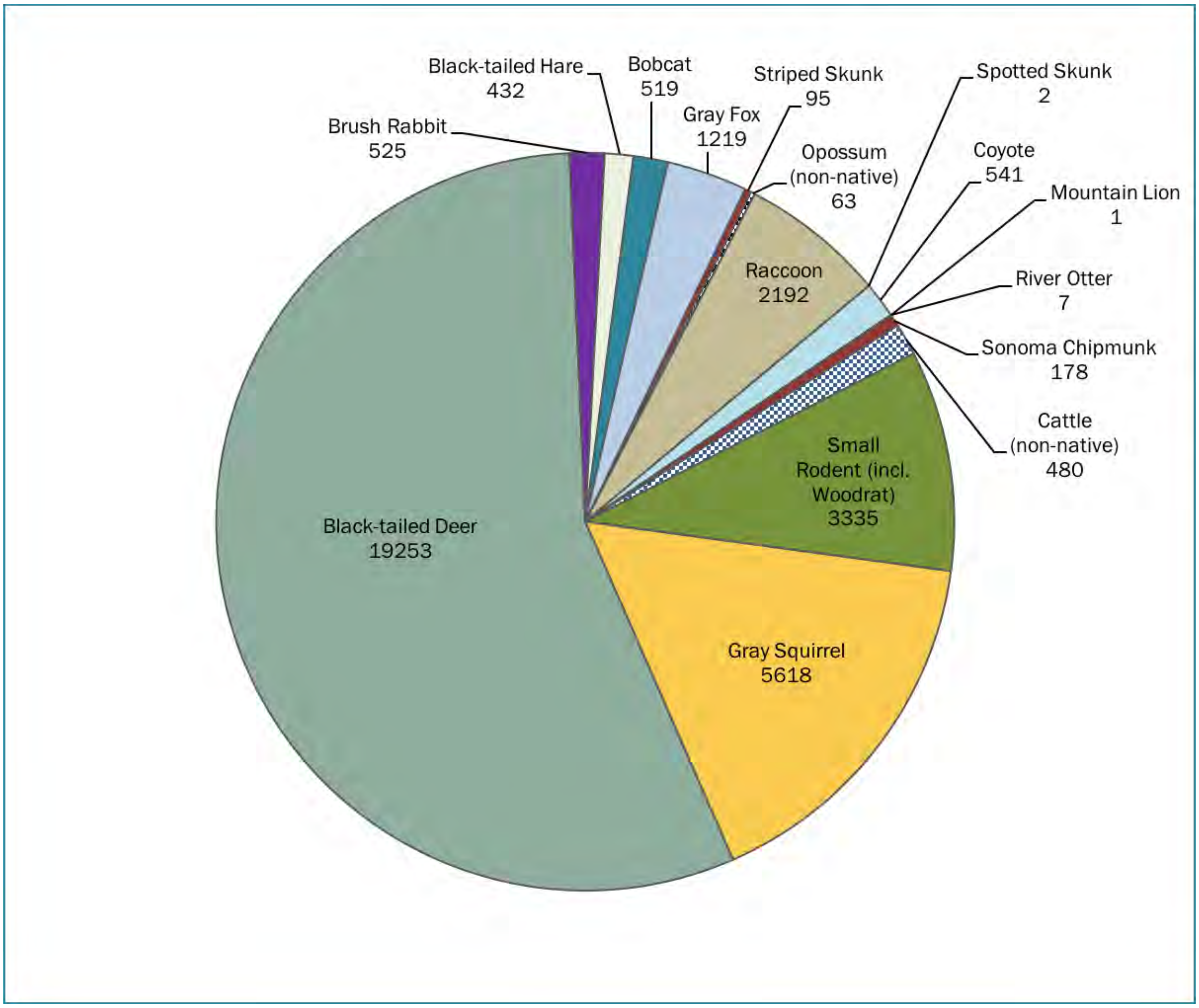
Condition Thresholds:

- **Good:** 15 or more native mammal species detected
- **Caution:** 14 native mammal species detected
- **Significant Concern:** Fewer than 14 native mammal species detected

Current Condition: Good

Fifteen native mammal species have been detected through the MWPIP to date. Fourteen of these species are depicted below (Figure 19.1). Since the preliminary analysis of the MWPIP data, American badgers were also detected on MWPIP cameras just outside the Mt. Tam area of focus boundary. In addition, there are some mammal species known to be present at Point Reyes National Seashore that are possible for detection by cameras on Mt. Tam. Additionally, with climate change shifting vegetation and communities, we should be ready for the possibility of new mammal species moving into the Mt. Tam area of focus.

FIGURE 19.1 MAMMAL SPECIES AND NUMBER OF INDIVIDUAL DETECTIONS CAPTURED ON CAMERA IN THE FIRST THREE MONTHS OF THE MARIN WILDLIFE PICTURE INDEX PROJECT (TOWNSEND, 2015)



Confidence: Moderate

Our confidence is "Moderate" based upon recent MWPIP work and data analysis and having a large number of cameras in the field. However, grassland habitats may be under-sampled.

Trend: Unknown

We have not been collecting data for long enough to determine a trend yet. However, baseline estimates will allow for trend analysis in 2017. Trend analysis requires a year of baseline data, and then a minimum of two additional data points. Occupancy estimates so far have established that the condition of the mammalian community represents most to all of the expected species.

METRIC 2: PRESENCE AND DISTRIBUTION OF RARE SPECIES

Baseline: Rare species such as western spotted skunks (*Spilogale gracilis*), American badgers, and mountain lions (*Puma concolor*) are an important component of the mammalian diversity of Mt. Tam. Spotted skunks are reported to be in decline in the central coast of California (B. Merkle, personal communication). Spotted skunks were detected during Muir Woods inventory work (Howell, et al., 1998) and a single spotted skunk was detected during Point Reyes National Seashore inventory work (Fellers & Pratt, 2002). American badgers are fairly common in grassland and coastal scrub habitats at Point Reyes (D. Press, personal communication). They were detected in the Marin Headlands in association with a 2014 bioblitz, and Marin County recently confirmed badgers in the Lucas Valley Preserve just north of Mt. Tam. American badgers are discussed in more detail in Chapter 20.

Mountain lions have extremely large home ranges that likely only allow for a few individuals. In a two-and-a-half-year study utilizing camera traps around Marin County, 55 detection events of lions, including at least two males were recorded. However, one male that could be identified by an ocular defect was responsible for 40 of the detection events (Fifield et al., 2015). Ringtail cats are a rare and elusive species that not been detected at Mt. Tam, but have been detected at nearby Point Reyes National Seashore. Additional survey work in appropriate areas, or to follow up on observations, may allow us to confirm the presence and get a better idea of the distribution of ringtail cats in Marin County.

Condition Goals:

- Rare species are detected in appropriate habitat types
- More detections at more cameras (greater distribution) is desired
- Document extant range within study area with the goal to maintain the presence of these species

Condition Thresholds:

- **Good:** All of species defined as rare are detected in appropriate habitat types
- **Caution:** Rare species documented as present, though only at a limited number of cameras
- **Significant Concern:** One or more rare species not detected

Current Condition: Significant Concern

Photos of spotted skunks have been extremely rare, and a few mountain lions have been captured on camera to date. Badgers caught on camera so far have been outside of the One Tam area of focus. Ringtail cats have not been detected, but we are currently trying to confirm a possible observation.

Confidence: Low

Trend: Unknown

METRIC 3: WILDLIFE PICTURE INDEX FOR KEY GROUPS

Baseline: Use trophic-level occupancy estimates to measure trends in abundance for key mammal groups including:

- Top predators (e.g., mountain lions [*Puma concolor*], coyotes [*Canis latrans*], and North American river otters [*Lontra canadensis*])
- Mesocarnivores (e.g., bobcats [*Lynx rufus*], gray fox [*Urocyon cinereoargenteus*], American badgers [*Taxidea taxus*], and western spotted skunks [*Spilogale gracilis*])
- Human associated mesocarnivores (raccoons [*Procyon lotor*] and striped skunks [*Mephitis mephitis*])
- Grazers (e.g., black-tailed deer [*Odocoileus hemionus*])
- Small prey (e.g., dusky-footed woodrat [*Neotoma fuscipes*], Sonoma chipmunk [*Tamias sonomae*], Western gray squirrel [*Sciurus grisus*], black-tailed jackrabbit [*Lepus californicus*], and brush rabbit [*Sylvilagus bachmani*])

Three years of data are needed to calculate a Wildlife Picture Index (WPI) and set standards and assessment (Townsend, 2015). At the time of this writing, the MWPIP has only two years' worth of data.

Condition Goal: Undetermined due to lack of data

Condition Thresholds:

- **Good:** Occupancy estimates for each trophic level are stable or increasing compared to baseline or desired goal (to be established); mammals are well distributed over the landscape and trophic levels are appropriately represented
- **Caution:** One or more trophic level is declining after trend is established
- **Significant Concern:** One or more trophic level continues to decline after three years

Current Condition: Unknown

So far, most native mammals appear to be well represented on the landscape based on preliminary analysis of preliminary data. There is concern with low number of detections for some rare species. Deer were far and away the species with the most detections (Figure 19.1; Townsend, 2015), though there are reasons why a simple count of detections would overestimate deer numbers. Deer can have ecosystem impacts through their browsing and seed predation on acorns. California Department of Fish and Wildlife is currently conducting research across Marin County to better determine deer abundance.

Confidence: Low

Trend: Unknown

There is not yet enough data from the MWPIP to assess the condition and trend; however, this important metric is included here to be updated as data become available.

METRIC 4: INVASIVE, NON-NATIVE MAMMAL SPECIES

Baseline: Non-native mammals in the One Tam area of focus and its surroundings include:

- Red fox (*Vulpes vulpes*) is an introduced species that is not commonly observed in Marin County.
- Feral cats (*Felis catus*) are present in some areas, probably focused around human developments. Where present they have large detrimental effects on birds, small mammals, reptiles, and amphibians.
- Fox squirrels (*Sciurus niger*) are an eastern species that is spreading westward, particularly in urban areas.
- Opossums (*Didelphis virginiana*) are non-native species that are established in Marin County, but not at very high densities.
- Feral pigs (*Sus scrofa*) were largely eradicated from Marin County in the late 1980s because of the dramatically detrimental effects they have on terrestrial ecosystems.
- Black (*Rattus rattus*) and Norway rats (*R. norvegicus*) are commonly found surrounding human development. These may not be reliably detected by MWPIP cameras due to their small size.

Condition Goal: No non-native mammals present, especially feral pigs or cats, as they have greater effects on ecological communities

Condition Thresholds:

- **Good:** Two or fewer non-native mammal species detected; and these species are not detected widely throughout study area; no feral pigs or cats detected
- **Caution:** Three to four non-native mammal species detected, or feral cats detected
- **Significant Concern:** Four or more non-native mammal species detected; evidence of a non-native mammal displacing a native species; or the presence of feral pigs

Current Condition: Good

Opossums and cattle have been the only non-native mammals detected during MWPIP Phase I to date.

Confidence: Moderate

While preliminary data and field observations indicate a low level of non-native mammal in the One Tam area of focus, more data are needed before a “High” level of confidence can be attained.

Trend: Unknown

The three months of data available to date is not sufficient for us to determine a trend (Townsend, 2015).

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

MARIN WILDLIFE PICTURE INDEX PROJECT

The MWPIP study area is approximately 32 square kilometers mostly, but not entirely, in the One Tam area of focus. 128 camera stations were deployed at 0.5-kilometer intervals in north south grids in the study area. Camera stations were set to maximize the likelihood of mammal and bird detections and, when possible, perpendicular to a logical animal pathway at a height to capture small mammals, such as gray squirrels, if they pass as close as a few feet from the camera.

Data from the camera's memory cards were downloaded onto computers for analysis. Trained staff and volunteers recorded the species and number of individuals for each image. A preliminary summary of the methods and results, including the species detected, how often, and other data was compiled (Townsend, 2015). In order to calculate a WPI, at least three years are needed to determine trend. In future years the MWPIP can be calculated to see if biodiversity is trending up or down or staying stable.

NPS TERRESTRIAL VERTEBRATE INVENTORY WORK

The National Park Service has completed terrestrial vertebrate inventory work at Muir Woods (Howell et al., 1998), Point Reyes National Seashore (Fellers & Pratt, 2002), and Golden Gate National Recreation Area (Semenoff-Irving & Howell., 2005).

OTHER SUPPORTING DATA SOURCES

Information for this chapter also came from staff and visitor observations, as well as observations and data from local non-profit organizations studying carnivores, including:

- **The River Otter Ecology Project** started a study of North American river otters in 2012 in Marin County. They perform non-invasive camera trapping and scat collection along coast, wetland, riverine, pond, and reservoirs, including some in the One Tam area of focus. Data collected may be analyzed for prey species, male/female ratios, degree of relatedness and abundance using molecular methods. Camera trapping allows for family structure analysis, vocalization studies and basic abundance information. (*riverotterecology.org*).

- **The Felidae Conservation Fund** conducted a San Francisco Bay Area bobcat study, which has seen large numbers of this species in Marin County. They have also had wildlife cameras in Marin County for the past four years to study mountain lion numbers, and believe that there are likely one transient and one resident male in the area. The Felidae Conservation Fund is working with other partners through the Bay Area Puma Project to initiate a mountain lion telemetry study in Marin County and the northern San Francisco Bay Area. (*felidaefund.org*).

- **California Department of Fish and Wildlife** conducting research on deer abundance and movement patterns in Marin, including study areas on Mt. Tam. This work includes camera traps, pellet collection, and DNA analysis along transects, and some deer telemetry.

INFORMATION GAPS

Climate Change: We do not know how the effects of climate change may alter mammal habitats on Mt. Tam.

Wildlife Camera Data: At least three years of data are required to analyze a WPI, so continuation of the MWPIP Phase I on Lagunitas Creek Watershed is needed. We are planning to implement Phase II of the MWPIP in Redwood Creek Watershed by early 2017.

Small Mammal Diversity and Population Information: We currently have very little population data for native small mammal species, apart from incidental sightings and a few small inventories. A needs statement to develop an assessment program for small mammals is included in Chapter 22 of this report.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Monitoring: Long-term MWPIP data collection to assess condition and trends beginning in 2014

Inventories: Mammal inventories in 1990–1997 and 2014 (NPS and MMWD)

FUTURE ACTIONABLE ITEMS

No future actionable items beyond continuing the MWPIP project as described above have been identified at this time.

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CHAPTER 20. AMERICAN BADGER (*TAXIDEA TAXUS*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Unknown

Trend: Unknown

Confidence: Unknown

WHY IS THIS RESOURCE INCLUDED?

The American badger may be found in larger patches of grasslands and coastal scrub habitats (i.e., treeless areas) on Mt. Tam (Figure 20.1; Lay, 2008; Bay Area Open Space Council [BAOSC], 2011). This species is an important indicator of the health of grassland ecosystems and connectivity. Their preference for open or mostly open landscapes, combined with their secretive, shy nature may make them more sensitive to human impacts. The badgers of Mt. Tam are part of a larger, connected, population complex extending to Point Reyes and Petaluma (BAOSC, 2011). Maintaining this badger population complex is very important because large forest tracts isolate Marin County badgers from badger populations to the north and east.

These upper-level predators prey upon small mammals, and may be considered a keystone species, as in their absence, their prey species may occur in higher than normal densities. They are also considered an important ecosystem engineer thanks to extensive and powerful digging associated with creating burrows for denning and when searching for prey. Their actions help aerate soils, churn up the seed bank, change soil moisture levels, increase diversity of plant species near dens, and provide shelter for numerous species including the burrowing owl, lizards, insects and other invertebrates, and amphibians (Lay, 2008).

OVERALL CONDITION

Designated by the California Department of Fish and Wildlife as a sensitive species (Bay Area Open Space Council [BAOSC], 2011), the American badger was historically persecuted by ranchers and is vulnerable to habitat fragmentation and habitat loss, vehicle strikes, and rodenticide exposure (Lay, 2008). Trapping and predator control have also been factors in its decline. The current status of American badgers on Mt. Tam is unknown, although the mountain has areas of suitable habitat (Figure 20.2). Remotely triggered cameras from the Marin Wildlife Picture Index Project (MWPIP) and Lucas Valley Open Space Preserve have detected badgers (Townsend, 2016) and the MWPIP cameras will continue to provide badger distribution and abundance data to assess its status. The cameras on the Lucas Valley Open Space Preserve lands are located a short distance north of the Mt. Tam area of focus, and the badgers detected there are a part of the larger Marin County badger complex.

FIGURE 20.1 HABITAT SUITABILITY FOR AMERICAN BADGERS IN THE SAN FRANCISCO BAY AREA (BAOSC, 2011)

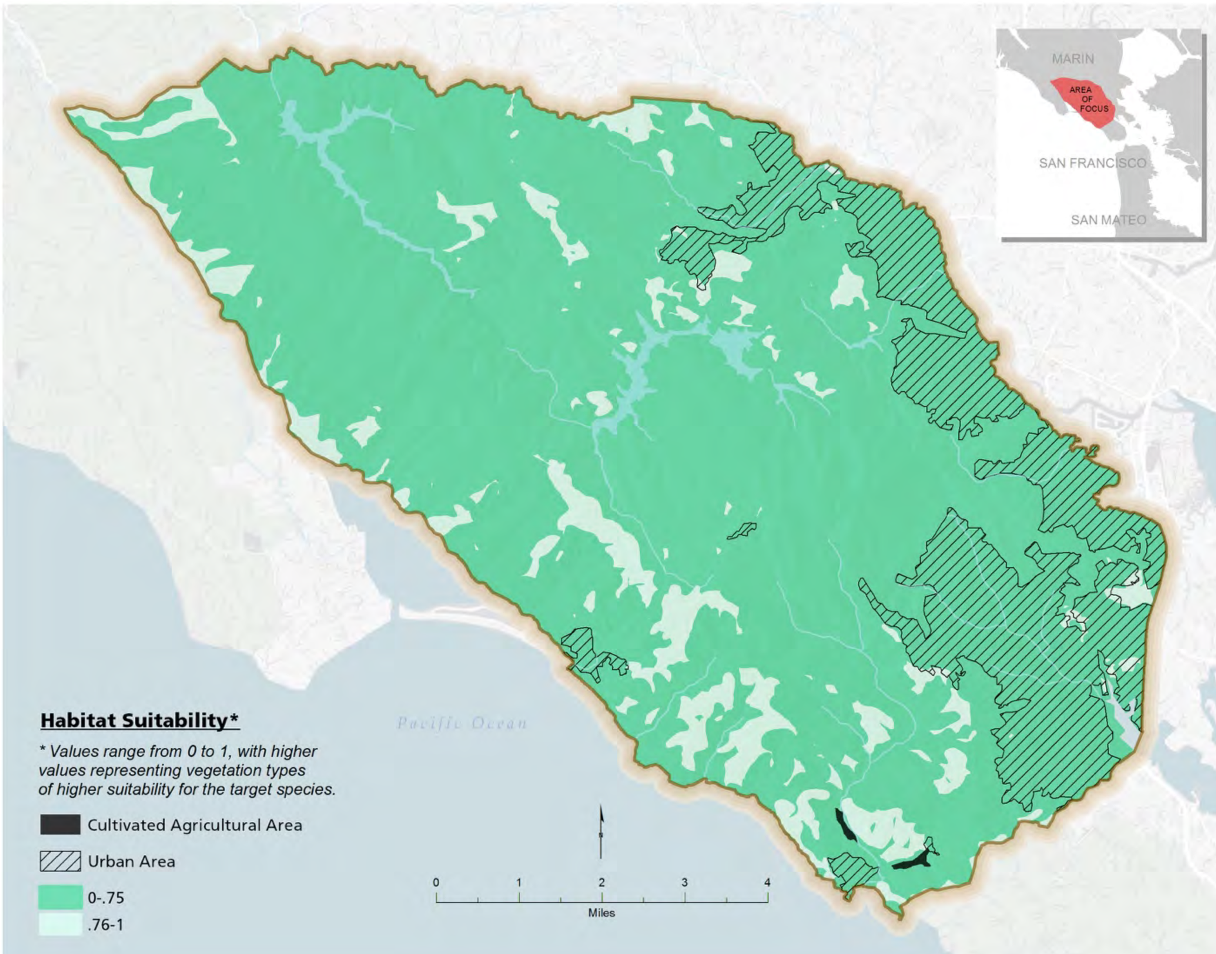
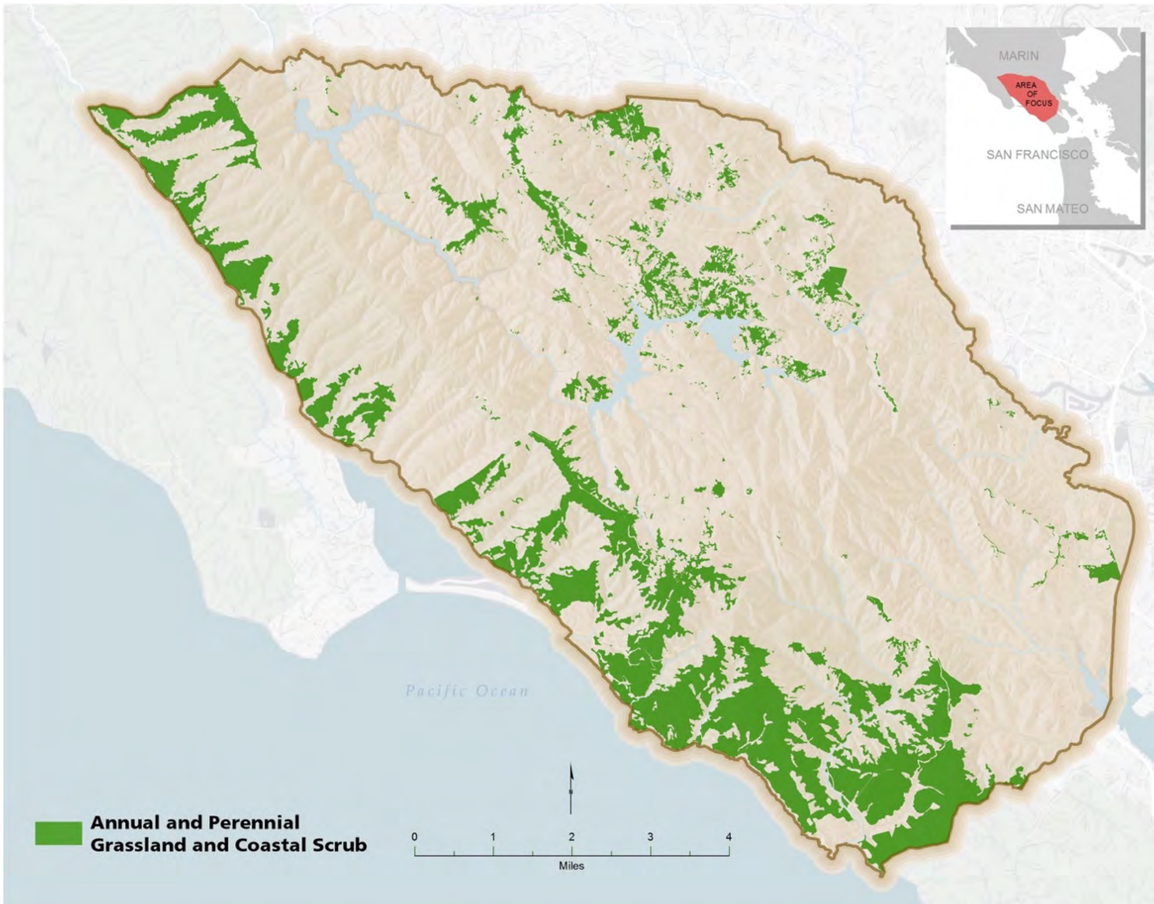


FIGURE 20.2 MAPPED GRASSLAND AND COASTAL SCRUB HABITAT WITHIN ONE TAM AREA OF FOCUS (BASED ON AGENCY DATA LAYERS)



DESIRED CONDITIONS

The desired condition is that American badgers are present in all suitable grassland and coastal scrub habitat patches in the One Tam area of focus.

STRESSORS

Habitat Loss, Fragmentation, and Development: American badgers are sensitive to habitat fragmentation and development because they require larger patches of grassland or coastal scrub habitats. Currently, the loss of grassland habitat and conifer encroachment is reducing their habitat within the protected lands of Mt. Tam. Vehicle strikes are also a significant threat to American badgers, and could be a factor on roads in the One Tam area of focus.

Past Land Uses: Historically, ranchers likely trapped American badgers to reduce livestock risks from their burrows. They also may have impacted prey populations for species like California ground squirrels.

Rodenticides: American badgers are susceptible to secondary exposure to rodenticides.

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: WILDLIFE PICTURE INDEX FOR AMERICAN BADGERS

Baseline: Data from the MWPIP will be used for this metric. Species-specific occupancy estimates will be used to establish baseline abundance, which will then be used to establish if the American badger remains present and if its abundance is stable, decreasing, or increasing. Camera trap data will also be used to track its presence and distribution. No badgers have been caught on camera in the One Tam area of focus, but they have been detected on MWPIP cameras outside the One Tam area of focus and Marin County Parks lands nearby (Townsend, 2016). Additional cameras being installed in grassland habitats in the near future may increase our ability to detect badgers on Mt. Tam as well.

The MWPIP will provide presence/absence data for grassland ecosystems and distribution and abundance data seasonally and yearly. The baseline abundance estimate will be established the first year, and whether abundance is stable, decreasing, or increasing can be determined over time. Increasing the extent of camera trapping effort in grasslands will provide more data upon which we can make stronger inferences about its current and future status.

Condition Goal: Information from the MWPIP for American badgers is stable or increasing.

Condition Thresholds: Unknown at this time. These will need to be determined from MWPIP data.

Current Condition: Unknown

Confidence: Unknown

There is not currently enough data to make an assessment of this metric.

Trend: Unknown

METRIC 2: AMERICAN BADGER PRESENCE IN SUITABLE HABITAT

Baseline: The baseline for this species is still being established through the MWPIP.

The distribution of American badgers will be determined by mapping detections obtained through photographs at camera traps. Additionally, cameras in grasslands that have no detections (seasonally or yearly) will also be noted as this species potentially being absent from suitable habitat. The goal is to eventually obtain detections in areas where badgers were previously absent, increase rates of detection in areas where badgers were detected but are rare, and/or increase the number of seasons that badgers are detected over the course the year.

Condition Goals:

- American badgers are detected at all camera locations in grassland or coastal scrub habitat patches greater than 1,000 acres

- Maintain at least six suitable grassland and/or coastal scrub habitat patches of greater than 1,000 acres; this goal is based on the estimate of 6,700 acres of grassland and coastal scrub habitat in One Tam area of focus (Figure 20.2), and that female American badgers require at least about 1,000 acres for their home range (BAOSC, 2011)

Condition Thresholds: A habitat assessment and more camera data are required to determine condition thresholds.

Status: Unknown

Confidence: Unknown

More data are needed to make this assessment.

Trend: Unknown

Baseline data are still being established for this species.

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

INVENTORIES AND SURVEYS

Inventories at Point Reyes National Seashore detected American badgers (Fellers & Pratt, 2002), and this species is commonly observed in the seashore's grasslands (D. Press, personal communication). Inventories in the Golden Gate National Recreation Area have only found American badgers incidentally (Semenoff-Irving & Howell, 2005), and they were not detected in grassland plots in a survey of Muir Woods (Howell et al., 1998). Badgers were detected with remote wildlife cameras in the Marin Headlands in association with a 2014 bioblitz (Edson et al., 2016)

No American badgers have been confirmed in the One Tam area of focus yet using remote, motion-activated wildlife cameras in Phase I of the MWPIP, but they have been detected by this project outside of the One Tam area of focus See Townsend (2015) for a full description of methods.

A survey of potential American badger burrows in the Lucas Valley Open Space Preserve documented 20 burrows in several clusters. Camera traps installed in 2015 detected American badgers at three locations, indicating a local population of one to three animals (Townsend, 2016).

OTHER INFORMATION SOURCES

There are anecdotal accounts of American badgers at Mount Burdell Open Space Preserve and Vince Mulroy Preserve, both in the northeastern part of Marin County. The majority of collected or detected American badgers have been from coastal Marin County around Olema and Nicasio. A total of 11 specimens were collected in Marin County between 1913–2011 (Townsend, 2016).

INFORMATION GAPS

Inventory Data: We lack adequate American badger inventory data for the One Tam area of focus.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Monitoring: Collecting MWPIP data to confirm the presence of this species in the One Tam area of focus

Outreach: Sharing the environmental dangers of rodenticides with the public

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Inventory and Monitoring:

- **American Badger Monitoring:** Expand the existing MWPIP array into large grasslands patches to improve our understanding of badger status and trends within the One Tam area of focus

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CHAPTER 21. NORTH AMERICAN RIVER OTTER (*LONTRA CANADENSIS*)

INTRODUCTION

CONDITION, TREND, AND CONFIDENCE

Condition: Good

Trend: Improving

Confidence: Moderate

WHY IS THIS RESOURCE INCLUDED?

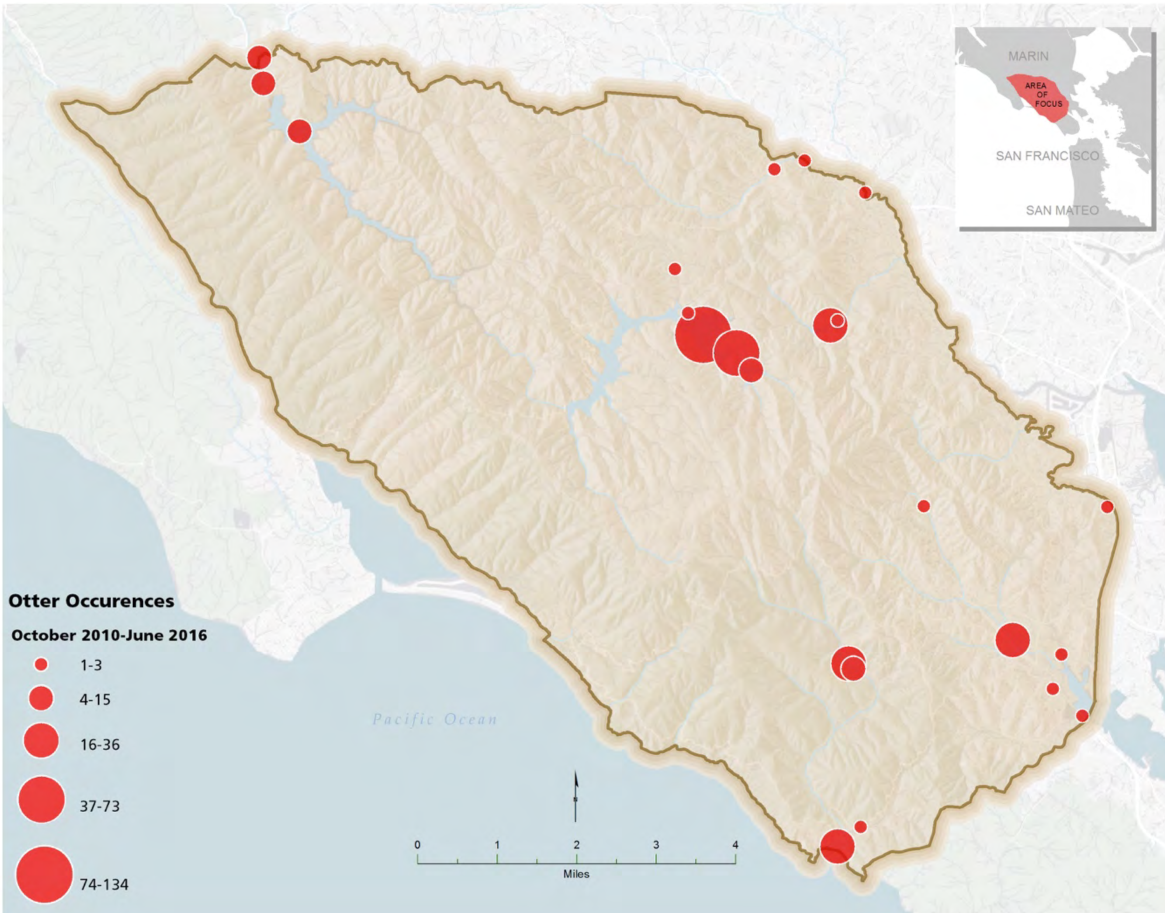
North American river otters are charismatic predators that make excellent ambassadors for watershed conservation and wetland restoration. They are highly observable and often detected, which also makes them good candidates for citizen science monitoring. River otters are considered an indicator species and their presence is a hopeful sign of improving watershed conditions.

These apex aquatic predators play an important role in ecosystem health, as they eat fish, crustaceans, invertebrates, birds, and amphibians. Their high energetic demands require them to consume 15–20% of their body weight in prey daily (Serfass et al., 1990). North American river otters spend 75% of their time on land (Kruuk, 2006), with the remaining time hunting and traveling in waterways. Their use of both terrestrial and aquatic habitats, combined with their attractiveness to the public, make them an ideal species for fostering public engagement in Mt. Tam's watershed health.

OVERALL CONDITION

Historically extirpated from the San Francisco Bay Area, the return of North American river otters after a decades-long absence is a true wildlife success story. Their populations here have significantly increased both in number and distribution over the last decade (Bouley et al., 2015). Currently, North American river otters can be found in every part of Mt. Tam's watersheds, from the headwaters to the coast and San Francisco Bay (Figure 21.1; Bouley et al., 2015). Observational data from the River Otter Ecology Project also indicate the presence of otters in most water bodies in the One Tam area of focus (Bouley et al., 2015; River Otter Ecology Project, 2016).

FIGURE 21.1 NORTH AMERICAN RIVER OTTER OBSERVATIONS (RIVER OTTER ECOLOGY PROJECT, 2016)



DESIRED CONDITIONS

The desired condition is that North American river otters are present in all suitable water bodies in the One Tam area of focus.

STRESSORS

Human-related Stressors: Historic persecution, loss of habitat, and poor water quality were probably major factors in the extirpation of North American river otters from the San Francisco Bay Area. Fur trapping may have also contributed to their decline. Today, they are susceptible to being hit by vehicles as they traverse terrestrial habitats (Bouley et al., 2015).

Fishery Declines: Fish are a primary prey for North American river otters, so declines or collapses of fisheries can have serious impacts on their population numbers and distribution.

Watershed Development: Because of their dependence on aquatic ecosystems, the loss or degradation of these habitats—as a result of human development or land use changes—can negatively affect North American river otters. They are also vulnerable to aquatic pollution, as well as secondary exposure to rodenticides.

Disease: North American river otters are susceptible to diseases such canine distemper, feline and canine parvovirus, and rabies, and may be susceptible to mercury poisoning from the fish they prey upon (Gaydos, 2014).

CONDITION AND TRENDS ASSESSMENT

METRICS AND GOALS

METRIC 1: NORTH AMERICAN RIVER OTTER PRESENCE

Baseline: North American river otters have increased dramatically over the last decade, and now occupy most of the suitable water bodies within the One Tam area of focus (Figure 21.1, Bouley et al., 2015).

Condition Goal: North American river otters are present in all suitable water bodies

Condition Thresholds:

- **Good:** North American river otters present in >80% of suitable water bodies
- **Caution:** North American river otters present in <80% and >/=60% of suitable water bodies
- **Significant Concern:** North American river otters present in <60% of suitable water bodies

Current Condition: Good

Observational data from the River Otter Ecology Project indicate the presence of North American river otters in most suitable water bodies (Figure 21.1; Bouley et al., 2015).

Confidence: Moderate

Additional data are needed to determine presence in all suitable water bodies.

Trend: Improving

North American river otters have come back from being extirpated in the San Francisco Bay Area, to now being present in most suitable water bodies in the One Tam area of focus (Bouley et al., 2015).

SUPPORTING DATA, OBSERVATIONS, RESEARCH, AND MANAGEMENT

RIVER OTTER ECOLOGY PROJECT

Since 2012, the River Otter Ecology Project has been collecting observations of North American river otters and monitoring coastal and riverine populations in Marin County through non-invasive camera trapping and scat collection. Camera trap and observational data from 2012 and 2013 are published and available (Bouley et al., 2015; *riverotterecology.org/maps-of-bay-area-sightings.html*).

San Francisco State University is conducting ongoing genetic analysis of collected scat that can eventually reveal number of haplotypes, male/female sex ratios, population abundance, family relationships, whether the population is growing rapidly, and its range. Yearly analyses of bacterial cultures for *Salmonella* and *Vibrio* species have revealed four species of *Vibrio* and no *Salmonella* in the samples tested so far.

MARIN WILDLIFE PICTURE INDEX PROJECT (MWPIP)

A small number of North American river otter pictures have been captured through Phase I of the MWPIP since September 2014, though most project cameras are not situated near aquatic habitats. See Townsend (2015) for additional details about this project's methodology and its findings.

INFORMATION GAPS

Population Data: While North American river otters have been documented in Mt. Tam's watersheds, little is yet known known about their population demographics beyond their presence and limited abundance data. Data on their home range and dispersal patterns are also lacking, and the distribution and abundance of prey are poorly understood. River Otter Ecology Project observational and genetic work in progress should ultimately help to answer some of these questions.

Water Quality Impacts: Insufficient information is available about how the health of North American river otters is linked to water quality indicators for toxins and pathogens.

PAST AND CURRENT MANAGEMENT, RESTORATION, MONITORING, AND RESEARCH EFFORTS

Below are some of the stewardship and management activities that have been undertaken over the years to monitor, protect, and restore this health indicator.

Restoration: Improvement of aquatic habitats and salmonid populations at Muir Beach

Management: Installation of otter crossing signs near Muir Woods National Monument to help reduce road kills (NPS and State Parks)

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Existing Program Support:

- **Habitat Restoration for Salmonids:** Continue ongoing management and monitoring efforts in partnership with the River Otter Ecology Project; Continue riparian and wetland restoration for salmonids, which will also benefit otters

SOURCES

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CHAPTER 22. WILDLIFE INDICATOR NEEDS STATEMENTS

There are many things that remain unknown about Mt. Tam's wildlife, as evidenced by the information gaps identified in the preceding chapters of this report, as well as the initial proposed indicators that did not make it into this report (see Appendix 1).

The resources described below are a subset of that initial list of possible indicators for which sufficient information may be attainable in the near future. For many, the missing data are relatively easy to gather and/or there are already plans to collect this data soon.

The following summaries describe the current state of knowledge about these indicators and what it might take to gather enough additional information for them to be included in the next iteration of this assessment.

INSECTS

WHY THIS IS AN IMPORTANT INDICATOR

Insects represent the largest part of the Earth's known biological diversity, comprising over half of all named species (Grimaldi & Engel, 2005). In terrestrial ecosystems, they are well known for performing many important functions such as herbivory, predation, parasitism, pollination, and decomposition. These ecosystem services are critical to sustaining healthy plant diversity and soil composition. Insects are also a food source for many other species, and constitute a vital part of the food web.

Unfortunately, there are few complete summaries of the insect components of most ecosystems, including those found on Mt. Tam, due to their unparalleled diversity, small size, and the cryptic habits of the vast majority of species. The most recent inventory of a large order of insects in Marin County was conducted in the area burned by the 1995 Mount Vision Fire on Inverness Ridge. This inventory produced a total of 600 species of Lepidoptera (Powell, 2005). Only the roughest estimates about insect diversity can be made in the absence of baseline information from a detailed insect survey. Given Mt. Tam's complex and varied topography, geology, vegetation communities, and microclimates, some experts suggest that the number of insects could be six to ten times greater than the number of plants found on the mountain (P. DaSilva, personal communication).

POTENTIAL MONITORING AND DATA COLLECTION

COLLECTIONS ANALYSIS

Some entomologists and scientific institutions (e.g., California Academy of Sciences, Essig Museum of Entomology, and College of Marin) have conducted research on Mt. Tam that has resulted in published articles and preserved specimens. Information from these efforts should be analyzed and consolidated as availability of electronic information continues to increase, and subsequent periodic queries of databases could yield updated species lists. Additionally, direct examination of collections of specific taxa that have not yet been digitized could be undertaken with the help of specialists.

INVENTORIES AND FIELD WORK

Additional inventories and collections are essential to update the information available from collections and publications. A workshop with local entomologists would be necessary to help focus inventories on which orders or specific species could be best used as indicators, and how best to address data gaps on species richness and population trends.

Targeted surveys of selected taxa on Mt. Tam—conducted by specialists who could help interpret the results in the context of larger-scale patterns of richness and population fluctuation—would provide valuable information. Taxa-specific inventories might include dragonflies and damselflies (Odonata), ground beetles (Carabidae), butterflies and moths (Lepidoptera), ants (Formicidae), and bees (Apoidea).

All-taxa bioblitzes involving experts and interested community members could also produce valuable information on the insect fauna of select habitats of interest over a number of years.

FUTURE ACTIONABLE ITEMS

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Analyze Invertebrate Collections: Reviewing and consolidating species records from existing collections is a crucial step in developing monitoring programs for taxonomic groups of greatest concern. Digitizing specimen records as part of this process would greatly facilitate input from the broader research community.

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Grimaldi, D. & Engel, M.S. (2005). *Evolution of the Insects*. Cambridge, UK: Cambridge University Press.

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CALIFORNIA GIANT SALAMANDERS (*DICAMPTODON ENSATUS)*

The One Tam area of focus supports California giant salamander populations in various streams. However, our current knowledge of giant salamanders is limited to a larval inventory of the species in Redwood Creek in Muir Woods and Mount Tamalpais State Park, limited stream surveys by the U.S. Geological Survey on federal lands in the region, and incidental observations during fish surveys.

WHY THIS IS AN IMPORTANT INDICATOR

Although not federally listed, this species is a special status animal and has a state Natureserve rank of S2/S3 (imperiled/vulnerable) (explorer.natureserve.org/nsranks.htm) and an IUCN status of near threatened (iucnredlist.org/details/59080/0). California giant salamanders are excellent indicators of stream health due to their relatively long lives and stable population sizes. They live year-round in headwater streams and adjacent riparian areas, and can be useful as indicators for the health of these habitats.

POTENTIAL MONITORING AND DATA COLLECTION

The primary goal of California giant salamander monitoring would be to establish a baseline status (i.e., presence/not found) for all of the headwater streams in the One Tam area of focus. Inventory techniques would likely include visual surveys using stream view boxes or snorkel surveys. Other inventory methods could involve the use of dip or kick nets.

California giant salamanders are easily distinguished from other salamanders and newts in the area, and would be suitable for a community science inventory and monitoring program. Identification of streams with populations of this species would aid in their protection, support monitoring for emerging salamander diseases, and provide opportunities for scientific study.

Goals of the giant salamander monitoring program would be to:

- Establish presence/not found status for all headwater streams in the One Tam area of focus
- Determine their distribution in streams where they are present
- Assess the presence/absence of predatory fish and introduced crayfish
- Develop metrics for assessing the status of giant salamanders in the One Tam area of focus
- Enhance public information and outreach regarding the status of this species
- Monitor key sites for emerging salamander diseases as needed
- Foster opportunities for scientific research on the species in the One Tam area of focus that would assist in understanding their biology and conservation

BATS

WHY THIS IS AN IMPORTANT INDICATOR

Bats are good ecological indicators because they are sensitive to climate change, habitat loss, pesticides, disease, and disturbance at breeding colonies. In addition, white-nose syndrome, which can decimate bat colonies, was recently detected on the West Coast in Washington state. Thus, there are concerns of this disease spreading southward down the coast.

Mt. Tam supports a diverse bat community; however, our current knowledge of bats on Mt. Tam is limited to inventory studies of bats at Muir Woods (Heady & Frick, 2004) and Marin Municipal Water District structures (Garcia and Associates, 2003), as well as very limited monitoring and research.

FUTURE ACTIONABLE ITEMS

Priorities for bat monitoring include inventories to establish species diversity in priority habitats (e.g., redwood and Douglas-fir forests, oak woodlands, and riparian and lake habitats). Inventory techniques would likely be based around an array of acoustic monitoring devices and mist netting surveys. Also, identifying locations of key maternity colonies would allow these sites to be monitored, protected, and investigated for white-nose syndrome

The following section contains needs identified by agency and local scientists as a part of the development of this report. These are actions not currently funded through agency programs, and will be further evaluated and prioritized for future funding and implementation outside of this health assessment process.

Implement Bat Inventory and Monitoring Program: Completion of a comprehensive bat inventory is a necessary first step in developing a monitoring program that can inform meaningful protection for at least 12–14 bat species believed to occur on Mt. Tam. Implementing components of the North American Bat Monitoring Program (NABat) would allow One Tam partners to not only improve their understanding and protection of local bat populations, but to contribute to continental level efforts to protect bat populations. NABat describes four approaches to gather monitoring data to assess changes in bat distributions and abundances: winter hibernaculum counts, maternity colony counts, mobile acoustic surveys along road transects, and acoustic surveys at stationary points. A One Tam regional effort is likely to employ a subset of these approaches.

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https://irma. nps.gov/DataStore/Reference/Profile/143323

SMALL MAMMALS

Small mammals are relatively difficult to study because trapping is typically involved. The small mammal communities of Mt. Tam have not been well studied. Vertebrate inventories of the Golden Gate National Recreation Area (Semenoff-Irving & Howell, 2005), Muir Woods National Monument (Howell et al., 1998), and Point Reyes National Seashore (Fellers & Pratt, 2002) have been completed, but not updated.

Additional small mammal work on Mt. Tam includes an inventory at Muir Beach (Takekawa et al., 2003) and SOD research on deer mice and woodrats (Swei et al., 2011). The Marin Wildlife Picture Index Project is providing information on the terrestrial mammal community larger than one kilogram, and more information on the state of small mammals on Mt. Tam would complement that project.

WHY THIS IS AN IMPORTANT INDICATOR

Small mammals are sensitive to habitat change, are an important food resource for predatory species, and can impact vegetation by consuming and dispersing seeds (Converse et al., 2006). For example, dusky-footed woodrats (*Neotoma fuscipes*) are the primary food item of the federally threatened Northern Spotted Owl (*Strix occidentalis caurina*). Research conducted in Marin County, including on Mt. Tam, demonstrated that Sudden Oak Death (SOD) has led to an increase in deer mice (*Peromyscus maniculatus*) and decrease in dusky-footed woodrats (Swei et al., 2011).

POTENTIAL MONITORING AND DATA COLLECTION

The goal of small mammal monitoring would be to inventory small mammals in priority habitat types, including updating previously done monitoring work. Particular attention would be paid to making sure we know what species are currently present, so we can identify if species are disappearing from, or moving into, the One Tam area of focus. Particular attention should be paid to habitat types that are rapidly changing.

Such a program would include:

- Identifying priority habitats for small mammal inventory or monitoring work
- Developing a study plan including areas to trap, number of traps and trap nights, and trap revisit frequency
- Determining whether focused studies of particular species or habitats are needed (e.g., dusky-footed woodrats), and which of those could be accomplished through focused research

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Takekawa J.Y., Bias, M.A., Woo, I., Demers, S. A., & Boydston, E. E. (2003). *Small mammal survey at Big Lagoon, Muir Beach, Marin County, CA* (Unpublished progress report). Vallejo, CA: U.S. Geological Survey.

CHAPTER 23. USING INDICATORS TO SEE THE BIGGER PICTURE OF MT. TAM'S ECOLOGICAL HEALTH

The preceding chapters of this report have described how certain species (e.g., Osprey, coho salmon), taxonomic groups (e.g., birds, mammals), or vegetation communities (e.g., open-canopy oak woodlands, serpentine barrens) can be used to take some measure of the health of Mt. Tam. These indicators were chosen because they were objectively or subjectively viewed as important components of the One Tam area of focus. There may be many more indicators not described here that could also be used to assess ecological health. The ability to measure and track important indicators is invaluable for understanding how the mountain's natural resources are faring. However, indicators only represent some portion of the overall ecological community and natural processes of which they are part.

Combining—or "rolling up"—these health indicators in various ways allows us to communicate a more complete understanding of how well ecological systems and landscape-level processes are functioning or being affected within the entire One Tam area of focus. Furthermore, understanding the health of these larger systems and the linkages between health indicators and stressors can help managers know when to take resource protection or restoration actions.

Rolling up indicators for this purpose is not an exact science; instead, it provides another tool for land managers and scientists to track the mountain's health. The interactions among human use, health indicators, and ecosystem processes are complicated, interesting, and tell an important story about what is happening in the area. Roll-ups can help land managers understand those stories in a new way. However, this approach also runs the risk of obscuring important details as a result of combining different indicators together. For example, rolling up some individual species and community-level indicators to predict the health of an ecosystem may result in that ecosystem being described as doing well overall, while some species within that system are actually doing poorly. Given the range of possible contributing factors, it can also be challenging to decide what to include—or not include—in the roll-up.

Participants in the March 10–11, 2016 workshops considered a number of ways that indicators could be combined to communicate broader ecosystem health in a publicly meaningful way (see next section). Out of all of the possible roll-ups that were considered, the ones for which we have enough information to represent are summarized in the Landscape-level Indicators Summary section of this chapter. Those that were not included were left out because the necessary data are not already available or easy to obtain, and/or the analysis cannot be taken on with current staff and funding. These efforts will be prioritized and undertaken as resources are secured.

POSSIBLE WAYS TO COMBINE INDICATORS

Ecosystems include vegetation communities, the wildlife species known to be associated with them, and associated natural processes. For example, the health of grasslands as described in Chapter 8 considers a suite of metrics related to just the vegetation community itself. However, mammals, insects, birds, extirpated species, the role of natural processes (including disturbances), and the impacts of all ecological stressors are all also important ecosystem components to consider when assessing grassland health.

Watersheds are physically defined landscape features and useful lenses through which to look at a number of ecological functions and processes. A consideration of the numerous ecological aspects that speak to watershed health would include wildlife and plant communities; floodplain and other habitat connectivity; sediment transport; groundwater recharge; erosion; channel incision; water withdrawals; human-built components such as roads, trails, culverts, and bridges; and potentially the effects of restoration or management actions within the watershed. Such an analysis would provide valuable information about which watersheds are the healthiest, and which ones should perhaps be the focus of additional work. Analyzing all indicators within each watershed separately may reveal health patterns that might highlight some watersheds as better or worse than others.

Mt. Tam's tremendous levels of native **biodiversity** are what make the mountain such an ecological treasure. Measures of biodiversity as a whole would include several indicators and metrics for all of the taxonomic groups on Mt. Tam including species richness and evenness indices. In addition to revealing the current conditions and trends of both native and non-native biodiversity, similar analyses in the future may reveal important biodiversity changes. An understanding of the number and type of species that have been extirpated—or are close to extirpation—from the One Tam area of focus would also provide an important measure.

A rapidly changing climate is going to be the major challenge for managers working to maintain the health of Mt. Tam. The **climate vulnerability** of particular species or communities is an important factor in how their condition or trend might be affected by current and future environmental conditions. Plants or animals with known specific temperature or precipitation/fog requirements would be included in this analysis, as would those that are dependent on habitats that are predicted to change or disappear (e.g., grassland- or maritime chaparral-dependent species).

Historic records of species or community changes, as well as using global climate models to project potential changes to vegetation, could be used to inform this analysis. The results would be particularly helpful for long-term planning and goal setting by helping reveal sensitive locations, species, and/or entire communities that could be targeted for management interventions. It could help managers prioritize places (e.g., foggy areas) to protect and actively manage to reduce other stressors impacting certain communities (e.g., redwoods). Alternately it can help managers determine when to embrace changes that are inevitable and decide which species or communities they may not be able to maintain under future conditions.

Landscape connectivity is another way to use individual species or community data to understand and manage for climate change impacts. In a hotter future, Mt. Tam may be a refuge for cooler climate- or fog-dependent species, but only if they are able to migrate and disperse into the region. Landscape connectivity is already a key component of ecosystem health, and it will become even more vital as plants and animals need to migrate due to changing climate conditions. Regional landscape connectivity mapping and planning efforts may provide some of this information, as would looking at certain species such as mountain lions that depend on large swaths of connected areas.

Models that project future potential changes to the mosaic of vegetation across a region can help predict which species may thrive on Mt. Tam in the future, and can be used to facilitate decisions about assisted migration for species that may not be able to move on their own. Unfortunately, certain species may not be able to survive in their current locations under projected future climate conditions regardless of what land managers do. Climate adaptation strategies could be used to strengthen each species' resistance and resilience to changing climate and their ability to respond. A focus on restoring and protecting ecosystem function and diversity will likely have to take priority over saving individual species, even if it the resulting ecosystems are different than what is there now. However, rare and other special status species may be given higher priority for conservation. An analysis of broader aspects of ecosystem health such as watershed, hydrologic, or geomorphic processes, ecosystem functions, and habitat patch size can also be used to support overall climate change resiliency management.

Recreational use of Mt. Tam's open spaces can affect the mountain's ecological health. An analysis of impacts associated with infrastructure supporting recreational use could include metrics on road and trail density, condition, and patterns, and the resulting potential ecological impacts such as erosion and habitat fragmentation. Levels of impervious surfaces, invasive species introduced or spread by human use, and road kill data could also be considered. Providing recreational opportunities is an important mandate of the national, state, and county park agencies on Mt. Tam. A comprehensive analysis of recreational use impacts could help them continue to meet this mission, while also allowing them to meet their resource protection goals.

Stewardship opportunities including volunteer activities, community science needs, and education and outreach programs may be revealed by looking at those species or systems where individuals or community groups may most readily and effectively contribute to achieve resource management goals and support land managers' work. Identifying goals and metrics for volunteer participation that alleviate the impacts of ecological stressors—like the spread of invasive species—could help strategically focus community-based support.

Broad, **publicly compelling topics** such as wildlife, or individual species such as coho salmon (*Oncorhynchus kisutch*) or Northern Spotted Owls (*Strix occindentails caurina*), are powerful engagement tools. Focusing on the conditions and overall health of iconic species can benefit entire ecological communities (e.g., protecting coho salmon and Northern Spotted Owls helps support redwood forest health). People may also have strong emotional connections to species that have been lost or might soon disappear, or those that are unique to Mt. Tam.

The experiences people have on Mt. Tam and its ecosystem health are also directly connected. For example, changing viewsheds as a result of Douglas-fir encroachment can make hiking less enjoyable. There is also an important connection between the mountain's streams and reservoirs and local residential water supply. A roll-up of these kinds of topics would require a better understanding of what people care most about and what they perceive as the biggest threats to Mt. Tam. It could enable land managers to more effectively communicate about their most pressing management issues in ways that the public may find most meaningful, and engage them in possible solutions or further research. It could also be a chance to use science to build trust, and help scientists and the community to become better partners in advocating for the mountain's health.

From the above options, the roll-ups we were able to include below are:

- Biodiversity
- Climate change and expected impacts to some indicators
- Ecological communities

THE ANALYSIS PROCESS

To roll-up species, vegetation communities, or taxonomic guild indicators in a way that speaks to the health of larger themes, each indicator had to have its own condition score, trend, and a certain level of confidence in the data. In many cases, this meant that only vegetation communities and bird guilds were included because their associations were much more well established than those of other taxonomic groups. In other cases, habitat generalists, such as some mammals, were not included because they do not reveal anything in particular about specific communities. Other species were omitted due to a current lack of sufficient data on their condition or trend.

Two main tools were used to interpret the health of Mt. Tam: the individual metrics and goals selections that were developed for each indicator, and the species trait-status database (see Appendix 4).

Any time indicator data were aggregated, whether it was by taxonomic group, habitat community, or a broader theme, the calculation used the following principles derived from the National Park Service's Natural Resource Condition Assessment process (*nature.nps.gov/water/nrca/*), and modified slightly based on best professional judgement of Health of Mt. Tam's Natural Resources Advisory Committee members (see Appendix 3 for a list of committee members). The Glossary of Terms at the beginning of this document has additional information about the terms used below.

To determine the combined **condition**, each "Significant Concern" score (red chart segment) is assigned zero points, each "Caution" (yellow segment) is assigned 50 points, and each "Good" (green segment) is assigned 100 points. "Unknown" condition scores (gray segments) are omitted from the calculation. Once the average is calculated, the following scale is used to determine the resultant condition: Good = 75–100, Caution = 26–74, Significant Concern = 0–25.

To determine the overall trend, all trend metrics are arranged in the following order: "Declining," "No Change," "Improving." The median value is then calculated. Cases where trend is "Unknown" are omitted from this calculation. If the median result is half way between two values (such as "Declining" and "No Change"), the mode and best professional judgement were used to determine the correct trend value. This method of determining trend deviated from the National Park Service's Natural Resource Condition Assessment process, but was necessary to accommodate the relatively small number of metrics that many of the indicators and roll-ups had. In the charts below, a result of "Improving" is indicated by an upward arrow, "Declining" by a downward arrow, and "No Change" is indicated by a horizontal double-ended arrow.

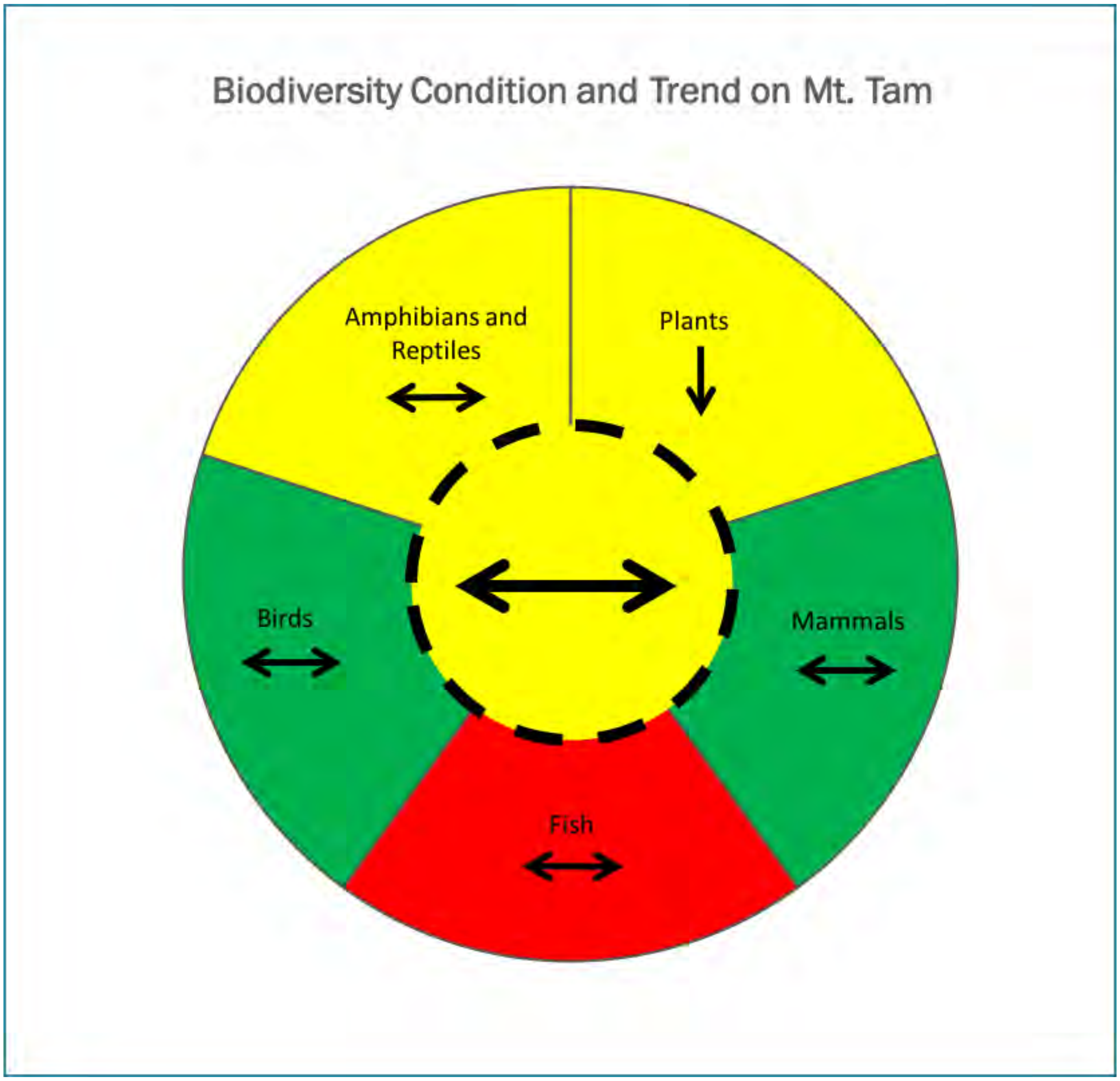
To determine the combined **confidence** level, each "Low" confidence is assigned zero points, each "Moderate" confidence is assigned 50 points, and each "High" confidence is assigned 100 points. "Unknowns" are omitted from the calculation, but every metric with a condition is assumed to have at least "Low" confidence. Once the average is calculated, the following scale is used to determine the resulting level of confidence in the data: High = 75–100, Moderate = 26–74, Low = 0–25. In the charts below, "High" confidence is indicated by a solid line, "Moderate" confidence by a dashed line, and "Low" confidence by no line.

The pie charts below are an **illustrative representation** of the components that were included in these roll-ups. The center color and arrow represents the overall combined condition and trend. Individual segments around the edge represent the condition and trend for each component that was considered in the roll-up. It is important to note that these components **are not weighted and are represented graphically solely for the purpose of communicating what was included.**

LANDSCAPE-LEVEL INDICATORS SUMMARY

BIODIVERSITY

FIGURE 23.1 BIODIVERSITY CONDITION AND TREND IN THE ONE TAM AREA OF FOCUS



Condition: Caution

Trend: No Change

Confidence: Moderate

The health of the biodiversity of Mt. Tam is represented by a collection of key taxonomic groups. Each group has one equal segment, and each segment was given its own condition, trend, and confidence score by aggregating the metrics of the species within them (Figure 23.1). All vegetation indicators have been combined into the group “plants,” which may bias the analysis in favor of the wildlife guilds included.

For plants, the aggregated condition and trend was calculated from our knowledge of key biodiversity characteristics. Four plant lists were utilized:

- Likely extirpated plants from the One Tam area of focus, developed by comparing what we currently have with what was known to exist on Mt. Tam (see Appendix 7)
- The status of rare plant populations (see Appendix 6)
- The status of locally rare plant populations (as defined as plants with three or fewer populations or plants at the edge of their range/disjunct population)
- An assessment of the number of non-native species compared to native

For birds, the aggregated condition and trend was calculated from the species trait-status database (Appendix 4), these species were chosen as good representatives of the overall bird population on Mt. Tam. First, the individual status and trends of the indicator species were rolled up to habitat community level (e.g., riparian areas, oak woodlands), then aggregated again to obtain an overall condition and trend.

The other taxonomic groups were assessed by aggregating the condition and trends of the individual indicators within that group. For example, the mammal grouping included native mammal diversity, American badgers (*Taxidea taxus*), and North American river otters (*Lontra canadensis*).

Future work to refine this overall biodiversity assessment could include looking at extirpated fauna species, as well as other important taxonomic groups currently lacking in data, such as fungi, lichens, and invertebrates.

Overall biodiversity on Mt. Tam is in a “Cautionary” condition. Some taxonomic groups have experienced local or global extirpations and include species that are in perilous condition, while other taxonomic groups are faring better with limited extinctions and generally healthy populations of extant species. The trend in overall biodiversity is “Declining” as we have lost native species and have not gained new ones; some taxonomic groups are faring better than others.

Biodiversity for plants has a “Cautionary” condition and a downward trend. Currently, there are over 750 known native plant species, but also over 300 non-native species. While some non-native species have limited distribution and impact, many others are noxious invasives that are impacting native species and processes. These impacts include outcompeting and displacing native species, altering habitat, altering the fire regime, and huge costs associated with control and eradication (Mack & D’Antonio, 1998; Hobbs & Mooney, 2005; Pimentel et al., 2005).

In addition, there have been 68 documented likely plant extirpations (Appendix 7). Of the known extant native plant species, over 40 are considered rare, threatened, or endangered. These special status plants are susceptible to stochastic events and existing stressors that could lead to further imperilment and even local or global extinction.

Despite the loss of species, and threats from non-native species and other stressors, the floristic biodiversity of the area is high, and supports an equally high diversity of habitats that host dozens of wildlife species. These vegetation and habitat types are defined by high variability in topography, temperature, precipitation, and soils within the One Tam area of focus (see Chapter 1).

VEGETATION COMMUNITIES

All global climate models (GCMs) predict warmer temperatures for California through the next century, though they do not agree on changes to precipitation. Here we examine several recent attempts to model potential changes to vegetation in the One Tam area of focus. A collection of species and plant communities that are potentially vulnerable to climate change should make good indicators of how rapidly the mountain is being affected by changing conditions.

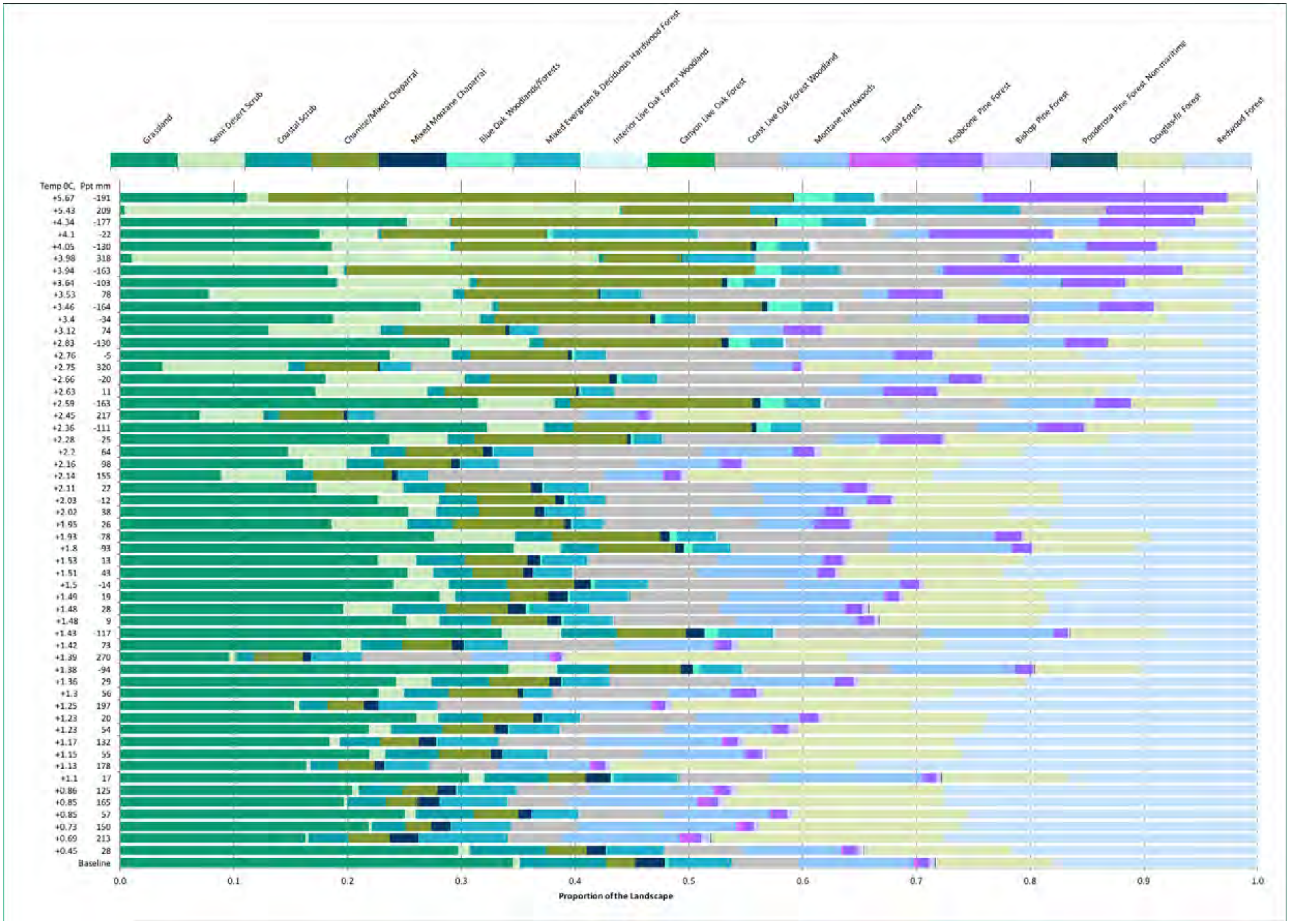
Two recently published assessments of the potential impacts of climate change to vegetation in California can offer useful projections of the sensitivities, vulnerabilities, and potential future distributions of major vegetation types. Ackerly et al. (2015) used probabilistic logistic regression to model vegetation sensitivity and potential future distributions in response to future climate changes in San Francisco Bay Area counties. Based on 54 different future climate scenarios, covering a broad range of temperature and precipitation projections and 22 major vegetation types, the authors found that as projected temperature increases, 12 vegetation types are projected to decline in extent, six are projected to increase, and three are projected to first increase, then expected to decline.

Those projected to increase in extent represent those from relatively hotter and drier climates within the study area and included chamise chaparral, blue oak woodland, interior live oak woodland, semi-desert scrub, and coast live oak forest and woodlands. These types are expected to shift more toward the coast and to lower elevations. Those that were projected to decline in extent generally represented vegetation found in cooler and moister locations, and several were projected to substantially retract (including redwood forest and coastal scrub) or disappear entirely (including black oak forest/woodland, canyon live oak forest, tanoak forest). These declining vegetation types are expected to shift more away from the coast and to higher elevations.

Grasslands are currently the most extensive vegetation type in the Marin Coast Range area that were also projected to decline in extent, though the impact to grasslands was highly dependent upon future rainfall amounts. The fate for grasslands in particular may be influenced by management actions to prevent conversion to other vegetation types.

Figure 23.2 summarizes the projected future relative frequencies or extents of 16 broad vegetation types for the Marin Coast Range area under 54 different potential future climates. Most of these types are present in the One Tam area of focus. The bottom bar indicates the current relative extents of the vegetation types. Moving up the vertical axis represents incremental increases in future temperature, but either increases or decreases in precipitation. Temperature increases up to a maximum of 10.2° F (5.7° C) while precipitation varies between 7.5 inches less up to 12.6 inches more rain compared to historic averages. Moving up the graph (increasing temperature), one can see how some vegetation types shrink in width (extent) while others expand.

FIGURE 23.2 PROJECTED FUTURE RELATIVE FREQUENCIES OR EXTENTS OF 16 VEGETATION TYPES FOR THE MARIN COAST RANGE AREA UNDER 54 DIFFERENT POTENTIAL FUTURE CLIMATES (BASED ON ACKERLY ET AL., 2015)

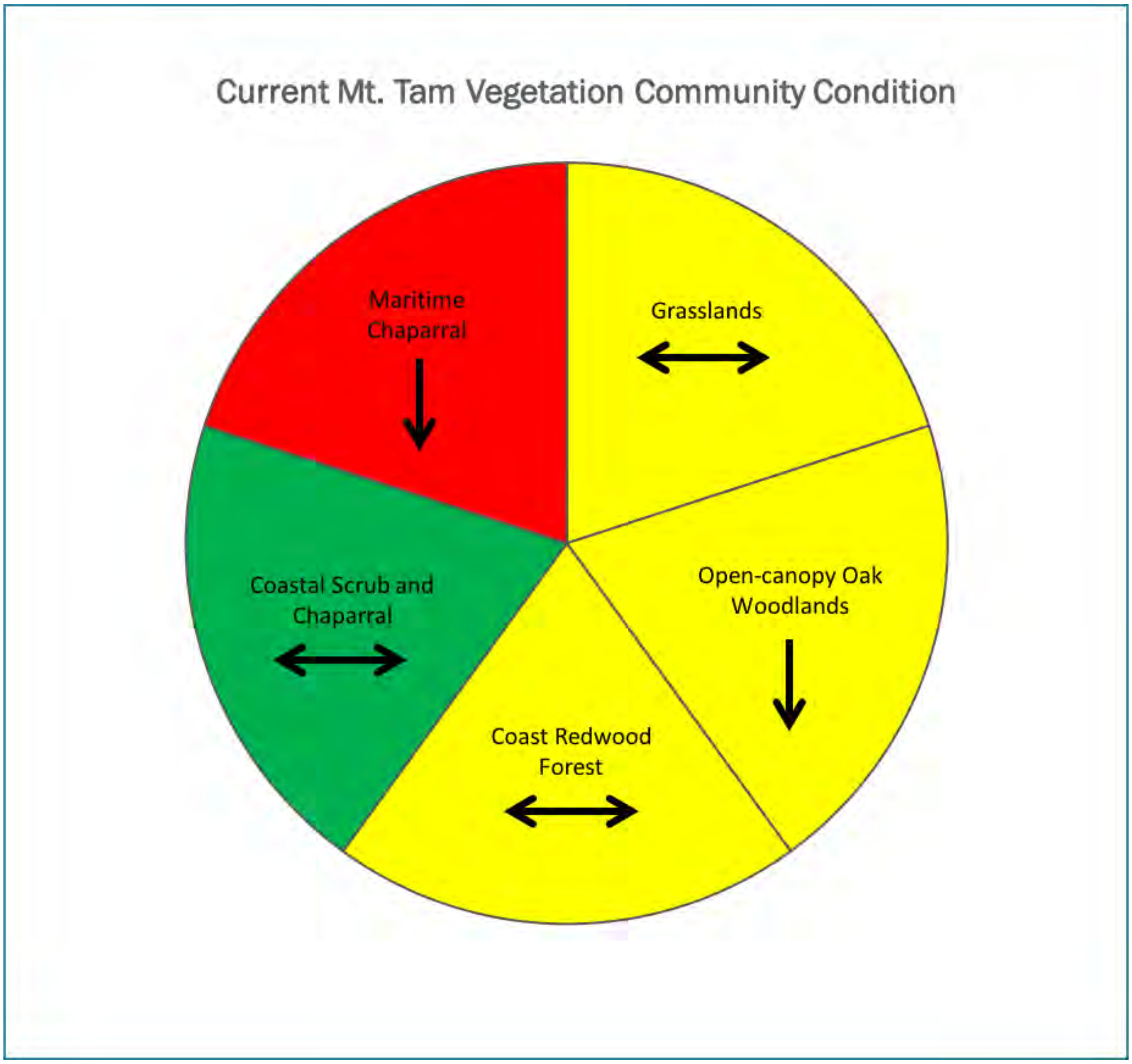


The models developed by Ackerly et al. (2015) assumed that, as some existing vegetation types declined, other existing types had to take their place; no novel vegetation types were introduced. A surprising result from this modeling exercise was that vegetation located in what would be considered relatively moist and cool sites—thought to be potential climate refugia—was the most sensitive to increasing temperatures. Sensitivity was defined as the magnitude of the projected change in vegetation at a given location. This model, as well as others, does not predict when or exactly how the changes will occur. The path for all vegetation types may be slow, and at times, quick in response to disturbances (such as fire), and will depend upon each species' mechanisms and abilities for dispersal and migration, as well as any barriers to these processes.

Another recently published assessment of the vulnerability of California's terrestrial vegetation to potential future climate scenarios concluded that all vegetation types were moderately to highly vulnerable (Thorne et al., 2016). The authors structured their analysis using two climate models and two emissions scenarios, yielding four different future climate scenarios. Climate vulnerability ranks were then assigned to 31 vegetation types (called "macrogroups") based on life history traits that would indicate its sensitivity to, and adaptive capacity for, a changing climate as well as the projected climate exposure and future extent of unsuitable distribution. Climate vulnerability categories included: moderate, mid to high, and high. The higher the vulnerability of a vegetation type to future climate scenarios, the more likely it will be stressed by future climates. Most of the selected vegetation community indicators had a comparable match to the assessed macrogroups, except for the serpentine barrens, which is not included in this assessment (Figures 23.3A and B).

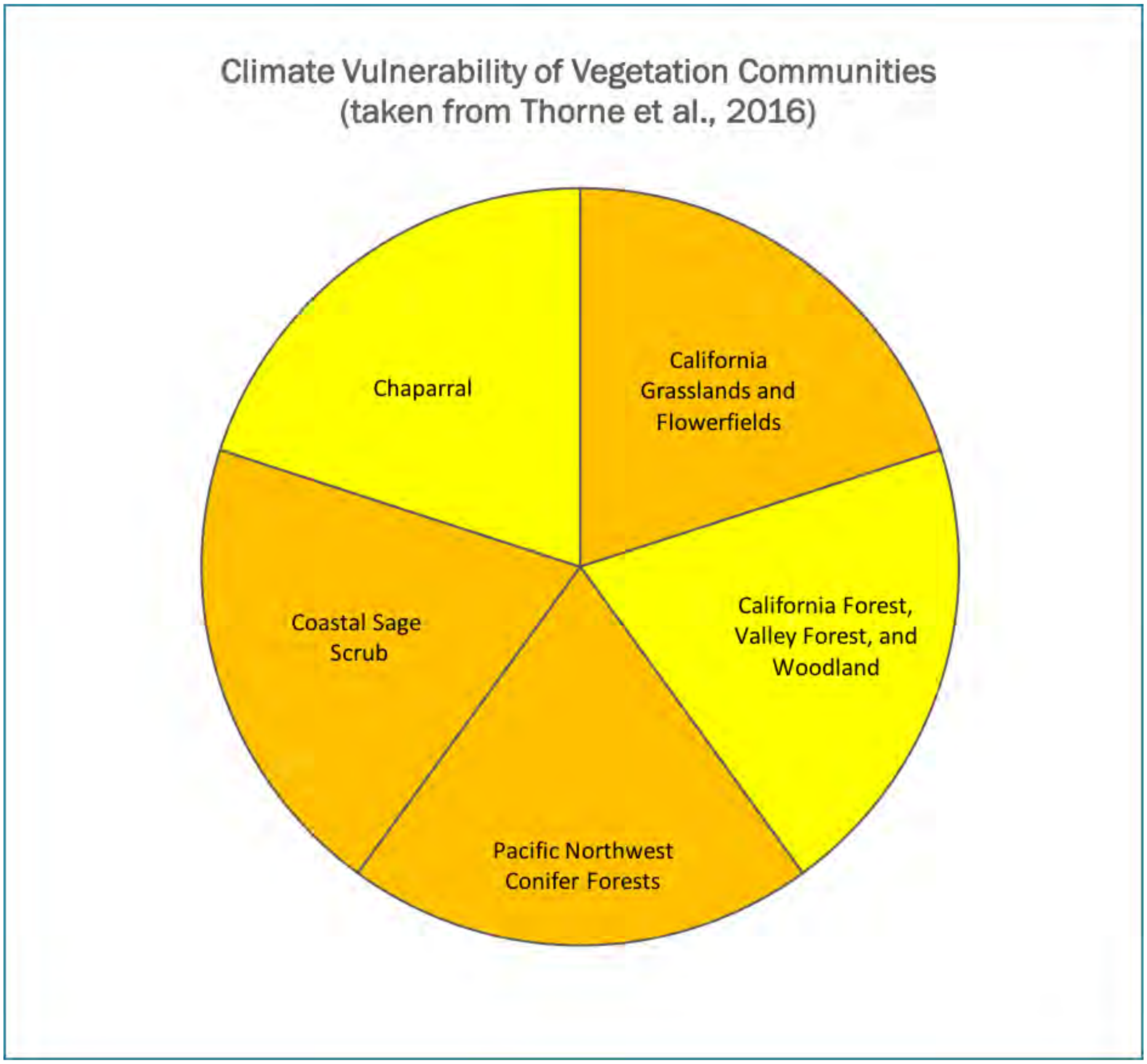
We took the results from those macrogroups which related to our key vegetation community indicators, and displayed them next to a graphic depicting the current condition and trend of these communities within the One Tam area of focus. From this comparison of how our communities are faring right now, and how vulnerable they are likely to be in the face of climate change, we can see which communities might be facing the biggest pressures and are in more significant danger of future impacts as a response to climate change.

FIGURE 23.3A CLIMATE VULNERABILITY OF SELECTED VEGETATION COMMUNITIES



Key to condition of vegetation communities:

FIGURE 23.3B CLIMATE VULNERABILITY OF SELECTED VEGETATION COMMUNITIES



Key to mean climate vulnerability rank:

The table below shows the vegetation macrogroup identified and the vulnerability assigned by Thorne et al. (2016) to the vegetation indicators chosen for this report (only serpentine barrens are not included).

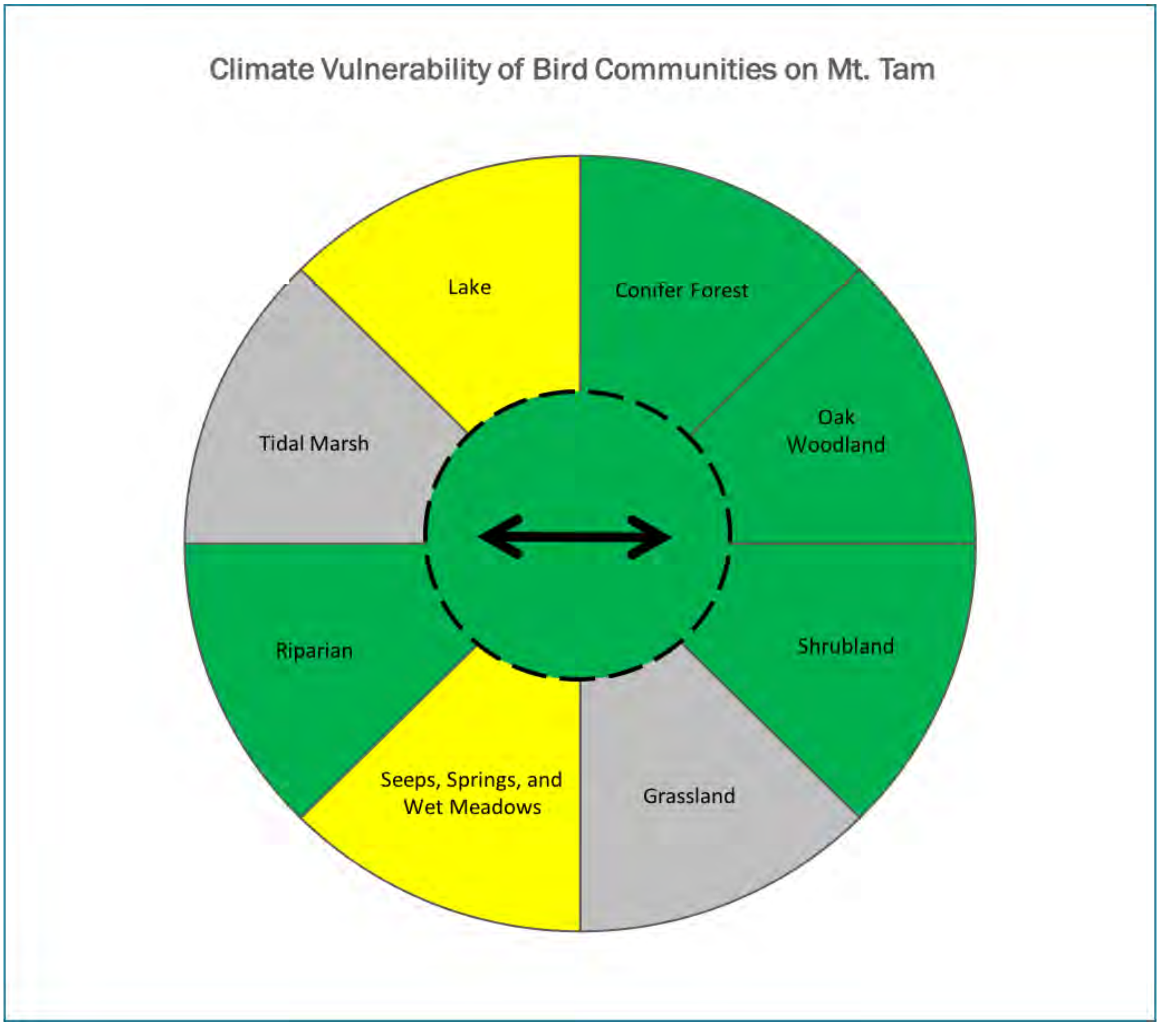
TABLE 23.1 VEGETATION MACROGROUPS, INDICATORS, AND VULNERABILITY USED IN CLIMATE VULNERABILITY ANALYSIS

Vegetation Macrogroup	Vegetation Indicator	Vulnerability
Chaparral	Maritime chaparral	Moderate
California grasslands and flowerfields	Grasslands	Mid to High
California forest, valley forest, and woodland	Oak woodlands	Moderate
Pacific Northwest conifer forests	Redwood forest	Mid to High
Coastal sage scrub	Coastal scrub and chaparral	Mid to High

Thorne et al. (2016) concluded that the chosen vegetation indicators had climate vulnerabilities of either moderate or mid to high. Maritime chaparral and oak woodlands were considered moderately sensitive to climate change while the remaining vegetation indicators were even more so, earning them a rank of mid to high sensitivity. Their analysis indicates that climate change is, and will continue to be, a major stressor to vegetation communities throughout the One Tam area of focus. This will result in shifts in vegetation communities as plants are lost to climate stress-driven mortality and as vegetation responds to stressful conditions and is forced to shift to more suitable habitats. A hotter future climate could also result in more severe fires that could lead to large-scale punctuated vegetation changes. In at least some locations, the natural succession following those fires will likely result in different community types or different compositions than existed before.

Although the two modeling exercises summarized here are not directly comparable because they used different methods, different study areas, and had different foci, they appear to be broadly in agreement. For example, Ackerly et al. (2015) projected that chamise chaparral will increase in frequency or extent across the San Francisco Bay Area. Thorne et al. (2016) predicted that chamise chaparral would be moderately vulnerable and less vulnerable than most other vegetation types and most of Marin County would remain suitable for this type, allowing it to expand its range as other more vulnerable types decline. For redwood forests, Ackerly et al. (2015) concluded that this type will decline in extent in the northern San Francisco Bay Area. Thorne et al. (2016) concluded that this type has mid to high sensitivity with most of Marin County becoming unsuitable under future climates. For grasslands, Ackerly et al. (2015) project declines in extent, especially at much higher temperatures. Thorne et al. (2016) rank grasslands as having mid to high vulnerability and project that under warmer and wetter futures, much of Marin County will be unsuitable for this vegetation type.

FIGURE 23.4 CLIMATE-VULNERABLE BIRD COMMUNITIES IN THE ONE TAM AREA OF FOCUS



Condition: Good

Trend: No Change

Confidence: Moderate

This roll-up was created using a subset of birds from the species trait-status database that scored "yes" for climate vulnerability, which were then sorted by habitat association. Each habitat got one segment in the chart above regardless of the number of birds within that habitat type (the fewest was one bird per guild, the most was 13). Condition, trend, and confidence were rolled-up to the habitat for that chart segment, then rolled-up again for the overall current condition, trend, and confidence.

The climate change vulnerability assessment for birds relied heavily on only one component of vulnerability: whether a species probability of occurrence within the One Tam area of focus was predicted to change. We visually compared contemporary occurrence with two climate change futures, based on two different climate models (*data.prbo.org/cadc/tools/ccweb2/index.php*), and when the probability was predicted to decline, we considered the species vulnerable. Although we also considered a species to be vulnerable if they were ranked as such in Gardali et al. (2012), this added very few species to the total number considered vulnerable.

Overall, climate change vulnerable bird species are in “Good” condition with “No Change” in trend. This may be because any likely reductions in probability of occurrence as predicted are not yet realized. In other words, the climatic and vegetation conditions used by the model that result in predictions of change are not yet occurring in the One Tam area of focus, or if they are, there is a lag time in bird response. It is also possible that some species can adapt to changing conditions and hence not behave as predicted by changes in climate and vegetation alone.

Results for tidal marsh and grassland associated species were uncertain. For tidal marsh species in particular, it would be desirable to obtain condition data given the added impact of sea level rise.

A more complete picture of climate change vulnerability that includes factors other than change in probability of occurrence would provide a more accurate picture of which birds are the most sensitive indicators of change.

CLIMATE-VULNERABLE ICONIC SPECIES

Coho salmon (*Oncorhynchus kisutch*) are good indicators of the effects of climate change on a variety of habitats as they require freshwater and open ocean habitats in order to thrive. Coho salmon will not fare well under the current climate projections of shorter, more intense periods of rainfall and extended droughts. Rising temperatures will likely cause greater evaporation of streams and floodplain habitats, and intense rainfall can cause erosion and harmful sediment deposition. However, the many habitat restoration projects both completed and in progress in the watersheds of the One Tam area of focus may help counteract some of these impacts.

California red-legged frogs (*Rana draytonii*) are good climate change indicators as they require a variety of aquatic and terrestrial habitats for different parts of their lifecycle. Under hotter, drier current climate projections, survival rates of egg masses and tadpoles are likely to decrease. Increased frequency and elevation of high tides from sea level rise or more intense storms could also raise salinity levels in low-lying breeding habitat.

Coast redwoods (*Sequoia sempervirens*) are temperature- and precipitation-sensitive, but how predicted climate changes will impact redwood forest health is complex. Redwoods have shown increased growth with climate changes so far, but increasing soil aridity and the loss of fog could be serious threats. In general, models project that this species will decline in extent across the north coast.

Marin manzanita (*Arctostaphylos virgata*) is a particularly good indicator of changes in summertime fog. There has been a declining trend in the number of foggy days along the California coast and future hotter climates could further reduce fog frequency.

ECOLOGICAL COMMUNITIES

Each ecological community or ecosystem roll-up was created by taking all of the vegetation and wildlife metrics from individual indicators that were pertinent to that ecosystem, and then aggregating them. Each individual metric has its own condition, trend, and confidence level as already determined in the individual indicator assessment.

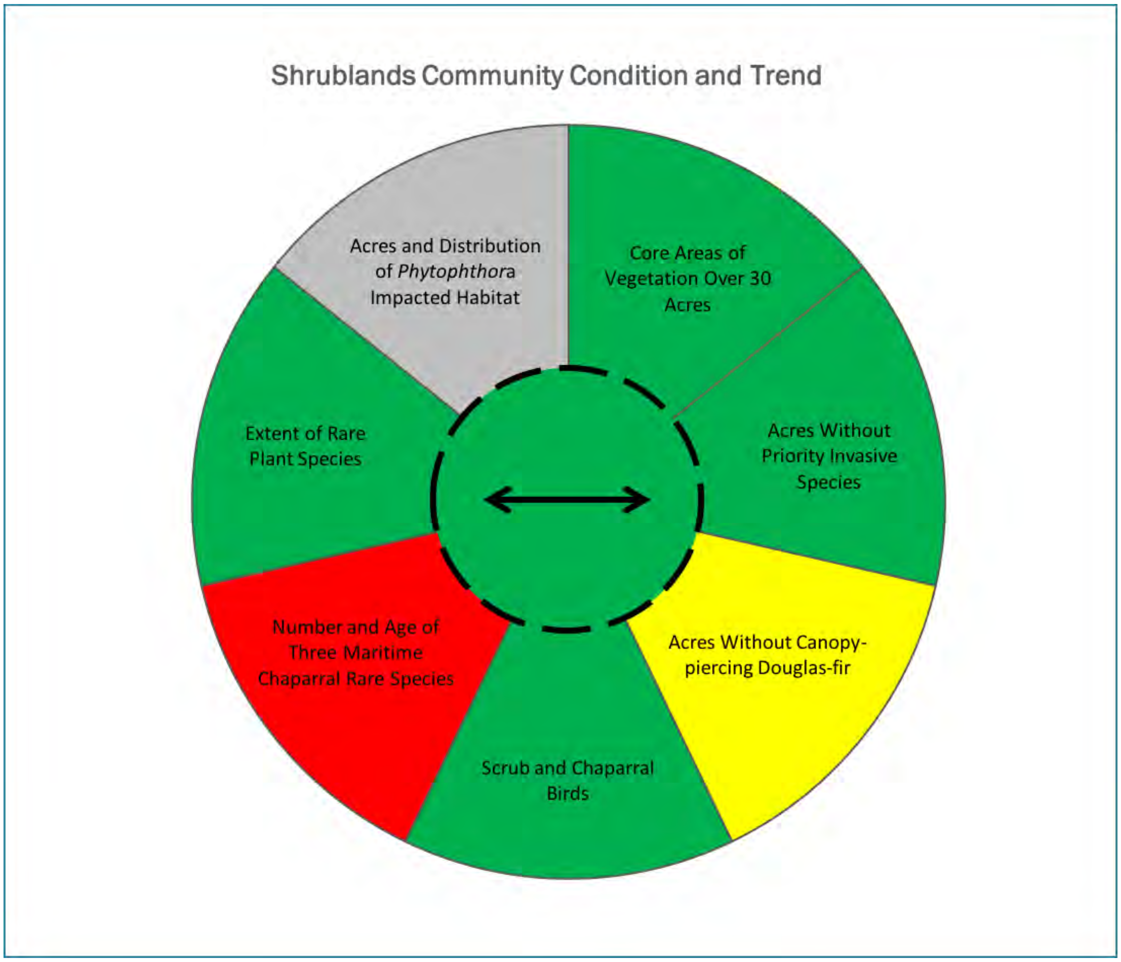
This methodology omitted large data gaps to focus more upon what *could* be said about the state of the ecosystems on Mt. Tam. However, if a metric had already been described and assessed within one of the chapters presented in this report it was included in the roll-up regardless of whether there is currently enough data to assign a condition score or not. This means that some taxonomic communities, such as invertebrates, are currently under-represented within these ecosystem roll-ups, even though they are incredibly important to the overall health of Mt. Tam. These omissions are only due to a lack of analyzable data, and as data gaps are filled, the ecosystem roll-ups will continue to be further refined.

The species trait-status database (see Appendix 4) was used within each taxonomic group to indicate which species had strong affiliation to a particular habitat type. As an example of how different components were rolled up into the grasslands ecosystem, there are three metrics taken from the grassland vegetation indicator, one American badger metric from the native mammal diversity indicator, and one bird metric for grassland birds. This approach allows more segments from other taxonomic groups to be added in the future, as strong habitat affiliations are uncovered, and more data are gathered.

Note: The overall ecosystem condition and trend assessments are preliminary and will be further refined as more data and metrics are included for missing taxa.

The following aggregated ecosystem assessments represent our early understanding based upon the data available and can be used as a tool to communicate a broader understanding of ecosystem health within the One Tam area of focus.

FIGURE 23.5 SHRUBLAND CONDITION AND TREND IN THE ONE TAM AREA OF FOCUS



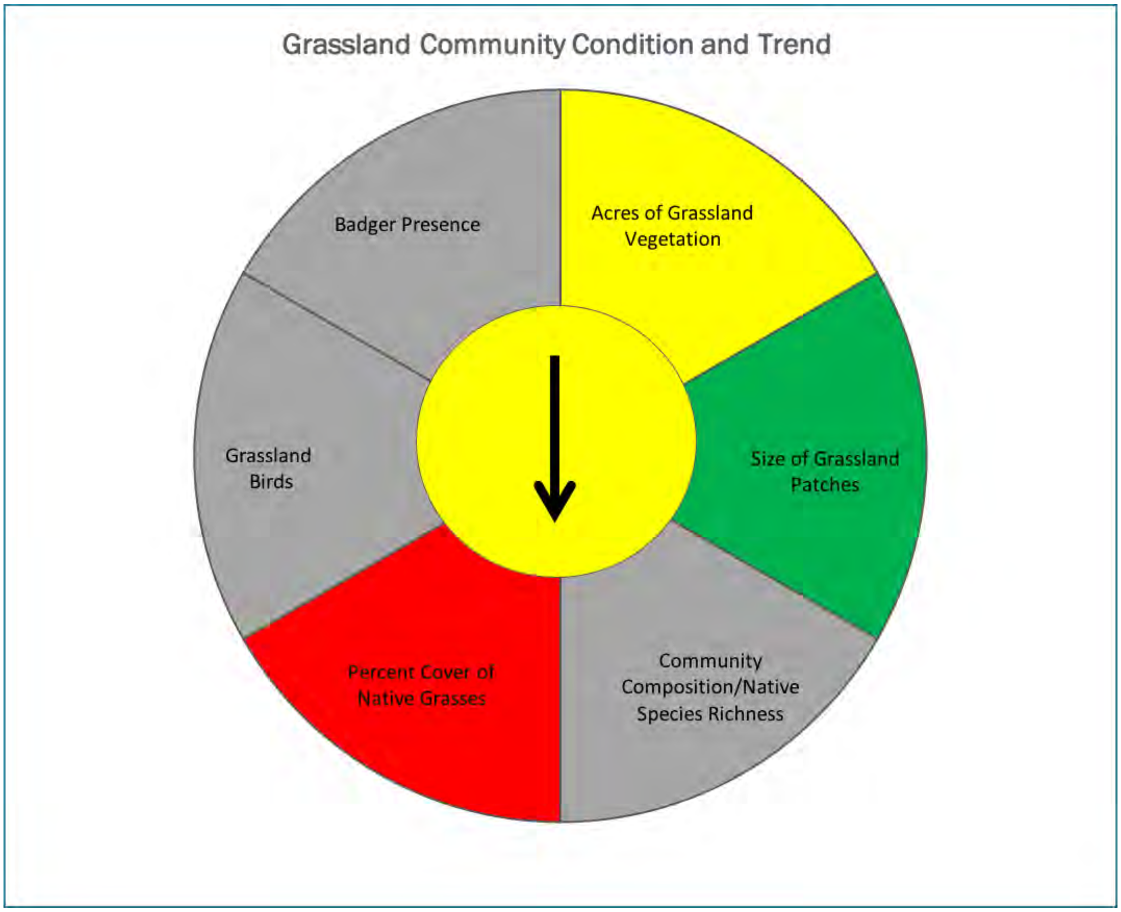
Condition: Good

Trend: No Change

Confidence: High

Shrubland communities are in "Good" condition with "No Change" in their overall trend. Coastal sage scrub- and other chaparral-dominated areas have been stable and show no major negative signs from the impacts of ecological stressors that are affecting many of Mt. Tam's other plant communities. They are usually relatively free of invasive species, and have experienced limited Douglas-fir (*Pseudotsuga menziesii*) encroachment. Their extent has remained fairly stable and they have a full complement of associated bird species. Recent analyses of projected future vegetation changes for the San Francisco Bay Area forecast increases in shrublands, especially chamise-dominated chaparral (Cornwell et al., 2012; Ackerly et al., 2015). However, even chaparral species that are adapted to—or tolerant of—very dry conditions are not immune to drought stress, and may suffer under hotter, drier climate scenarios within their current distributions (Jacobsen et al., 2007; Paddock et al., 2013). As a result, these shrub-dominated vegetation types are expected to shift to lower elevations and toward the coast.

FIGURE 23.6 GRASSLANDS CONDITION AND TREND IN THE ONE TAM AREA OF FOCUS



Condition: Caution

Trend: Declining

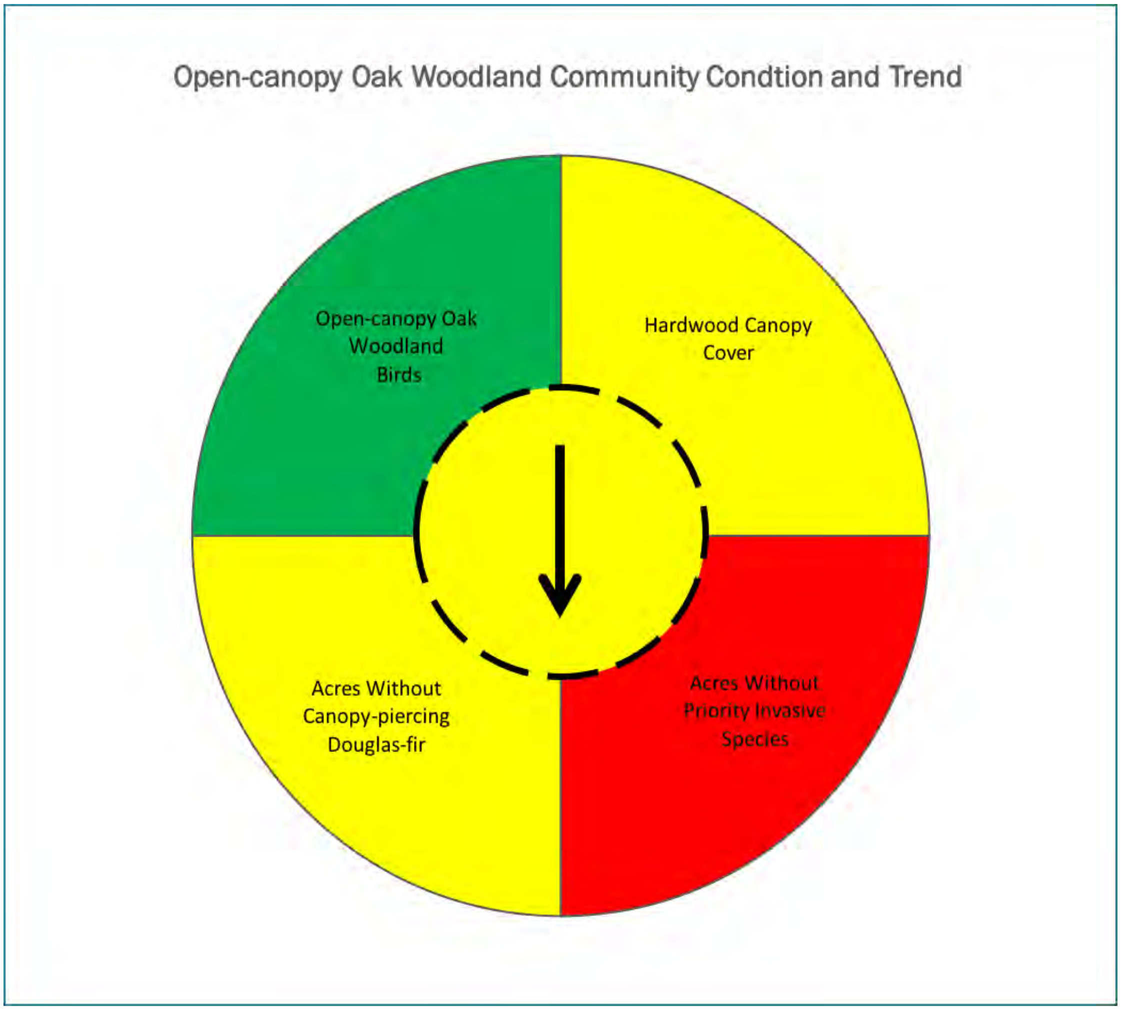
Confidence: Low

Grassland communities on Mt. Tam are in a “Cautionary” condition with a “Declining” trend. These areas have been relatively stable based on a recently assessed baseline for the total extent of grassland communities. However, Douglas-fir and coyote brush (*Baccharis pilularis*) recruitment into the edges and interior of some grassland patches mean that the overall patch size and number of large patches is below the desired condition. The presence and relative dominance of non-native, invasive grasses and forbs is further causing grassland habitat quality to decline.

In the future, Thorne et al. (2016) concluded that grasslands had mid to high climate vulnerability with much of the north coast being unsuitable for grasslands under a warmer and wetter future. Thus, grasslands will be expected to shift in space and change in composition and quality. Near the coast, some grasslands may be lost to coyote brush while, away from the coast, grasslands could expand at the expense of forests and woodlands (Cornwell et al., 2012; Ackerly et al., 2015), though management actions would play a key role in maintaining grasslands. These habitats are also vulnerable to succession in the absence of periodic wildfires. See Chapter 8 for more information about Mt. Tam's grasslands.

The American badger was historically an important component of grasslands, but this species was likely extirpated in many parts of the northern coast, including the One Tam area of focus. Recent sightings in other parts of Marin County indicate that his species may be slowly recovering in the region, but it has not been documented on Mt. Tam. There is also currently no empirical evidence of the presence and abundance of bird species within Mt. Tam's grassland communities, and so they cannot be included in the assessment at this time. Additional future research, surveys, and monitoring may provide the data needed to include these important grassland health indicators in future analyses.

FIGURE 23.7 OPEN-CANOPY OAK WOODLAND CONDITION AND TREND IN THE ONE TAM AREA OF FOCUS



Condition: Caution

Trend: Declining

Confidence: Moderate

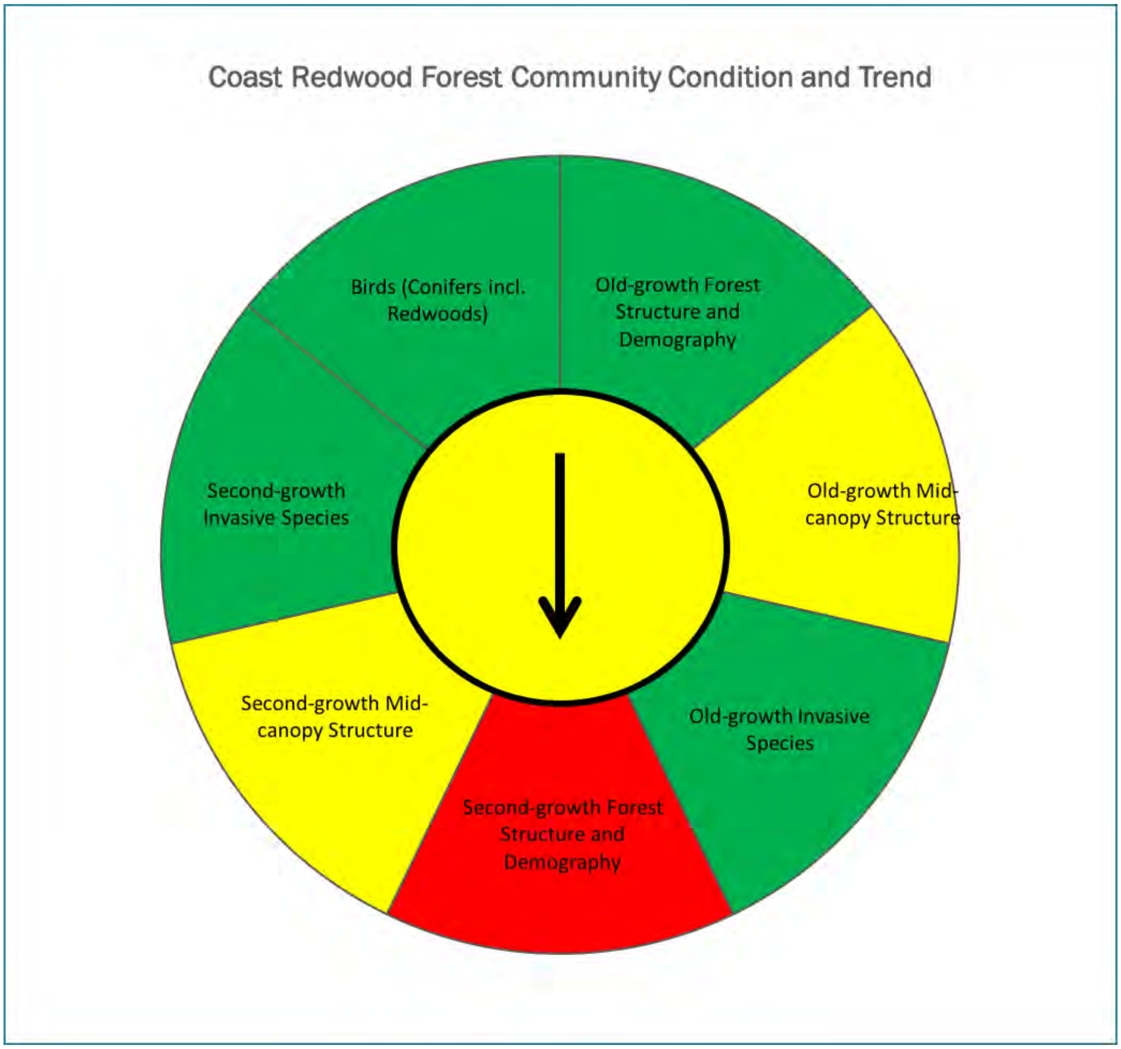
Open-canopy oak woodlands are in a "Cautionary" condition, with a "Declining" trend, mostly due to invasive species, Sudden Oak Death, and Douglas-fir encroachment (see Chapter 5). Although we have no empirical evidence on the demographic structure of oaks in this community type, local anecdotal evidence and empirical evidence from other parts of California indicate that some species of oaks are suffering from inadequate recruitment to replace adults lost to mortality (Tyler et al., 2006; Ripple & Beschta, 2008; Ackerly et al., 2013). These patches are dominated by older adults with insufficient young saplings and trees to maintain the existing adult densities.

There is some recruitment of Douglas-fir into these woodlands where they are in close association with existing mature Douglas-fir or mixed Douglas-fir, coast redwood, tanoak forests. This recruitment is leading to a slow change to mixed conifer, hardwood woodland and is likely driven by fire exclusion. Furthermore, several species of broom continue to rapidly invade and colonize within many of Mt. Tam's oak woodlands. Broom invasion has also likely led to a reduction in the diversity and abundance of birds and mammals (Freed & McAllister, 2008).

Sudden Oak Death continues to be the major stressor in this community, and estimates are that up to 30% or more of coast live oak adults and 20% or more of black oak adults have been lost (McPherson et al., 2010; Swiecki & Bernhardt, 2013). This disease is expected to continue to kill oaks and may eventually transform these oak woodlands into woodlands or forests with a very minor oak component.

Oak woodlands are known to be centers of high avian diversity (California Partners in Flight, 2002) and our current assessment of birds in this community type finds that the full complement of expected birds are present. The future of oak woodlands under future climate change scenarios is uncertain (Ackerly et al., 2012; Ackerly et al., 2015; Cornwell et al., 2012).

FIGURE 23.8 COAST REDWOOD FOREST CONDITION AND TREND IN THE ONE TAM AREA OF FOCUS



Condition: Caution

Trend: Declining

Confidence: High

Mt. Tam's coast redwood forest communities are in overall "Cautionary" condition with a "Declining" trend. An assessment of the avian community associated with coast redwood forests indicates that all expected species are present and the Northern Spotted Owls are doing well across the region in this habitat type. Due to the generally low understory light levels, non-native, invasive plant species are a relatively minor problem for this community compared to many others on Mt. Tam.

While old-growth redwood forests are in "Good" condition, second-growth, which make up the majority of these communities on Mt. Tam, are in "Cautionary" condition. This amount of second-growth forest is largely a result of historic logging in the area. In general, old-growth conditions represent a desirable state for redwood stands on Mt. Tam given their complex habitat structure and other ecological conditions that are resilient to wildfire and other stressors. Mt. Tam's second-growth stands exhibit greatly simplified structure, with an absence of larger trees in the canopy, simplified understory, and high densities of small diameter trees, although they vary widely in their characteristics and in the degree to which they have recovered from the impacts of logging.

Currently, the major stressor to both old- and second-growth forest structure is Sudden Oak Death and its impact on tanoaks that are common understory associates within redwood forests. Estimates across Marin County put the total tanoak mortality at about 50% or greater (McPherson et al, 2010; Swiecki & Bernhardt, 2013). In many stands within the One Tam area of focus, closer to 100% of the tanoaks have been impacted. These trees are stuck in a cycle of stem death, followed by root crown stem regeneration, followed by stem death. This turns them from mid-canopy redwood forest components to lower canopy and shrub layer components. It also adds a great deal of fuel to the forest floor, which could result in higher severity fires and higher mortality of nearby redwoods (Metz et al., 2013). See Chapter 3 for a more in-depth discussion of the health of Mt. Tam's redwoods.

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APPENDICES

APPENDIX 1. TABLE OF ALL HEALTH INDICATORS CONSIDERED

The following is a list of all the indicators for the health of Mt. Tam that were originally proposed, why it was proposed, if it was included in this report, and the rationale for that decision.

MMWD = Marin Municipal Water District
NPS = National Park Service
State Parks = California State Parks
MCP = Marin County Parks
USGS = U.S. Geological Survey

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Amphibians and Reptiles			
California giant salamander (*Dicamptodon ensatus*)	Although not federally listed, this species is a special status animal and has a state Natureserve rank of S2/S3 (imperiled/vulnerable) and an ICUN status of near threatened. They are excellent indicators of stream biological diversity due to their relatively long lives and stable population sizes. They can also provide some insights on riparian health, and smaller streams that do not have any fish to use as indicators.	Needs Statement	This species will be included in future iterations of this report when all of the known information needed to determine conditions can be compiled.
California red-legged frog (*Rana draytonii*)	Amphibians are good indicators of freshwater wetland condition because they are relatively long-lived and breed and rear in wetland and aquatic sites. The California red-legged frog was federally listed as a threatened species in 1996 and the One Tam area of focus is part of the species' core recovery area.	Yes	The NPS and USGS have collected sporadic data on breeding California red-legged frog populations in the Olema Valley and Bolinas Lagoon. Consistent annual surveys have occurred in the Redwood Creek Watershed since 2002.
Foothill yellow-legged frog (*Rana boylii*)	A good indicator of perennial stream conditions as they are sensitive to changes in water temperature and vulnerable to both recreational use and invasive aquatic species. They are a federal species of concern, a Forest Service sensitive species, and a California species of special concern, and considered vulnerable to climate change.	Yes	Sufficient data exist thanks to MMWD monitoring since 2004.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Western pond turtle (*Actinemys marmorata*)	A good indicator of freshwater aquatic conditions and, to some extent, terrestrial grassland conditions as well. In their aquatic habitat, they are vulnerable to predation and competition with invasive species. On land, breeding adults, nests, and hatchlings are vulnerable to habitat degradation, and predation by overly abundant ravens, crows, skunks, and raccoons. It is a California Department of Fish and Wildlife species of special concern and is considered vulnerable to climate change.	Yes	MMWD has done several years of turtle trapping and volunteer observational data, has monitoring data dating back to 2004, and has implemented restoration and other protection measures for this species in the One Tam area of focus. NPS also has western pond turtle inventory data from the One Tam area of focus from 1996 and from 2014–2015.
Birds			
Birds (overall)	Birds are recognized as indicators of ecological change and provide a wide variety of ecosystem services.	Yes	Agencies within the One Tam area of focus have a relatively long history of bird monitoring, enabling estimates of population trends for multiple species in multiple vegetation communities.
Osprey (*Pandion haliaetus*)	Osprey breeding success is a good indicator of water quality and the availability of fish. The Osprey is a California species of concern, a California conservation focal species and is protected by the Migratory Bird Treaty Act.	Yes	The Kent Lake Osprey was founded in the mid-1960s and has been monitored continuously by MMWD since 1985.
Northern Spotted Owls (*Strix occidentalis caurina*)	This species was listed as a federally threatened in 1990. They are good indicators of forest ecosystem condition. Species numbers appear to be decreasing dramatically across their range. However, the Marin County population appears to be stable.	Yes	Agencies have a wealth of inventory, and long-term monitoring data on this species in much of Marin County going back to the 1980s and 1990s.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Fish			
Coho salmon (*Oncorhynchus kisutch*)	Spending part of their lives in freshwater streams and part in the ocean, anadromous fish are good indicators of riparian habitat and hydrological conditions as well as ocean health, and an important food source for many species and source of nutrients for riparian forests. This species is federally endangered.	Yes	Data collected since the 1990s through various long-term monitoring programs provides data to understand condition and trends.
Steelhead trout (*Oncorhynchus mykiss*)	In addition to the same benefits of anadromous fish species described above, this species is federally threatened.	Yes	Data collected since the 1990s through various long-term monitoring programs provides data to understand condition and trends.
Threespine stickleback (*Gasterosteus aculeatus*)	See the aspects of anadromous fish species described above.	Yes	Despite limited data, this species is an important indicator that are easy to recognize, and conducive to citizen science monitoring.
Invertebrates			
Aquatic macroinvertebrates	Aquatic macroinvertebrates are important in aquatic food webs, and have been demonstrated to be good indicators of water quality.	Include in Invertebrate Needs Statement	This group will be evaluated as a part of the larger invertebrate discussion.
California freshwater shrimp (*Syncaris pacifica*)	Very limited global distribution.	Include in Invertebrate Needs Statement	Same as above.
Land snails and slugs	An important food source for many other species.	Include in Invertebrate Needs Statement	Same as above.
Pollinators	Pollinators provide import ecosystem services, and public has connection with them. Many pollinators are in decline worldwide, and may be sensitive to climate change/shifts in phenology.	Include in Invertebrate Needs Statement	Same as above.
Mammals			
Mountain lion (*Puma concolor*)	Mountain lions are iconic species and apex predators in the terrestrial systems, and higher numbers may indicate better habitat quality.	No	Included in overall mammal diversity section.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
North American river otter (*Lontra canadensis*)	This species is an important upper-level predator in aquatic systems, and may be sensitive to water quality. They have recently returned to the San Francisco Bay Area after having been extirpated for decades.	Yes	The River Otter Ecology Project has ongoing monitoring and seasonal observational information on likely denning and dispersal areas.
American badger (*Taxidea taxus*)	This species is an important predator in grassland/coastal scrub. They are recognized as a species of concern by some agencies. Their relatively large home ranges make them sensitive to habitat loss and a good indicator of grassland patch size and condition.	Yes	This species is one of the few mammals on Mt. Tam that is associated with specific habitat types (grassland and coastal scrub). Although data are currently very limited, additional wildlife cameras may provide more data in the relatively near future.
Native mammal richness (overall)	Looking at a suite of native mammals provides a more complete picture of terrestrial ecosystem condition, trophic relationships, and different mammal guilds.	Yes	Preliminary data are available from the Marin Wildlife Picture Index project, and One Tam agencies plan on continuing this project in the future.
Coyote (*Canis latrans*)	Important upper-level predators that are recovering from historic persecution, and are now commonly observed in Marin County.	No	Included in overall mammal richness section.
Bobcat (*Lynx rufus*)	These important upper-level predators are found in many types of habitats in the One Tam area of focus.	No	Included in overall mammal richness section.
Gray fox (*Urocyon cinereoargenteus*)	This species is a key predator in terrestrial ecosystems, and seem to be increasing after a distemper outbreak in mid-1990s.	No	Included in overall mammal richness section.
Raccoon (*Procyon lotor*)	This omnivorous native species is common in riparian and developed areas where they can reach nuisance levels.	No	Included in overall mammal richness section.
Striped skunk (*Mephitis mephitis*)	This omnivorous native species is common in riparian and developed areas where they can reach nuisance levels.	No	Included in overall mammal richness section.
Black-tailed deer (*Odocoileus hemionus*)	These herbivores are prey species for mountain lions, coyotes, and bobcats. Their grazing may be reducing tree regeneration, and overabundant deer may be a nuisance adjacent to neighborhoods, and hazard on roads.	No	Included in overall mammal richness section.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Brush rabbit (*Sylvilagus bachmani*)	An important prey species in terrestrial ecosystems.	No	Included in overall mammal richness section.
Black-tailed jackrabbit (*Lepus californicus*)	An important prey species in terrestrial ecosystems.	No	Included in overall mammal richness section.
Western gray squirrel (*Sciurus griseus*)	This species is a wide-ranging omnivore and an important prey species in terrestrial ecosystems.	No	Included in overall mammal richness section.
Sonoma chipmunk (*Tamias sonomae*)	An important prey species in terrestrial ecosystems.	No	Included in overall mammal richness section.
Bats (overall)	Bats are good ecological indicators as they are sensitive to climate change, habitat loss, pesticides, disease, and disturbance at breeding colonies. They are upper-level predators that provide key ecosystem services. Bats are highly susceptible to certain diseases such as white-nose syndrome, which is known to be spreading.	Needs Statement	Very limited information is available about bats, both on a species level and also geographically.
Townsend's big-eared bat (*Corynorhinus townsendii*)	Townsend's big-eared bats are a candidate species under the California Endangered Species Act, and a federal species of concern.	Needs Statement	This species will be included in the overall Needs Statement for bats.
Dusky-footed woodrat (*Neotoma fuscipes*)	This species builds large nests that are used by other wildlife. They are potentially sensitive to Sudden Oak Death because they feed on acorns. They are also the primary prey species of the threatened Northern Spotted Owl.	No	Insufficient data exist to make any statements about the status or trends of this species.
Vegetation Communities			
Grasslands	Mammals and grassland-nesting birds—many of which are declining—rely on large patches of grassland for reproduction and forage. There is concern about grassland quality and extent declining due to increasing exotic species and colonization by woody plants	Yes	MMWD and MCP have recent data on grassland habitat extent and condition.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Open-canopy oak woodlands	Valley open-canopy oak woodland is a plant community of concern. Oak woodlands on Mt. Tam have been heavily impacted by Sudden Oak Death.	Yes	MMWD and MCP have recent data representing at least half of this habitat type on Mt. Tam and so can be used to extrapolate to what might be happening on NPS and State Parks lands as well.
Redwood forests	Redwood forests can be used as an indicator of biological integrity/biodiversity, natural disturbance regime, and habitat quality. Northern Spotted Owls nest and Townsend's big-eared bats roost in large trees within redwood forests. Carbon storage is an essential ecosystem service provided by these forests. Old-growth redwood forests stand at 4% of their historic extent and are further threatened by climate change and disease.	Yes	Years of agency and Save the Redwoods League work in these forests provides data to make an assessment of current condition and trends. Data from the 2014 NPS and National Geographic bioblitz at Muir Woods provide additional supporting information for age structure at and redwood forest health.
Sargent cypress communities	Sargent cypress communities can be used as an indicator of biological integrity and diversity, natural disturbance regimes, and habitat quality. They are also relatively limited in distribution and globally rare. Sargent cypress provides habitat for large ground cone (*Kopsiopsis strobilacea*) and pleated gentian (*Gentiana affinis* ssp. *ovata*) which are also locally rare.	Yes	Agency data on this plant community are sufficient to make some assessment of condition and trend.
Seeps springs and wet meadows	Seeps, springs and wet meadows can be used as an indicator of biological integrity and diversity, natural processes and climate change vulnerability, natural disturbance regime, and habitat quality. This plant community has limited distribution and provides favorable conditions for several rare plants. Butterflies and band-tailed pigeons rely on seeps for essential minerals. Native amphibians, chorus frogs, breed in wet meadow habitats to avoid American bullfrogs in perennial waters. Other wildlife	Needs Statement	Appropriate metrics and data need further work. More baseline data across broader geography are needed.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
	can use these features for drinking water.		
Shrublands	Chaparral and coastal scrub communities are important habitats for numerous wildlife species. They are potentially threatened by heat and drought stress as a result of climate change. Chaparral is largely resilient to non-native plant invasion. Coastal scrub is more susceptible, but large core areas remain free of target weed species, which are actively managed by NPS and State Parks.	Yes	Agency data on this plant community are sufficient to make some assessment of condition and trend.
Rocky outcrops	Rocky outcrops are important to birds and are easily damaged. They often contain plant species that are adapted to survive extremely low soil moisture conditions that may add value when compared with other communities.	No	Represents a small portion of area with some overlap with birds, serpentine barrens, and lichen indicators/metrics.
Mixed hardwoods	Mixed hardwoods constitute approximately 17% of the open space in the One Tam area of focus. They are susceptible to plant pathogen impacts and changed fire regimes.	Needs Statement	Need to develop metrics and also assess baseline data needs.
Serpentine barrens	Serpentine barrens constitute approximately 0.2% of the open space in the One Tam area of focus. They are largely resistant to invasion, but barbed goatgrass and purple false brome are encroaching, and lack of fire may allow native shrubs to overtake open areas.	Yes	Agency data on this plant community are sufficient to make some assessment of condition and trend.
Maritime chaparral	Maritime chaparral is a plant community of concern in California, and its community endemics can be used as an indicator of biological integrity or diversity, natural disturbance regime, and habitat quality.	Yes	Current MMWD and NPS rare plant monitoring data allow for an assessment of status and trends for this plant community.

Indicator	Why is This Considered an Indicator of Mt. Tam's Health	Included in This Report?	Is There Adequate Existing Data?
Hydrological Systems			
Hydrological systems (overall)	This overarching indicator could include water quality (temperature, dissolved oxygen, nitrogen deposition, etc.); stream flow; depth to groundwater; wetland extent; and hydro-fluvial geomorphic character.	No	Need to develop metrics and assess what baseline data exists.
Lagunitas Creek* below dams	Provides an important measure of floodplain connectivity.	No	Not capturing totality of Lagunitas Creek.
Watershed function: Redwood Creek, Eskoot Creek, and Corte Madera Creek	Indicators for the hydrological conditions in this system include: flow that approximates a maximum naturalistic hydrograph, (acknowledging current constraints), winter flows, summer flows, diversion, temperatures, and floodplain connectivity.	No	Need to develop metrics and also assess baseline data needs.
Wetlands overall: lakes/reservoirs; seeps/springs; isolated ponds	These aquatic resources provide essential habitats and drinking water to numerous species across multiple taxonomic groups.	No	Need to develop metrics and also assess baseline data needs.

7/12/16- DRAFT AND PRE-DECISIONAL FOR PLANNING PURPOSES ONLY

State of Mt. Tam Report Card

NORTHERN SPOTTED OWL

Strix occidentalis caurina

RESOURCE TOPIC AREA: Birds
RELATED FOCAL RESOURCES AND PROCESSES: Small mammals (Dusky-footed woodrat), Forest systems

Condition: Good

Trend: No Change

Confidence: High

WHY IS THIS RESOURCE INCLUDED?

Iconic and charismatic Northern Spotted Owls are good indicators of Marin County's forest health, as their success depends on the presence of diverse, robust evergreen forest ecosystems in this area and the abundance of food resource across the landscape . Northern Spotted Owls are important upper level predators that feed on a variety of rodents, especially dusky-footed woodrats (*Neotoma fuscipes*).

One Tam land management agencies have a wealth of inventory and long-term monitoring data on this species covering most of Marin County. Data on long-term trends in Northern Spotted Owl territory occupancy, reproductive success, and nesting habitat preferences help managers track population trends, avoid nesting season disturbances, and evaluate the impacts of potential threats including encroaching Barred Owls, Sudden Oak Death (SOD), and climate change.

Overall Status: Listed as threatened in 1990 under the Endangered Species Act, Northern Spotted Owl numbers appear to be dramatically decreasing across their range, which extends from southern British Columbia to Marin County, California (Dugger et al., 2016). In contrast, Marin's Northern Spotted Owl population appears stable (Ellis, 2016; Marin Municipal Water District [MMWD] unpublished data).

Marin County's Northern Spotted Owls are unique in their isolation from Northern Spotted Owl populations to the north and by their high density and fecundity. Genetic work conducted on Marin Northern Spotted Owls indicates that they have some unique haplotypes and that there is more gene flow out of the population than coming in to the population. They have also only recently been impacted by Barred Owls (*S. varia*) (Ellis, 2016). On Mt. Tam, they occur at high densities in native evergreen forests, most with some conifer component (Ellis, 2016; MMWD unpublished data). Current monitoring efforts on and around the mountain indicate that Northern Spotted Owl territory occupancy is high and relatively steady. Their fecundity is variable, but within a historic range of variation.

Desired Conditions: A healthy population of Northern Spotted Owls on Mt. Tam would remain stable or increase over time. Additionally, existing high levels of pair occupancy and fecundity are maintained within the observed normal range of variability, or above long-term average values based on monitoring data. Lastly, the threat from Barred Owls would remain low.

STRESSORS

- **Barred owls:** This eastern American species has expanded its range westward into the Pacific Northwest, and more recently southward into California, including Muir Woods in 2002 (Jennings et al., 2011). Researchers have found that Barred Owls negatively impact Northern Spotted Owl reproduction and survival, as they are slightly larger, are more aggressive, and eat a wider range of prey (USFWS, 2011; Wiens 2014; Duggers, 2016). Although ongoing monitoring has not resulted in any Barred Owl detections in Marin County since 2015, managers will continue to check for their presence (Ellis 2016).
- **Habitat loss:** In Marin County, Northern Spotted Owls live in a mix of forest types, including Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), and even hardwoods like California bay laurel (*Umbellularia californica*) and oaks. Though much of their habitat here is on protected lands, Northern Spotted Owls will nest in areas of relatively high recreational use and residential areas, and habitat protections have been important in maintaining habitat quality. Because some Northern Spotted Owl pairs nest adjacent to residential areas, development of private lots can also be a concern.
- **Sudden Oak Death:** This disease, caused by the water mold *Phytophthora ramorum*, affects many species of native trees in the One Tam area of focus. Wide-spread die-off of oak trees and understory species such as tan oak as a result of SOD is dramatically changing the structure of forests where Northern Spotted Owls live, which could have positive or negative impacts on the birds. Research conducted in Marin County demonstrated a decrease in dusky-footed woodrat abundance with increasing SOD disturbance, likely because the woodrats use oaks for food and shelter (Swei et al., 2011). On the other hand, the opening up of the forest understory may make it easier for Northern Spotted Owls to hunt.
- **Climate change:** Results from climate change models are mixed for Northern Spotted Owls. Bird distribution models developed by Point Blue Conservation Science (Point Blue) show an increase in potential Northern Spotted Owl distribution in the future (http://data.prbo.org/cadc/tools/ccweb2/index.php). In addition, they were not identified as an at risk species in a vulnerability assessment of California birds (Gardali et al., 2012). However, Glenn et al. (2011) found that warmer, wetter winters and hotter, drier summers (as some models predict for this area) negatively affect Northern Spotted Owl survival at six study areas in Oregon and Washington. Northern Spotted Owl habitat in Marin County is different than the habitat further north, and the primary prey species, the dusky-footed woodrat, is different than the prey in Oregon and Washington. Other potential climate impacts to Northern Spotted Owls in Marin County include drought, catastrophic fire, or more frequent large storms during spring breeding.
- **Noise and disturbance:** Disturbance from recreational users, trail construction and maintenance projects, and other human activities can detrimentally affect Northern Spotted Owls during their February—July breeding season. On-going Northern Spotted Owl monitoring tracks nest locations to help managers avoid disruptive activities near nests on public lands. However, public knowledge of Northern Spotted Owl noise regulations in residential areas is sporadic, so owls in these areas are particularly at risk to disturbance.
- **Rodenticides:** Northern Spotted Owls are at risk of potentially deadly rodenticide exposure, especially where they live adjacent to residential areas.

METRICS AND GOALS

- **Metric 1: Pair Territory Occupancy**

Baseline: Annual National Park Service (NPS) monitoring has shown average of 81 percent of potential territories were occupied by Northern Spotted Owl pairs between 1999—2015.
Status: High. 1999-2012 avg.=79% territories occupied by pairs. 15% decline over 5 years; >50% decline over two years
Confidence: High
Northern Spotted Owls are monitored on an annual basis within and adjacent to Mt. Tam on both NPS and California State Park lands, as well as by Point Blue on and adjacent to MMWD and Marin County Parks (MCP) lands.

Trend: No Change

Northern Spotted Owl pair occupancy of territories remains high, with some variation (Ellis, 2016). Over the 17 years of monitoring, the threshold for Caution would have only been exceeded in 2009, with this metric returning to good status for all years after that.

Condition Goals:

- Pair territory occupancy remains high
- Pair territory occupancy within the range of variability of the long-term average
- Pair territory occupancy in the good range

Condition Thresholds:

- *Good:* Three-year average pair occupancy >=75 percent and no more than current year with three-year moving average pair occupancy below 75 percent
- *Caution:* Current year and at least one additional, consecutive year with three-year moving average pair occupancy <75 percent and >/=65 percent, or a >50 percent decline in average pair occupancy between current year and next previous year
- *Significant Concern:* Current year and at least one additional, consecutive year with the three-year moving average <65 percent

Current Condition: Good

National Park Service monitoring from 1999—2015 revealed that Northern Spotted Owl pair occupancy of territories ranged from 60 percent—93 percent (Ellis, 2016), with an average pair occupancy of 81 percent. Only three individual years have had pair occupancy below 75 percent, with one of these at 60 percent. A three year moving average was used to smooth the data, and remove the effects of a single bad year. Thresholds were based on the distribution of the three year moving average data. The NPS monitoring program was designed to be able to detect a 15 percent decline over five years (Press et al., 2010). In 2015, 79 percent of territories were occupied by pairs and the three year moving average value was 82.7 percent, well above the good threshold.

- **Metric 2: Fecundity**

Baseline: Fecundity is defined as the number of female young per territorial female, and is measured by following reproductive status and determining nesting success during annual monitoring. Data collected between 1999—2015 show an average fecundity of 0.36.

Status: Good

From 1999—2015 fecundity ranged from 0.0 to 0.69 at NPS-monitored sites, with an average fecundity of 0.36. The standard deviation from the mean was 0.20, and standard errors for each year vary, but are roughly about +/- 0.10 around the calculated value. Fecundity has been variable over time, but 2007 was the only year where no breeding was observed at NPS sites. A three year moving average was used to smooth the data, and remove the effects of a single bad year. Thresholds were based on the distribution of the three year moving average data. The NPS monitoring program was designed to be able to detect a cumulative 34 percent decline over five years (Press et al., 2011).

Confidence: High

Northern Spotted Owls are monitored on an annual basis within and adjacent to Mt. Tam by the National Park Service (NPS) on both NPS and California State Park lands, as well as by Point Blue on MMWD and MCP lands.

Trend: No Change

Fecundity appears to be moving within the range of variation, though there is some concern in that only one of the last five years has had fecundity above the long-term average.

Condition Goals:

- Fecundity remains high
- Fecundity within range of long-term average variability
- Fecundity in the good range

Condition Thresholds:

- *Good:* Three-year average fecundity >/=0.28 and no more than current year with three-year average fecundity <0.28
- *Caution:* Current year and more than one consecutive, previous year with three-year average fecundity <0.28, >50 percent decline in fecundity between current year and year previous and/or two consecutive years with no breeding
- *Significant Concern:* Current year and next two consecutive, previous years with three-year average fecundity <0.24, or three of the last six years with no breeding

- **Metric 3: Barred Owl Presence**

Baseline: Barred Owls were first detected in Marin County in Muir Woods in 2002, and first confirmed breeding in Muir Woods in 2007 (Jennings, 2011, Ellis, 2016). Two other confirmed Barred Owls in Olema Valley were also documented over the last several years. In 2015, two Barred Owls were collected from Marin County as part of a research project being led by UC Berkeley in conjunction with the California Academy of Science (Ellis, 2016). Another Barred Owl that had been previously captured and fitted with a radio transmitter was found dead in Muir Woods in 2015. Based on NPS and Point Blue surveys and monitoring of the eBird site, no confirmed Barred Owls were present in Marin County as of the end of the 2015 breeding season.
Status: Good
Currently, there are no confirmed Barred Owls within monitored areas in Marin County (Ellis, 2016).
Confidence: High
Incidental Barred Owl detections are recorded during annual Northern Spotted Owl monitoring by NPS and Point Blue, and NPS conducts annual surveys for Barred Owls in areas outside of Northern Spotted Owl monitoring territories. Staff also monitor Barred Owl reports on eBird.
Trend: Improving
At least three Barred Owls were thought to occur in Marin County at the start of 2015; however, after the management and monitoring efforts described above, Marin County currently has no confirmed Barred Owls.

Condition Goals:

- No Barred Owls present, which is the historic condition for Marin County (Jennings et al., 2011)

Condition Thresholds:

- *Good:* Barred Owls occupy two or fewer areas within monitored areas in Marin County
- *Caution:* Barred Owls occupy three to six areas within monitored areas in Marin County
- *Significant Concern:* Barred Owls occupy more than six areas within monitored areas in Marin County

DATA/OBSERVATIONS/RESEARCH

Northern spotted owls reach the southern end of their range in Marin County. The northern spotted owl was federally listed as threatened in 1990. Spotted owls have been well studied in Marin, and especially within the Mt. Tam area. Inventory work was begun in the late 1980s, and continued in the early 1990's, with more complete inventories completed in 1997 and 1998 and 2006 (citations). Annual monitoring of spotted owls has been conducted since 1999 through a partnership with NPS covering federal and state park lands and Point Blue Conservation monitoring MMWD and MCOSD lands.

Spotted owls on Mt. Tam occur at high densities in native evergreen forests, most with some conifer component. Genetic work conducted on Marin spotted owls indicates that spotted owls here have some unique haplotypes and that there is more gene flow out of the population than coming in to the population.

INFORMATION GAPS

- **Sudden Oak Death:** While this disease has impacted forest habitats where Northern Spotted Owls breed, it is unclear how observed changes in breeding habitat as a result of SOD may affect Northern Spotted Owl foraging or its primary food item, the dusky-footed woodrat.
- **Climate change:** It is unknown how climate change may affect Northern Spotted Owl fecundity, survivorship, or their habitat.
- **Factors affecting fecundity:** Weather and climate, landscape and habitat factors, and the presence of Barred Owls affect Northern Spotted Owl fecundity across their entire range, but their effects have not been studied specifically in Marin County or Mt. Tam area.
- **Dispersal:** It is not known how juveniles disperse and where they travel to while waiting for opportunities to occupy breeding territories.
- **Habitat:** Habitat was identified as an important metric, but it needs to be further analyzed to be used to assess Northern Spotted Owl condition. Agencies currently have data on the size of nest trees, information about the area immediately surrounding them, and GIS data on landscape features. Landscape analysis around nest trees has revealed some of the features associated with Northern Spotted Owl habitat (Stralberg et al., 2009).
- **Dusky-footed woodrats:** Dusky-footed woodrats were considered a potential metric to assess Northern Spotted Owl populations, as they are their primary food resource. However, we do not currently have good data on woodrat abundance across Northern Spotted Owl sites. This metric is being developed as an indicator under mammals, with photo data from the Marin Wildlife Picture Index project.
- **Survivorship:** Survivorship is measured by banding and re-sighting Northern Spotted Owls during annual monitoring. Mark-recapture analyses are then used to calculate survivorship estimates. In addition, having marked individuals provides information on territory turnover, and shifts in the locations of territories over time. Survivorship is an important metric in assessing Northern Spotted Owls, but is unlikely to be adopted, unless part of a research based project. Due to limited resources, NPS and Point Blue stopped banding Northern Spotted Owls in 2003 after initiating a banding program in 1998 (Ellis, 2016), and focused their efforts on continuing to collect territory occupancy and fecundity data.

KEY ACTIONS

Current and past efforts:

- **Monitoring:** Continue to support Barred Owl monitoring to inform potential management of Barred Owls
- **Habitat protections:** Continue breeding season habitat protections for Northern Spotted Owls

Future planned work/actions:

- **Monitoring:** Continue long-term Northern Spotted Owl monitoring; continue to support Barred Owl monitoring and consider management as necessary
- **Habitat protections:** Continue habitat protections for breeding Northern Spotted Owls
- **Fecundity analysis:** Conduct a long-term trend analysis including assessing fecundity; analyze factors affecting fecundity specific to Marin populations

Actions needed to improve status/trend: Annual Monitoring

- Continue support for long-term monitoring
- Continue to support barred owl monitoring and consider continued management of barred owls
- Continue breeding season habitat protections for spotted owls

KEY LITERATURE

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APPENDIX 3. ATTENDEES OF THE MARCH 10–11, 2016 SCIENTIST WORKSHOP

*Indicates this person is also on the Health of Mt. Tam's Natural Resources Advisory Committee

David Ackerly, Ph.D. – University of California, Berkeley

Greg Andrews – Marin Municipal Water District

Ethan Bell – Ecological Consultant

Shelly Benson – California Lichen Society

Emily Burns, Ph.D. – Save the Redwoods League

Richard Cobb, Ph.D. – University of California, Davis

Renee Comier – Point Blue Conservation Science

Paul da Silva, Ph.D. – College of Marin

Marie Denn – National Park Service

Raymond Dodd – Felidae Conservation Fund

Joe Drennan – Ecological Consultant

Eric Ettlinger – Marin Municipal Water District

Gina Farr – Project Coyote

Sharon Farrell – Golden Gate National Parks Conservancy*

Leslie Ferguson – San Francisco Bay Regional Water Quality Control Board

Allen Fish – Golden Gate Raptor Observatory*

Alan Flint, Ph.D. – USGS

Lorraine Flint – US Geological Survey

Darren Fong – National Park Service

Holly Forbes – University of California Botanical Garden at Berkeley

Alison Forrestel, Ph.D. – National Park Service

Susan Frankel - USDA Forest Service, Pacific Southwest Research Station

Brett Furnas, Ph.D. – University of California, Berkeley

Tom Gardali – Point Blue Conservation Science*

Sandy Guldman – Friends of Corte Madera Creek Watershed

John Hafernik – San Francisco State University

Bree Hardcastle – California State Parks

Peter Hartsough, Ph.D. – University of California, Davis

Daphne Hatch – National Park Service

Megan Isadore – River Otter Ecology Project

Dave Johnston, Ph.D. – Ecological Consultant

Clint Kellner, Ph.D. – California Native Plant Society, Marin Chapter

Todd Keeler-Wolf, Ph.D. – California Department of Fish and Wildlife

Patrick Kleeman - USGS Western Ecological Research Center

Janet Klein – Marin Municipal Water District

John Krause – California Department of Fish and Wildlife

Bill Kuhn, Ph.D. – Marin County Parks*

Sarah Kupferberg, Ph.D. – Ecological Consultant

Roger Levinthal – Ecological Consultant

Karla Marlow – Ecological Consultant

Mischon Martin – Marin County Parks

Bill Merkle, Ph.D. – National Park Service*

Lisa Micheli, Ph.D. – Pepperwood Preserve

Mia Monroe – National Park Service

Ally Nauer – Felidae Conservation Fund

Michelle O'Herron – Science Communications Consultant

Tom Parker, Ph.D. – San Francisco State University

Barbara Salzman – Marin Audubon Society

Carolyn Shoulders – National Park Service

Doreen Smith – California Native Plant Society, Marin Chapter

Robert Steers, Ph.D. – Ecological Consultant

Scott Stephens, Ph.D. – University of California, Berkeley

Andrea Swei, Ph.D. – San Francisco State University

Christina Toms – San Francisco Bay Regional Water Quality Control Board

Sue Townsend, Ph.D. – Ecological Consultant

Mike Vasey, Ph.D. – San Francisco State University

Stu Weiss, Ph.D. – Creekside Center for Earth Observation

Kristen Ward – National Park Service

Andrea Williams – Marin Municipal Water District*

Eric Wrubel – National Park Service

Andy Zink, Ph.D. – San Francisco State University

APPENDIX 4. DESCRIPTION OF THE SPECIES TRAIT-STATUS DATABASE

Indicator Traits Database: Introduction and Instructions for Use

The database was created to help identify which indicators would be most meaningful and relevant for reporting on the overarching environmental goals for maintaining a “healthy” Mt. Tam over time.

Those goals include:

- Mt. Tam’s ecosystems are resilient (able to function/recover despite change or shock).
- The full complement of plants, animals, and other life is present and able to find food, shelter, water, and mates.
- Natural processes occur in a manner and frequency considered “normal” based on historic evidence.

We wanted to be flexible in our approach, and design a tool that would allow us to roll-up the status and trends of indicators in multiple ways based upon certain common traits. Once complete, we envision that the database can be queried in multiple ways. For example, for species that might serve as good indicators for addressing a specific goal of question (such as what is the state of the birds, oak woodlands, the mountain in the face of climate etc.). The condition and trends of those species could then get rolled up to address that question.

Resource specialists have populated the database with information based upon the agency monitoring programs, research, data sources and professional opinion. The planning team looks forward to feedback and contributions from participating scientists during the workshop, as there are gaps, and areas unknown.

Each indicator has its own row in the database, and pick lists represent the column choices available. While using the database, it is important to note that it was designed to be uniform across taxonomic groups, therefore not all options may be appropriate to all species; it is perfectly fine to leave a column blank if it does not apply to a particular species. Also note that the intent is to find good species indicators for the traits, therefore please choose the strongest option from a pick list even if more than one could apply.

Below is the data dictionary which outlines the definitions for each column and the choices available:

Column Heading		Description	Menu Options
Vegetation	Primary affiliation	This is the vegetation affiliation most strongly associated with the focal species	Open-canopy oak woodland, Closed canopy forest (mixed), Conifers, Grassland, Riparian, Tidal marsh, Scrub/ chaparral, Serpentine barrens, Sargent cypress, Lakes, Springs/ seeps and wet meadows
	Secondary affiliation	This is a vegetation affiliation associated with the focal species	

Column Heading		Description	Menu Options
	Does species use 3 or more vegetation types?	if the species associates with 3 or more vegetation types it is regarded as a generalist	Yes, No
Niche	Trophic level/ diet	What main role does the species play within its ecosystem	Carnivore, Insectivore, Omnivore, Piscivore, Granivore, Detritivore/decomposer, Herbivore, Primary producer
	Regulatory or other special status	Which conservation list does the species appear on	Federal T and E, State T and E, CRPR list, GNC global rank, CDFW species of special concern, Other, None
	Reproduction - specific or habitat requirement	Only the most important to a species should be chosen	Tree/snag cavity, Wetland/ aquatic, Ground nester, Shrub nester, Canopy nester, Subterranean nest/ den/ burrow, Fire
	Species seasonality	How much of the species life cycle is carried out within Mt. Tam area	Visitor- breeds here, Visitor- breeds elsewhere, Resident
Climate change vulnerable?		Is the local species population particularly vulnerable to likely changes in the climate within the Mt. Tam area of focus? Vulnerability is a measure of the susceptibility or amount of risk of a population to negative impacts. We define climate vulnerability as the amount of evidence that climate change will negatively impact a population. Consideration should be given to intrinsic traits (such as physiological tolerances) of species that make them vulnerable and extrinsic factors (such as increasing temperatures or habitat loss) that will result from climate change. For example, a species that is highly sensitive to increasing temperature would be more vulnerable if the magnitude of climate change is larger within that species' geographic range than the same species would be if the magnitude of climate change for its range was smaller.	Yes, No, Unlikely, Unknown
Landscape requirement		What size home range does the species require to carry out all necessary life functions	Small area required, Large area required, Beyond Mt. Tam
Highly restricted distribution		The level of endemism for species with a restricted distribution (or select Not restricted)	Mt. Tam only, Marin Only, Regional only, Locally rare, Not restricted
Iconic		Does the species fit one of the following categories: Charismatic to local cultural perspectives. Current status is likely to draw broad attention or concern. Emblematic of a local habitat or region.	Yes, No

Column Heading		Description	Menu Options
		Widely-recognized by the public, and/or its name refers to a locality within the One Tam region	
Stressors	Mechanical disturbance	Is the local species population particularly sensitive to disturbance from mechanical processes, such as grass cutting, brush cutting, fuelbreak maintenance etc.	Yes, No
	Invasive species	Is the local species population particularly vulnerable to threats from invasive species	Yes, No
	Disease	Is the species particularly sensitive to threats from disease	Yes, No
	Fire regime change	Is the species particularly vulnerable to threats from a significant change in fire regime than considered natural	Yes, No
	Pollution (air, water, noise)	Is the species particularly sensitive to threats from pollutants such as noise, water pollution, air pollution	Yes, No
	Compaction or trampling	Is the species particularly sensitive to threats from trampling/disturbance or ground compaction	Yes, No
	Human presence	Is the local species population particularly sensitive to its proximity to human presence	Yes, No
	Drought	Is the local species population particularly sensitive to threats caused by drought-related issues	Yes, No
	Pesticides or rodenticides	Is the local species population particularly sensitive to the threats caused by pesticides, herbicides or rodenticides	Yes, No
	Habitat loss and fragmentation	Is the local species population particularly sensitive to the effects of reduced habitat or reduced habitat connectivity	Yes, No
	Trophic-level disruptions	Is the local species population particularly sensitive to changes in its ecosystem trophic levels, beyond what is considered natural, such as changes in availability of preferred prey or reduced predation by natural predators	Yes, No
Condition and trend statement	Condition	The current condition of the focal species based on its metric: Good - The goal is 67-100% met. Caution - The goal is 34-66% met. Significant Concern - The goal is 0-33% met. Unknown - Not enough information to state condition	Good, Caution, Significant concern, Unknown
	Confidence	The level of confidence when returning the condition and trend statement	High, Moderate, Low, Unknown

Column Heading		Description	Menu Options
	Trend	The change in condition of the focal species based on current versus previous measure(s); independent of status (e.g., a resource may be "Declining" but still be in "Good" condition)..Improving - The condition is getting better. No Change - The condition is unchanging. Declining - The condition is deteriorating/getting worse. Unknown - Not enough information to state trend.	Improving, No change, Declining, Unknown
The number of land managing agencies within the One Tam Area of Focus with available data	Presence /absence	How many agencies have presence/ absence data for this species	1 Agency, 2 agencies, 3 agencies, All agencies, Not available
	Abundance	How many agencies have abundance data for this species	1 Agency, 2 agencies, 3 agencies, All agencies, Not available
	Reproductive success	How many agencies have reproductive success data for this species	1 Agency, 2 agencies, 3 agencies, All agencies, Not available

SPECIES LISTS

The following are lists of all the known species for particular taxonomic groups found in the One Tam areas of focus.

They represent current, verified information compiled by One Tam partner agencies at this time, and will likely be updated in the future through further review of additional technical reports, inventories, and validation of other data sources. Please see *onetam.org/biodiversity* for the latest versions.

APPENDIX 5. PLANT SPECIES OF MT. TAM

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual grass	*Beckmannia syzigachne*		American sloughgrass	X
Annual grass	*Polypogon monspeliensis*		Annual beard grass	
Annual grass	*Poa annua*		Annual blue grass	
Annual grass	*Phalaris canariensis*		Annual canary grass	
Annual grass	*Deschampsia danthonioides*		Annual hairgrass	X
Annual grass	*Koeleria gerardii*		Annual june grass, bristly koeleria	
Annual grass	*Hordeum marinum*	*Hordeum marinum* ssp. *gussoneanum*	Barley	X
Annual grass	*Echinochloa crus-galli*		Barnyard grass	
Annual grass	*Hordeum vulgare*		Common barley	
Annual grass	*Cynosurus echinatus*		Dogtail grass	
Annual grass	*Bromus tectorum*		Downy chess	
Annual grass	*Aira elegans*		Elegant hair grass	
Annual grass	*Eleocharis engelmannii*		Engelmann's spikerush	X
Annual grass	*Hordeum murinum*	*Hordeum murinum* ssp. *glaucum*	Foxtail	X
Annual grass		*Hordeum murinum* ssp. *leporinum*	Farmer's foxtail	X
Annual grass	*Alopecurus saccatus*		Foxtail	X
Annual grass	*Bromus madritensis*	*Bromus madritensis* ssp. *rubens*	Foxtail brome	
Annual grass	*Aegilops triuncialis*		Goatgrass	
Annual grass	*Phalaris paradoxa*		Hood canarygrass	
Annual grass	*Poa howellii*		Howell's blue grass	X
Annual grass	*Juncus kelloggii*		Kellogg's dwarf rush	X
Annual grass	*Juncus capitatus*		Leafy bracted dwarf rush	
Annual grass	*Phalaris lemmonii*		Lemmon's canarygrass	X
Annual grass	*Briza minor*		Little rattlesnake grass	
Annual grass	*Isolepis cernua*		Low bulrush	X
Annual grass	*Elymus caput-medusae*		Medusa head	
Annual grass	*Gastridium phleoides*		Nit grass	
Annual grass	*Briza maxima*		Rattlesnake grass	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual grass	*Bromus diandrus*		Ripgut brome	
Annual grass	*Scribneria bolanderi*		Scribneria	X
Annual grass	*Aira caryophyllea*		Silvery hairgrass	
Annual grass	*Festuca microstachys*		Small fescue	X
Annual grass	*Bromus hordeaceus*		Soft chess	
Annual grass	*Bromus sterilis*		Sterile brome	
Annual grass	*Cyperus difformis*		Variable flatsedge	
Annual grass	*Avena fatua*		Wildoats	
Annual herb	*Zeltnera muehlenbergii*		Muehlenberg's centaury	X
Annual herb	*Zeltnera trichantha*		Alkali centaury	X
Annual herb	*Minuartia pusilla*		Annual sandwort	X
Annual herb	*Urtica urens*		Annual stinging nettle	
Annual herb	*Melilotus indicus*		Annual yellow sweetclover	
Annual herb	*Crassula aquatica*		Aquatic pygmy weed	X
Annual herb	*Nemophila menziesii*	*Nemophila menziesii* var. *atomaria*	Baby blue eyes	X
Annual herb		*Nemophila menziesii* var. *menziesii*	Menzies' Baby blue eyes	X
Annual herb	*Cryptantha flaccida*		Beaked cryptantha	X
Annual herb	*Trifolium barbigerum*		Bearded clover	X
Annual herb	*Amsinckia lunaris*		Bent flowered fiddleneck	X
Annual herb	*Erodium botrys*		Big heron bill	
Annual herb	*Veronica persica*		Bird's eye speedwell	
Annual herb	*Brassica nigra*		Black mustard	
Annual herb	*Gilia capitata*	*Gilia capitata* ssp. *capitata*	Blue field gilia	X
Annual herb	*Borago officinalis*		Borage	
Annual herb	*Pholistoma auritum*		Blue fiestaflower	X
Annual herb	*Claytonia exigua*	*Claytonia exigua* ssp. *exigua*	Viridis	X
Annual herb		*Claytonia exigua* ssp. *glauca*	Blue leaved spring beauty	X
Annual herb	*Rorippa curvipes*		Bluntleaf yellow cress	X
Annual herb	*Callitriche heterophylla*	*Callitriche heterophylla* var. *bolanderi*	Bolander's water starwort	X
Annual herb	*Plagiobothrys*		Bracted allocarya	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
	bracteatus			
Annual herb	*Trifolium dichotomum*		Branched indian clover	X
Annual herb	*Cotula australis*		Brass buttons	
Annual herb	*Calandrinia breweri*		Brewer's calandrinia	X
Annual herb	*Astragalus breweri*		Brewer's milk vetch	X
Annual herb	*Leptosiphon acicularis*		Bristly leptosiphon	X
Annual herb	*Parentucellia latifolia*		Broadleaf parentucellia	
Annual herb	*Malva nicaeensis*		Bull mallow	
Annual herb	*Trifolium fucatum*		Bull clover	X
Annual herb	*Amaranthus californicus*		California amaranth	X
Annual herb	*Medicago polymorpha*		California burclover	
Annual herb	*Rafinesquia californica*		California chicory	X
Annual herb	*Logfia filaginoides*		California cottonrose	X
Annual herb	*Gilia achilleifolia*		California gilia	X
Annual herb	*Caulanthus lasiophyllus*		California mustard	X
Annual herb	*Plantago erecta*		California plantain	X
Annual herb	*Epilobium foliosum*		California willowherb	X
Annual herb	*Navarretia heterodoxa*		Calistoga navarretia	X
Annual herb	*Erigeron canadensis*		Canada horseweed	X
Annual herb	*Zeltnera exaltata*		Cancha lagua	X
Annual herb	*Nemophila heterophylla*		Canyon nemophila	X
Annual herb	*Lysimachia minima*		Chaffweed	X
Annual herb	*Sidalcea calycosa*	*Sidalcea calycosa* ssp. *calycosa*	Checker mallow	X
Annual herb	*Salvia columbariae*		Chia sage	X
Annual herb	*Lupinus microcarpus*	*Lupinus microcarpus* var. *densiflorus*	Chick lupine	X
Annual herb	*Stellaria media*		Chickweed	
Annual herb	*Plantago truncata*	*Plantago truncata* ssp. *firma*	Chilean plantain	X
Annual herb	*Acmispon wrangelianus*		Chilean trefoil	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Collinsia heterophylla*		Chinese houses	X
Annual herb	*Galium aparine*		Cleavers	X
Annual herb	*Trifolium glomeratum*		Clustered clover	
Annual herb	*Plagiobothrys undulatus*		Coast allocarya	X
Annual herb	*Microseris bigelovii*		Coast microseris	X
Annual herb	*Sedum radiatum*		Coast range stonecrop	X
Annual herb	*Erodium cicutarium*		Coastal heron's bill	
Annual herb	*Madia sativa*		Coastal tarweed	X
Annual herb	*Silene gallica*		Common catchfly	
Annual herb	*Cryptantha clevelandii*		Common cryptantha	X
Annual herb	*Amsinckia intermedia*		Common fiddleneck	X
Annual herb	*Thysanocarpus curvipes*		Common fringe pod	X
Annual herb	*Senecio vulgaris*		Common groundsel	
Annual herb	*Gratiola ebracteata*		Common hedge hyssop	X
Annual herb	*Madia elegans*		Common madia	X
Annual herb	*Brassica rapa*		Common mustard	
Annual herb	*Cicendia quadrangularis*		Common microcalis	X
Annual herb	*Lapsana communis*		Common nipplewort	
Annual herb	*Phacelia distans*		Common phacelia	X
Annual herb	*Portulaca oleracea*		Common purslane	
Annual herb	*Mimulus congdonii*		Congdon's monkeyflower	X
Annual herb	*Spergula arvensis*		Corn spurry	
Annual herb	*Platystemon californicus*		Cream cups	X
Annual herb	*Castilleja rubicundula*	*Castilleja rubicundula* ssp. *lithospermoides*	Cream sacs	X
Annual herb	*Trifolium obtusiflorum*		Creek clover	X
Annual herb	*Mauranthemum paludosum*		Creeping Daisy	
Annual herb	*Hedypnois cretica*		Crete weed	
Annual herb	*Glebionis coronaria*		Crown daisy	
Annual herb	*Plantago*		Cut leaf plantain	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
	coronopus			
Annual herb	*Castilleja densiflora*	*Castilleja densiflora* ssp. *densiflora*	Dense flower owl's clover	X
Annual herb	*Phacelia divaricata*		Divaricate phacelia	X
Annual herb	*Anthemis cotula*		Dog fennel	
Annual herb	*Microseris douglasii*	*Microseris douglasii* ssp. *douglasii*	Douglas' microseris	X
Annual herb	*Minuartia douglasii*		Douglas' sandwort	X
Annual herb	*Croton setigerus*		Dove weed	X
Annual herb	*Athysanus pusillus*		Dwarf athysanus	X
Annual herb	*Trifolium depauperatum*	*Trifolium depauperatum* var. *amplectens*	Pale sack clover	X
Annual herb		*Trifolium depauperatum* var. *depauperatum*	Dwarf bladder clover	X
Annual herb		*Trifolium depauperatum* var. *truncatum*	Dwarf sack clover	X
Annual herb	*Sagina apetala*		Dwarf pearlwort	X
Annual herb	*Oxalis micrantha*		Dwarf woodsorrel	
Annual herb	*Cakile maritima*		European searocket	
Annual herb	*Campanula angustiflora*		Eastwood's harebell	X
Annual herb	*Pterostegia drymarioides*		Fairy mist	X
Annual herb	*Leptosiphon androsaceus*		False babystars	X
Annual herb	*Clarkia amoena*	*Clarkia amoena* ssp. *amoena*	Farewell to spring	X
Annual herb		*Clarkia amoena* ssp. *huntiana*	Farewell to spring	X
Annual herb	*Clarkia rubicunda*		Farewell to spring	X
Annual herb	*Trifolium oliganthum*		Few flowered clover	X
Annual herb	*Hesperevax sparsiflora*	*Hesperevax sparsiflora* var. *sparsiflora*	Few flowered evax	X
Annual herb	*Amsinckia menziesii*		Fiddleneck	X
Annual herb	*Torilis arvensis*		Field hedge parsley	
Annual herb	*Sherardia arvensis*		Field madder	
Annual herb	*Calendula arvensis*		Field marigold	
Annual herb	*Silene coniflora*		Fire following campion	X
Annual herb	*Papaver californicum*		Fire poppy	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Linum bienne*		Flax	
Annual herb	*Myosotis discolor*		Forget me not	
Annual herb	*Polycarpon tetraphyllum*		Four leaved allseed	
Annual herb	*Vicia tetrasperma*		Four seeded vetch	
Annual herb	*Sidalcea diploscypha*		Fringed checkerbloom	X
Annual herb	*Scleranthus annuus*		German knotgrass	
Annual herb	*Eriogonum luteolum*	*Eriogonum luteolum* var. *caninum*	Tiburon buckwheat	X
Annual herb		*Eriogonum luteolum* var. *luteolum*	Golden buckwheat	X
Annual herb	*Lasthenia californica*		Goldfields	X
Annual herb	*Clarkia gracilis*	*Clarkia gracilis* ssp. *gracilis*	Graceful clarkia	X
Annual herb	*Lathyrus sphaericus*		Grass Peavine	
Annual herb	*Campanula griffinii*		Griffin's harebell	X
Annual herb	*Najas guadalupensis*		Guadalupe water nymph	X
Annual herb	*Madia gracilis*		Gumweed	X
Annual herb	*Claytonia gypsophiloides*		Gypsum spring beauty	X
Annual herb	*Cordylanthus pilosus*	*Cordylanthus pilosus* ssp. *pilosus*	Hairy bird's beak	X
Annual herb	*Leontodon saxatilis*	*Leontodon saxatilis* ssp. *saxatilis*	Hairy Hawkbit	X
Annual herb	*Oxalis pilosa*		Hairy wood sorrel	X
Annual herb	*Hemizonia congesta*	*Hemizonia congesta* ssp. *lutescens*	Hayfield tarweed	X
Annual herb	*Sisymbrium officinale*		Hedge mustard	
Annual herb	*Yabea microcarpa*		Hedge parsley	X
Annual herb	*Yabea microcarpa*		Hedge parsley	X
Annual herb	*Cannabis sativa*		Herb	
Annual herb	*Heterocodon rariflorum*		Heterocodon	X
Annual herb	*Acmispon parviflorus*		Hill lotus	X
Annual herb	*Collinsia sparsiflora*	*Collinsia sparsiflora* var. *collina*	Hillside collinsia	X
Annual herb		*Collinsia sparsiflora* var. *sparsiflora*	Spinster's blue eyed mary	X
Annual herb	*Lupinus succulentus*		Hollow stem blue lupine	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Navarretia mellita*		Honey navarretia	X
Annual herb	*Trifolium campestre*		Hop clover	
Annual herb	*Stebbinsoseris heterocarpa*		hybrid microseris	X
Annual herb	*Mollugo verticillata*		Indian chickweed	
Annual herb	*Trifolium albopurpureum*		Indian clover	X
Annual herb	*Navarretia intertexta*		Interwoven navarretia	X
Annual herb	*Carduus pycnocephalus*		Italian thistle	
Annual herb	*Pseudognaphaliu m luteoalbum*		Jersey cudweed	
Annual herb	*Datura stramonium*		Jimson weed	
Annual herb	*Castilleja ambigua*	*Castilleja ambigua* ssp. *ambigua*	Johnny nip	X
Annual herb	*Trifolium striatum*		Knotted clover	
Annual herb	*Chorizanthe polygonoides*	*Chorizanthe polygonoides* var. *polygonoides*	Knotweed spineflower	X
Annual herb	*Galium divaricatum*		Lamarck's bedstraw	
Annual herb	*Chenopodium album*		Lambs quarters	
Annual herb	*Leptosiphon grandiflorus*		Large flowered leptosiphon	X
Annual herb	*Cerastium glomeratum*		Large mouse ears	
Annual herb	*Antirrhinum kelloggii*		Lax snapdragon	X
Annual herb	*Castilleja minor*	*Castilleja minor* ssp. *spiralis*	Lesser paintbrush	X
Annual herb	*Lepidium didymum*		Lesser swine cress	
Annual herb	*Triphysaria pusilla*		Little owl's clover	X
Annual herb	*Astragalus gambelianus*		Loco weed	X
Annual herb	*Plectritis ciliosa*	*Plectritis ciliosa* ssp. *ciliosa*	Long spurred plectritis	X
Annual herb	*Gnaphalium palustre*		Lowland cudweed	X
Annual herb	*Trifolium macraei*		Macrae's clover	X
Annual herb	*Navarretia rosulata*		Marin county navarretia	X
Annual herb	*Hesperolinon congestum*		Marin western flax	X
Annual herb	*Bellardia trixago*		Mediterranean lineseed	
Annual herb	*Medicago praecox*		Mediterranean medick	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Crassula tillaea*		Mediterranean pygmy weed	
Annual herb	*Claytonia perfoliata*	*Claytonia perfoliata* ssp. *perfoliata*	Miner's lettuce	X
Annual herb	*Epilobium minutum*		Minute willowherb	X
Annual herb	*Agoseris heterophylla*		Mountain dandelion	X
Annual herb	*Streptanthus glandulosus*	*Streptanthus glandulosus* ssp. *pulchellus*	Mt. tamalpais jewel flower	X
Annual herb		*Streptanthus glandulosus* ssp. *secundus*	One sided jewelflower	X
Annual herb	*Epilobium torreyi*		Narrow boisduvalia	X
Annual herb	*Trifolium angustifolium*		Narrow leaved clover	
Annual herb	*Castilleja attenuata*		Narrow leaved owl's clover	X
Annual herb	*Logfia gallica*		Narrowleaf cottonrose	
Annual herb	*Tetragonia tetragonioides*		New zealand spinach	
Annual herb	*Lasthenia gracilis*		Needle goldfields	X
Annual herb	*Trifolium cernuum*		Nodding clover	
Annual herb	*Trifolium bifidum*	*Trifolium bifidum* var. *bifidum*	Notch leaf clover	X
Annual herb		*Trifolium bifidum* var. *decipiens*	Notch leaf clover	X
Annual herb	*Trifolium olivaceum*		Olive clover	X
Annual herb	*Cypselea humifusa*		Panal	
Annual herb	*Lepidium strictum*		Peppergrass	X
Annual herb	*Euphorbia peplus*		Petty spurge	
Annual herb	*Trifolium gracilentum*		Pin point clover	X
Annual herb	*Scabiosa atropurpurea*		Pincushions	
Annual herb	*Matricaria discoidea*		Pineapple weed	
Annual herb	*Petrorhagia prolifera*		Pink grass	
Annual herb	*Chorizanthe membranacea*		Pink spineflower	X
Annual herb	*Chloropyron maritimum*	*Chloropyron maritimum* ssp. *palustre*	Point Reyes bird's beak	X
Annual herb	*Lactuca serriola*		Prickly lettuce	
Annual herb	*Clarkia purpurea*	*Clarkia purpurea* ssp. *quadrivulnera*	Purple clarkia	X
Annual herb	*Lamium purpureum*		Purple dead nettle	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Mimulus douglasii*		Purple mouse ears	X
Annual herb	*Gilia clivorum*		Purple spot gilia	X
Annual herb	*Micropus californicus*	*Micropus californicus* var. *californicus*	Q tips	X
Annual herb	*Mimulus rattanii*		Rattan's monkeyflower	X
Annual herb	*Ammannia coccinea*		Red ammannia	X
Annual herb	*Calandrinia menziesii*		Red maids	X
Annual herb	*Clarkia concinna*	*Clarkia concinna* ssp. *concinna*	Red ribbons	X
Annual herb	*Plagiobothrys reticulatus*		Reticulate popcorn flower	X
Annual herb	*Euphorbia spathulata*		Reticulate seeded spurge	X
Annual herb	*Geranium robertianum*		Robert's geranium	
Annual herb	*Trifolium hirtum*		Rose clover	
Annual herb	*Calycadenia multiglandulosa*		Rosin weed	X
Annual herb	*Xanthium strumarium*		Rough cockleburr	X
Annual herb	*Plagiobothrys nothofulvus*		Rusty haired popcorn flower	X
Annual herb	*Crassula connata*		Sand pygmy weed	X
Annual herb	*Stebbinsoseris decipiens*		Santa cruz microseris	X
Annual herb	*Lysimachia arvensis*		Scarlet pimpernel	
Annual herb	*Amsinckia spectabilis*		Seaside fiddleneck	X
Annual herb	*Trifolium dubium*		Shamrock	
Annual herb	*Capsella bursa-pastoris*		Shepherd's purse	
Annual herb	*Stellaria nitens*		Shining chickweed	X
Annual herb	*Lepidium nitidum*		Shining pepper grass	X
Annual herb	*Acmispon brachycarpus*		Short podded lotus	X
Annual herb	*Plectritis congesta*	*Plectritis congesta* ssp. *brachystemon*	Shortspur seablush	X
Annual herb	*Uropappus lindleyi*		Silver puffs	X
Annual herb	*Navarretia squarrosa*		Skunkweed	X
Annual herb	*Silene antirrhina*		Sleepy catch fly	X
Annual herb	*Centaurium tenuiflorum*		Slender centaury	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Microsteris gracilis*		Slender phlox	X
Annual herb	*Plagiobothrys tenellus*		Slender popcorn flower	X
Annual herb	*Psilocarphus tenellus*		Slender woolly heads	X
Annual herb	*Hesperolinon micranthum*		Small flower western flax	X
Annual herb	*Acmispon micranthus*		Small flowered lotus	X
Annual herb	*Nemophila parviflora*	*Nemophila parviflora* var. *parviflora*	Small flowered nemophila	X
Annual herb	*Trifolium microcephalum*		Small head clover	X
Annual herb	*Madia exigua*		Small tarweed	X
Annual herb	*Trifolium variegatum*	*Trifolium variegatum* var. *geminiflorum*	Small-flowered variegated clover	X
Annual herb	*Claytonia parviflora*		Small-leaved miners lettuce	X
Annual herb	*Epilobium campestre*		Smooth boisduvalia	X
Annual herb	*Hypochaeris glabra*		Smooth cats ear	
Annual herb	*Soliva sessilis*		South american soliva	
Annual herb	*Sonchus oleraceus*		Sow thistle	
Annual herb	*Acmispon americanus*		Spanish Clover	X
Annual herb	*Veronica peregrina*	*Veronica peregrina* ssp. *xalapensis*	Speedwell	X
Annual herb	*Sonchus asper*		Spiny sowthistle	
Annual herb	*Medicago arabica*		Spotted burclover	
Annual herb	*Persicaria maculosa*		Spotted lady's thumb	
Annual herb	*Euphorbia maculata*		Spotted spurge	
Annual herb	*Limosella acaulis*		Stemless mudwort	X
Annual herb	*Navarretia viscidula*		Sticky navarretia	X
Annual herb	*Phacelia malvifolia*		Stinging phacelia	X
Annual herb	*Dittrichia graveolens*		Stinkwort	
Annual herb	*Acmispon strigosus*		Stringose lotus	X
Annual herb	*Trifolium subterraneum*		Subterranean clover	
Annual herb	*Galium triflorum*		Sweet bedstraw	X
Annual herb	*Sisymbrium altissimum*		Tall tumble mustard	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Streptanthus batrachopus*		Tamalpais jewel flower	X
Annual herb	*Lessingia micradenia*	*Lessingia micradenia* var. *micradenia*	Tamalpais lessingia	X
Annual herb	*Lathyrus tingitanus*		Tangier pea	
Annual herb	*Madia anomala*		Tarweed	X
Annual herb	*Lythrum tribracteatum*		Three bracted loosestrife	
Annual herb	*Layia platyglossa*		Tidy tips	X
Annual herb	*Galium murale*		Tiny bedstraw	
Annual herb	*Ranunculus hebecarpus*		Tiny buttercup	X
Annual herb	*Centaurea melitensis*		Tocalote	
Annual herb	*Trifolium willdenovii*		Tomcat clover	X
Annual herb	*Trifolium ciliolatum*		Tree clover	X
Annual herb	*Erigeron sumatrensis*		Tropical horseweed	
Annual herb	*Leptosiphon bicolor*		True babystars	X
Annual herb	*Eschscholzia caespitosa*		Tufted eschscholzia	X
Annual herb	*Stephanomeria virgata*		Twiggy wreath plant	X
Annual herb	*Lupinus nanus*		Valley sky lupine	X
Annual herb	*Trifolium microdon*		Valparaiso clover	X
Annual herb	*Leptosiphon parviflorus*		Variable linanthus	X
Annual herb	*Collomia heterophylla*		Varied leaved collomia	X
Annual herb	*Triodanis biflora*		Venus looking glass	X
Annual herb	*Githopsis specularioides*		Venus' looking glass	X
Annual herb	*Galium parisiense*		Wall bedstraw	
Annual herb	*Montia fontana*		Water montia	X
Annual herb	*Sagina decumbens*	*Sagina decumbens* ssp. *occidentalis*	Western pearlwort	X
Annual herb	*Hesperocnide tenella*		Western stinging nettle	X
Annual herb	*Plectritis macrocera*		White headed plectritis	X
Annual herb	*Stephanomeria elata*	*Stephanomeria exigua* ssp. *coronaria*	White plume wirelettuce	X
Annual herb	*Erodium brachycarpum*		White stemmed filaree	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual herb	*Erodium moschatum*		Whitestem filaree	
Annual herb	*Draba verna*		Whitlow grass	X
Annual herb	*Daucus pusillus*		Wild carrot	X
Annual herb	*Geranium dissectum*		Wild geranium	
Annual herb	*Torilis nodosa*		Wild parsley	
Annual herb	*Petrorhagia dubia*		Wilding pink	
Annual herb	*Epilobium brachycarpum*		Willow herb	X
Annual herb	*Epilobium densiflorum*		Willow herb	X
Annual herb	*Lactuca saligna*		Willow lettuce	
Annual herb	*Rigiopappus leptocladus*		Wire weed	X
Annual herb	*Antirrhinum vexillocalyculatum*		Wiry snapdragon	X
Annual herb	*Clarkia unguiculata*		Woodland clarkia	X
Annual herb	*Senecio sylvaticus*		Woodland groundsel	
Annual herb	*Layia gaillardioides*		Woodland layia	X
Annual herb	*Trifolium tomentosum*		Woolly clover	
Annual herb	*Carthamus lanatus*		Woolly distaff thistle	
Annual herb	*Lessingia hololeuca*		Woolly headed lessingia	X
Annual herb	*Centaurea solstitialis*		Yellow starthistle	
Annual herb (aquatic)	*Triglochin scilloides*		Flowering-quillwort	X
Annual herb (aquatic)	*Callitriche stagnalis*		Pond water starwort	
Annual herb, Vine	*Anthriscus caucalis*		Bur chevril	
Annual herb, Vine	*Tropaeolum majus*		Garden nasturtium	
Annual herb, Vine	*Vicia hirsuta*		Hairy vetch	
Annual herb, Vine	*Vicia benghalensis*		Purple vetch	
Annual herb, Vine	*Scandix pecten-veneris*		Shepherd's needle	
Annual herb, Vine	*Vicia sativa*	*Vicia sativa* ssp. *nigra*	Smaller common vetch	X
Annual herb, Vine		*Vicia sativa* ssp. *sativa*	Common vetch	X
Annual herb, Vine	*Vicia villosa*	*Vicia villosa* ssp. *Varia*	Thick fruited vetch	
Annual herb, Vine	*Cuscuta*		California dodder	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
(parasitic)	*californica*			
Annual herb, Vine (parasitic)	*Cuscuta subinclusa*		Canyon dodder	X
Annual herb, Vine (parasitic)	*Cuscuta pacifica*	*Cuscuta pacifica* var. *pacifica*	Pacific saltmarsh dodder	X
Annual, Biennial herb	*Dianthus armeria*	*Dianthus armeria* ssp. *armeria*	Grass pink	X
Annual, Biennial herb	*Geranium purpureum*		Herb robert	
Annual, Biennial herb	*Raphanus sativus*		Jointed charlock	
Annual, Biennial herb	*Melilotus albus*		White sweetclover	
Annual, Perennial grass	*Bromus catharticus*	*Bromus catharticus* var. *elatus*	Chilean brome	
Annual, Perennial grass	*Brachypodium distachyon*		False brome	
Annual, Perennial grass	*Bromus laevipes*		Narrow flowered brome	X
Annual, Perennial grass	*Avena barbata*		Slim oat	
Annual, Perennial grass	*Anthoxanthum odoratum*		Sweet vernal grass	
Annual, Perennial grass	*Avena sativa*		Wild oat	
Annual, Perennial herb	*Camissoniopsis cheiranthifolia*	*Camissoniopsis cheiranthifolia* ssp. *cheiranthifolia*	Beach evening primrose	X
Annual, Perennial herb	*Medicago lupulina*		Black medick	
Annual, Perennial herb	*Nuttallanthus texanus*		Blue toadflax	X
Annual, Perennial herb	*Helminthotheca echioides*		Bristly ox-tongue	
Annual, Perennial herb	*Cirsium quercetorum*		Brownie thistle	X
Annual, Perennial herb	*Ranunculus muricatus*		Buttercup	
Annual, Perennial herb	*Eschscholzia californica*		California poppy	X
Annual, Perennial herb	*Senecio minimus*		Coastal burnweed	
Annual, Perennial herb	*Geranium molle*		Crane's bill geranium	
Annual, Perennial herb	*Hypericum anagalloides*		Creeping st. john's wort	X
Annual, Perennial herb	*Senecio glomeratus*		Cutleaf burnweed	
Annual, Perennial herb	*Euphorbia lathyris*		Gopher weed	
Annual, Perennial herb	*Lunaria annua*		Honesty	
Annual, Perennial herb	*Lythrum hyssopifolia*		Hyssop loosestrife	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Annual, Perennial herb	*Cardamine oligosperma*		Idaho bittercress	X
Annual, Perennial herb	*Sisymbrium orientale*		Indian hedge mustard	
Annual, Perennial herb	*Centranthus ruber*		Jupiter's beard	
Annual, Perennial herb	*Aphanes occidentalis*		Ladie's mantle	X
Annual, Perennial herb	*Pseudognaphalium californicum*		Ladies' tobacco	X
Annual, Perennial herb	*Lupinus bicolor*		Lupine	X
Annual, Perennial herb	*Silybum marianum*		Milk thistle	
Annual, Perennial herb	*Arctotheca calendula*		Perennial Cape weed	
Annual, Perennial herb	*Arctotheca prostrata*		Prostrate cape weed	
Annual, Perennial herb	*Polygonum aviculare*	*Polygonum aviculare* ssp. *depressum*	Prostrate knotweed	X
Annual, Perennial herb	*Spergularia rubra*		Purple sand spurry	
Annual, Perennial herb	*Centaurea calcitrapa*		Purple star thistle	
Annual, Perennial herb	*Echium plantagineum*		Salvation echium	
Annual, Perennial herb	*Leucanthemum maximum*		Shasta daisy	
Annual, Perennial herb	*Elatine brachysperma*		Short seed waterwort	X
Annual, Perennial herb	*Heterotheca grandiflora*		Telegraph weed	X
Annual, Perennial herb	*Euphorbia serpyllifolia*	*Euphorbia serpyllifolia* ssp. *serpyllifolia*	Thymeleaf sandmat	X
Annual, Perennial herb	*Solanum americanum*		White nightshade	X
Annual, Perennial herb (rhizomatous)	*Mimulus guttatus*		Yellow monkey flower	X
Biennial herb	*Dipsacus sativus*		Indian teasel	
Biennial herb	*Pseudognaphalium ramosissimum*		Pink cudweed	X
Fern	*Pellaea mucronata*	*Pellaea mucronata* var. *mucronata*	Bird's foot fern	X
Fern	*Cystopteris fragilis*		Brittle fern	X
Fern	*Aspidotis californica*		California lace fern	X
Fern	*Adiantum jordanii*		California maidenhair fern	X
Fern	*Polypodium californicum*		California polypody	X
Fern	*Polystichum californicum*		California sword fern	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Fern	*Myriopteris intertexta*		Coastal lip fern	X
Fern	*Pellaea andromedifolia*		Coffee fern	X
Fern	*Equisetum arvense*		Common horsetail	X
Fern	*Pteris cretica*		Cretan brake	
Fern	*Polystichum dudleyi*		Dudley's sword fern	X
Fern	*Adiantum aleuticum*		Five finger maidenhair	X
Fern	*Equisetum telmateia*	*Equisetum telmateia* ssp. *braunii*	Giant horsetail	X
Fern	*Equisetum hyemale*	*Equisetum hyemale* ssp. *affine*	Giant scouring rush	X
Fern	*Pentagramma triangularis*	*Pentagramma triangularis* ssp. *triangularis*	Gold back fern	X
Fern	*Marsilea vestita*		Hairy waterclover	X
Fern	*Aspidotis densa*		Lace fern	X
Fern	*Myriopteris gracillima*		Lace lip fern	X
Fern	*Polypodium scouleri*		Leather fern	X
Fern	*Polypodium calirhiza*		Licorice fern	X
Fern	*Polypodium glycyrrhiza*		Licorice fern	X
Fern	*Azolla filiculoides*		Mosquito fern	X
Fern	*Polystichum imbricans*		Narrow leaved sword fern	X
Fern	*Isoetes nuttallii*		Nuttall's quillwort	X
Fern	*Pilularia americana*		Pillwort	X
Fern	*Isoetes howellii*		Quillwort	X
Fern	*Equisetum laevigatum*		Smooth scouring rush	X
Fern	*Dryopteris expansa*		Spreading wood fern	X
Fern	*Pteridium aquilinum*	*Pteridium aquilinum* var. *pubescens*	Western bracken fern	X
Fern	*Woodwardia fimbriata*		Western chain fern	X
Fern	*Athyrium filix-femina*	*Athyrium filix-femina* var. *cyclosorum*	Western lady fern	X
Fern	*Polystichum munitum*		Western sword fern	X
Fern	*Dryopteris arguta*		Wood fern	X
Fern (mosslike)	*Selaginella*		Wallace's spike moss	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
	wallacei			
Fern (rhizomatous)	*Aspidotis carlotta-halliae*		Carlotta hall's lace fern	X
Perennial grass	*Melica subulata*		Alaska melic	X
Perennial grass	*Elymus mollis*	*Elymus mollis* ssp. *mollis*	American dune grass	X
Perennial grass	*Carex amplifolia*		Ample leaved sedge	X
Perennial grass	*Stipa manicata*		Andean tussock grass	
Perennial grass	*Cortaderia jubata*		Andean pampas grass	
Perennial grass	*Juncus balticus*	*Juncus balticus* ssp. *ater*	Baltic rush	X
Perennial grass	*Carex utriculata*		Beaked sedge	X
Perennial grass	*Andropogon glomeratus*	*Andropogon glomeratus* var. *scabriglumis*	Beardgrass	X
Perennial grass	*Elymus triticoides*		Beardless wild rye	X
Perennial grass	*Agrostis exarata*		Bentgrass	X
Perennial grass	*Cynodon dactylon*		Bermuda grass	
Perennial grass	*Carex serratodens*		Bifid sedge	X
Perennial grass	*Elymus multisetus*		Big squirreltail grass	X
Perennial grass	*Festuca idahoensis*		Blue fescue	X
Perennial grass	*Elymus glaucus*	*Elymus glaucus* ssp. *glaucus*	Blue wild rye	X
Perennial grass		*Elymus glaucus* ssp. *virescens*	Virginia wildrye	X
Perennial grass	*Juncus bolanderi*		Bolander's rush	X
Perennial grass	*Carex bolanderi*		Bolander's sedge	X
Perennial grass	*Festuca bromoides*		Brome fescue	
Perennial grass	*Carex subfusca*		Brown sedge	X
Perennial grass	*Stipa purpurata*		Bristly needle grass	
Perennial grass	*Poa bulbosa*		Bulbous blue grass	
Perennial grass	*Elymus californicus*		California bottle grass	X
Perennial grass	*Bromus carinatus*		California bromegrass	X
Perennial grass	*Spartina foliosa*		California cord grass	X
Perennial grass	*Festuca californica*		California fescue	X
Perennial grass	*Melica californica*		California melic	X
Perennial grass	*Danthonia californica*		California oatgrass	X
Perennial grass	*Anthoxanthum occidentale*		California sweet grass	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial grass	*Phalaris californica*		Canarygrass	X
Perennial grass	*Festuca elmeri*		Coast fescue	X
Perennial grass	*Melica imperfecta*		Coast range melic	X
Perennial grass	*Holcus lanatus*		Common velvetgrass	
Perennial grass	*Carex cusickii*		Cusick's sedge	X
Perennial grass	*Juncus covillei*		Coville's rush	X
Perennial grass	*Paspalum dilatatum*		Dallis grass	
Perennial grass	*Polypogon interruptus*		Ditch beard grass	
Perennial grass	*Agrostis pallens*		Diego bent grass	X
Perennial grass	*Calamagrostis koelerioides*		Fire reed grass	X
Perennial grass	*Carex praegracilis*		Field sedge	X
Perennial grass	*Stipa lepida*		Foothill needle grass	X
Perennial grass	*Pennisetum setaceum*		Fountaingrass	
Perennial grass	*Hordeum jubatum*		Fox tail barley	X
Perennial grass	*Melica geyeri*		Geyer's onion grass	X
Perennial grass	*Carex feta*		Green sheathed sedge	X
Perennial grass	*Arundo donax*		Giant reed	
Perennial grass	*Deschampsia elongata*		Hairgrass	X
Perennial grass	*Luzula comosa*		Hairy wood rush	X
Perennial grass	*Agrostis hallii*		Hall's bent grass	X
Perennial grass	*Carex pendula*		Hanging sedge	
Perennial grass	*Phalaris aquatica*		Harding grass	
Perennial grass	*Carex leporina*		Hare or oval sedge	X
Perennial grass	*Melica harfordii*		Harford's melic	X
Perennial grass	*Carex hendersonii*		Henderson's sedge	X
Perennial grass	*Juncus xiphioides*		Iris leaved rush	X
Perennial grass	*Festuca perennis*		Italian rye grass	
Perennial grass	*Juncus articulatus*		Jointed rush	X
Perennial grass	*Koeleria macrantha*		June grass	X
Perennial grass	*Poa pratensis*		Kentucky blue grass	
Perennial grass	*Pennisetum clandestinum*		Kikuyu grass	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial grass	*Paspalum distichum*		Knot grass	X
Perennial grass	*Setaria parviflora*		Marsh bristlegrass	X
Perennial grass	*Hordeum brachyantherum*	*Hordeum brachyantherum* ssp. *brachyantherum*	Meadow barley	X
Perennial grass		*Hordeum brachyantherum* ssp. *californicum*	California meadow barley	X
Perennial grass	*Bromus maritimus*		Maritime brome	X
Perennial grass	*Alopecurus pratensis*		Meadow foxtail	
Perennial grass	*Carex mendocinensis*		Mendocino sedge	X
Perennial grass	*Juncus mexicanus*		Mexican rush	X
Perennial grass	*Carex harfordii*		Monterey sedge	X
Perennial grass	*Scirpus microcarpus*		Mountain bog bulrush	X
Perennial grass	*Eleocharis acicularis*		Needle spikerush	X
Perennial grass	*Trisetum canescens*		Nodding trisetum	X
Perennial grass	*Carex gynodynama*		Olney's hairy sedge	X
Perennial grass	*Dactylis glomerata*		Orchardgrass	
Perennial grass	*Agrostis avenacea*		Pacific bentgrass	
Perennial grass	*Cortaderia selloana*		Pampas grasss	X
Perennial grass	*Panicum acuminatum*	*Panicum acuminatum* var. *fasciculatum*	Pacific panic grass	X
Perennial grass	*Elymus pacificus*		Pacific wild rye	X
Perennial grass	*Juncus effusus*	*Juncus effusus* ssp. *pacificus*	Pacific rush	X
Perennial grass	*Poa secunda*	*Poa secunda* ssp. *secunda*	Pine bluegrass	X
Perennial grass	*Rytidosperma penicillatum*		Purple awned wallaby gras	
Perennial grass	*Stipa pulchra*		Purple needle grass	X
Perennial grass	*Festuca myuros*		Rattail sixweeks grass	
Perennial grass	*Festuca rubra*		Red fescue	X
Perennial grass	*Agrostis stolonifera*		Redtop	
Perennial grass	*Festuca arundinacea*		Reed fescue	
Perennial grass	*Carex globosa*		Round fruit sedge	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial grass	*Juncus bufonius*	*Juncus bufonius* var. *bufonius*	Toad rush	X
Perennial grass		*Juncus bufonius* var. *occidentalis*	Round fruited toad rush	X
Perennial grass	*Juncus patens*		Rush	X
Perennial grass	*Juncus phaeocephalus*	*Juncus phaeocephalus* var. *paniculatus*	Rush	X
Perennial grass		*Juncus phaeocephalus* var. *phaeocephalus*	Brown headed rush	X
Perennial grass	*Distichlis spicata*		Saltgrass	X
Perennial grass	*Carex densa*		Sedge	X
Perennial grass	*Calamagrostis ophitidis*		Serpentine reed grass	X
Perennial grass	*Carex simulata*		Short beaked sedge	X
Perennial grass	*Kyllinga brevifolia*		Short leaf spikesedge	
Perennial grass	*Carex brevicaulis*		Short stem sedge	X
Perennial grass	*Juncus occidentalis*		Slender juncus	X
Perennial grass	*Carex gracilior*		Slender sedge	X
Perennial grass	*Carex leptopoda*		Slender-footed sedge	X
Perennial grass	*Carex obnupta*		Slough sedge	X
Perennial grass	*Carex subbracteata*		Small bract sedge	X
Perennial grass	*Stipa miliacea*	*Stipa miliacea* var. *miliacea*	Smilo grass	X
Perennial grass	*Eleocharis macrostachya*		Spike rush	X
Perennial grass	*Carex tumulicola*		Split awn sedge	X
Perennial grass	*Elymus elymoides*		Squirrel tail grass	X
Perennial grass	*Cyperus eragrostis*		Tall cyperus	X
Perennial grass	*Glyceria elata*		Tall mannagrass	X
Perennial grass	*Arrhenatherum elatius*		Tall oatgrass	
Perennial grass	*Carex nudata*		Torrent sedge	X
Perennial grass	*Melica torreyana*		Torrey's melica	X
Perennial grass	*Deschampsia cespitosa*		Tufted hair grass	X
Perennial grass	*Cyperus involucratus*		Umbrella plant	
Perennial grass	*Ehrharta erecta*		Upright veldt grass	
Perennial grass	*Carex barbarae*		Valley sedge	X
Perennial grass	*Eleocharis rostellata*		Walking sedge	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial grass	*Polypogon viridis*		Water beard grass	
Perennial grass	*Festuca occidentalis*		Western fescue	X
Perennial grass	*Carex exsiccata*		Western inflated sedge	X
Perennial grass	*Carex luzulina*		Wood rush sedge	X
Perennial grass (aquatic)	*Glyceria leptostachya*		Manna grass	X
Perennial grass	*Glyceria declinata*		Waxy manna grass	
Perennial grass (aquatic)	*Glyceria Xoccidentalis*		Western manna grass	
Perennial grasslike herb	*Schoenoplectus californicus*		California bulrush	X
Perennial grasslike herb	*Schoenoplectus pungens*	*Schoenoplectus pungens* var. *longispicatus*	Common threesquare sedge	X
Perennial grasslike herb	*Juncus lescurii*		Saltmarsh rush	X
Perennial herb	*Chasmanthe floribunda*		African cornflag	
Perennial herb	*Piperia unalascensis*		Alaska piperia	X
Perennial herb	*Medicago sativa*		Alfalfa	
Perennial herb	*Frankenia salina*		Alkali heath	X
Perennial herb	*Heuchera micrantha*		Alum root	X
Perennial herb	*Veronica americana*		American brooklime	X
Perennial herb	*Mentha arvensis*		American wild mint	X
Perennial herb	*Ambrosia chamissonis*		Beach Bur	X
Perennial herb	*Fragaria chiloensis*		Beach strawberry	X
Perennial herb	*Actaea rubra*		Bearberry	X
Perennial herb	*Xerophyllum tenax*		Beargrass	X
Perennial herb	*Oxalis pes-caprae*		Bermuda buttercup	
Perennial herb	*Lotus corniculatus*		Bird's foot trefoil	
Perennial herb	*Cardamine californica*		Bitter cress	X
Perennial herb	*Sisyrinchium bellum*		Blue eyed grass	X
Perennial herb	*Viola adunca*		Blue violet, western dog violet	X
Perennial herb	*Anemone grayi*		Blue windflower	X
Perennial herb	*Cotula coronopifolia*		Brass buttons	
Perennial herb	*Egeria densa*		Brazilian water weed	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Lupinus latifolius*	*Lupinus latifolius* var. *latifolius*	Broad leaf lupine	X
Perennial herb	*Hosackia crassifolia*		Broad leaved lotus	X
Perennial herb	*Watsonia meriana*		Bulbil bugle lily	
Perennial herb	*Cirsium vulgare*		Bullthistle	
Perennial herb	*Senecio aronicoides*		Butterweed	X
Perennial herb	*Acaena pinnatifida*		California acaena	X
Perennial herb	*Angelica californica*		California angelica	X
Perennial herb	*Galium californicum*	*Galium californicum* ssp. *californicum*	California bedstraw	X
Perennial herb	*Scrophularia californica*		California bee plant	X
Perennial herb	*Thermopsis macrophylla*		California falselupine	X
Perennial herb	*Epilobium canum*		California fuchsia, zauschneria	X
Perennial herb	*Thermopsis californica*		California goldenbanner	X
Perennial herb	*Solidago velutina*	*Solidago velutina* ssp. *californica*	California goldenrod	X
Perennial herb	*Asyneuma prenanthoides*		California harebell	X
Perennial herb	*Stachys bullata*		California hedge nettle	X
Perennial herb	*Hoita macrostachya*		California hemp	X
Perennial herb	*Horkelia californica*		California horkelia	X
Perennial herb	*Silene laciniata*	*Silene laciniata* ssp. *californica*	California indian pink	X
Perennial herb	*Delphinium californicum*	*Delphinium californicum* ssp. *californicum*	California Larkspur	X
Perennial herb	*Artemisia douglasiana*		California mugwort	X
Perennial herb	*Romanzoffia californica*		California romanzoffia	X
Perennial herb	*Scutellaria californica*		California skullcap	X
Perennial herb	*Aralia californica*		California spikenard	X
Perennial herb	*Paronychia franciscana*		California whitlow wort	
Perennial herb	*Zantedeschia aethiopica*		Calla Lilly	
Perennial herb	*Calystegia subacaulis*	*Calystegia subacaulis* ssp. *subacaulis*	Cambria morning glory	X
Perennial herb	*Cirsium arvense*		Canada thistle	
Perennial herb	*Claytonia sibirica*		Candy flower	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Delphinium nudicaule*		Canyon larkspur	X
Perennial herb	*Dudleya cymosa*	*Dudleya cymosa* ssp. *cymosa*	Canyon liveforever	X
Perennial herb	*Delairea odorata*		Cape ivy	
Perennial herb	*Mimulus cardinalis*		Cardinal monkey flower	X
Perennial herb	*Modiola caroliniana*		Carolina bristle mallow	
Perennial herb	*Typha domingensis*		Cattail	X
Perennial herb	*Ligusticum apiifolium*		Celery leaved lovage	X
Perennial herb	*Lomatium californicum*		Celery weed	X
Perennial herb	*Iris longipetala*		Central coast iris	X
Perennial herb	*Chasmanthe bicolor*		Chasmanthe	
Perennial herb	*Erigeron petrophilus*		Cliff fleabane	X
Perennial herb	*Galium nuttallii*		Climbing bedstraw	X
Perennial herb	*Angelica hendersonii*		Coast angelica	X
Perennial herb	*Eriogonum latifolium*		Coast buckwheat	X
Perennial herb	*Arabis blepharophylla*		Coast rock cress	X
Perennial herb	*Sanicula laciniata*		Coast sanicle	X
Perennial herb	*Dudleya farinosa*		Coastal bluff lettuce	X
Perennial herb	*Ranunculus repens*		Creeping buttercop	
Perennial herb	*Potentilla anserina*	*Potentilla anserina* ssp. *pacifica*	Pacific cinquefoil	X
Perennial herb	*Grindelia stricta*		Coastal Gumweed	X
Perennial herb	*Cirsium occidentale*	*Cirsium occidentale* var. *occidentale*	Cobweb thistle	X
Perennial herb		*Cirsium occidentale* var. *venustum*	Coulter's thistle	X
Perennial herb	*Stachys albens*		Cobwebby hedge nettle	X
Perennial herb	*Aquilegia formosa*		Columbine	X
Perennial herb	*Ranunculus californicus*	*Ranunculus californicus* var. *californicus*	Common buttercup	X
Perennial herb	*Heracleum maximum*		Common cowparsnip	X
Perennial herb	*Phyla nodiflora*		Common lippia	X
Perennial herb	*Plantago major*		Common plantain	
Perennial herb	*Rupertia*		Common rupertia	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
	physodes			
Perennial herb	*Elodea canadensis*		Common water weed	X
Perennial herb	*Lithophragma affine*		Common woodland star	X
Perennial herb	*Trifolium wormskioldii*		Cow clover	X
Perennial herb	*Monardella villosa*	*Monardella villosa* ssp. *villosa*	Coyote mint	X
Perennial herb	*Eryngium armatum*		Coyote thistle	X
Perennial herb	*Hoita orbicularis*		Creeping leather root	X
Perennial herb	*Asarum caudatum*		Creeping wild ginger	X
Perennial herb	*Oxalis corniculata*		Creeping wood sorrel	
Perennial herb	*Trifolium incarnatum*		Crimson clover	
Perennial herb	*Oxalis incarnata*		Crimson woodsorrel	
Perennial herb	*Pseudognaphaliu m beneolens*		Cudweed	X
Perennial herb	*Rumex crispus*		Curly dock	
Perennial herb	*Scutellaria tuberosa*		Dannie's scullcap	X
Perennial herb	*Acmispon glaber*		Deerweed, california broom	X
Perennial herb	*Eryngium jepsonii*		Delta Coyote Thistle	X
Perennial herb	*Piperia elongata*		Dense flowered rein orchid	X
Perennial herb	*Persicaria punctata*		Dotted smartweed	X
Perennial herb	*Solanum douglasii*		Douglas' nightshade	X
Perennial herb	*Iris douglasiana*		Douglas iris	X
Perennial herb	*Lupinus adsurgens*		Drew's sticky lupine	X
Perennial herb	*Prosartes hookeri*		Drops of gold	X
Perennial herb	*Brodiaea terrestris*	*Brodiaea terrestris* ssp. *terrestris*	Dwarf brodiaea	X
Perennial herb	*Reseda luteola*		Dyer's mignonette	
Perennial herb	*Barbarea verna*		Early Wintercress	
Perennial herb	*Euphorbia oblongata*		Eggleaf spurge	
Perennial herb	*Piperia elegans*	*Piperia elegans* ssp. *elegans*	Elegant piperia	X
Perennial herb	*Bellis perennis*		English lawn daisy	
Perennial herb	*Viola odorata*		English violet	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Calypso bulbosa*	*Calypso bulbosa* var. *occidentalis*	Fairy slipper	X
Perennial herb	*Maianthemum dilatatum*		False lily of the valley	X
Perennial herb	*Gamochaeta ustulata*		Featherweed	X
Perennial herb	*Maianthemum racemosum*		Feathery false lily of the valley	X
Perennial herb	*Foeniculum vulgare*		Fennel	
Perennial herb	*Cirsium remotifolium*		Few leaved thistle	X
Perennial herb	*Cerastium viride*		Field chickweed	X
Perennial herb	*Rumex pulcher*		Fiddleleaf dock	
Perennial herb	*Jaumea carnosa*		Fleshy jaumea	X
Perennial herb	*Dichelostemma congestum*		Fork toothed ookow	X
Perennial herb	*Digitalis purpurea*		Foxglove	
Perennial herb	*Watsonia marginata*		Fragrant bugle lily	
Perennial herb	*Castilleja subinclusa*	*Castilleja subinclusa* ssp. *franciscana*	Franciscan paintbrush	X
Perennial herb	*Erysimum franciscanum*		Franciscan wallflower	X
Perennial herb	*Toxicoscordion fremontii*		Fremont's star lily	X
Perennial herb	*Tellima grandiflora*		Fringe cups	X
Perennial herb	*Gentiana affinis*	*Gentiana affinis* var. *ovata*	Gentian	X
Perennial herb	*Iris germanica*		German Iris	
Perennial herb	*Agoseris grandiflora*	*Agoseris grandiflora* var. *grandiflora*	Giant mountain dandelion	X
Perennial herb	*Vicia gigantea*		Giant vetch	X
Perennial herb	*Trillium chloropetalum*		Giant wakerobin	X
Perennial herb	*Hypericum concinnum*		Gold wire	X
Perennial herb	*Heterotheca sessiliflora*	*Heterotheca sessiliflora* ssp. *bolanderi*	Golden aster	X
Perennial herb	*Calochortus amabilis*		Golden fairy lantern	X
Perennial herb	*Viola purpurea*	*Viola purpurea* ssp. *quercetorum*	Goosefoot yellow violet	X
Perennial herb	*Rumex conglomeratus*		Green dock	
Perennial herb	*Micranthes californica*		Greene's saxifrage	X
Perennial herb	*Iris macrosiphon*		Ground iris	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Grindelia camporum*		Gumweed	X
Perennial herb	*Grindelia hirsutula*		Gumweed	X
Perennial herb	*Hypochaeris radicata*		Hairy cats ear	
Perennial herb	*Calochortus tolmiei*		Hairy star tulip	X
Perennial herb	*Sparaxis tricolor*		Harlequin flower	
Perennial herb	*Hosackia gracilis*		Harlequin lotus	X
Perennial herb	*Brodiaea elegans*	*Brodiaea elegans* ssp. *elegans*	Harvest brodiaea	X
Perennial herb	*Stachys ajugoides*		Hedge nettle	X
Perennial herb	*Stachys chamissonis*		Hedge nettle	X
Perennial herb	*Epipactis helleborine*		Helleborine	
Perennial herb	*Calystegia collina*	*Calystegia collina* ssp. *collina*	Hillside morning glory	X
Perennial herb (rhizomatous)		*Calystegia collina* ssp. *oxyphylla*	Mt. saint helena morning glory	X
Perennial herb	*Lathyrus vestitus*	*Lathyrus vestitus* var. *vestitus*	Hillside pea	X
Perennial herb	*Lomatium dasycarpum*	*Lomatium dasycarpum* ssp. *dasycarpum*	Hog fennel	X
Perennial herb	*Lomatium utriculatum*		Hog fennel	X
Perennial herb	*Holozonia filipes*		Holozonia	X
Perennial herb	*Ceratophyllum demersum*		Hornwort	X
Perennial herb	*Carpobrotus edulis*		Hottentot fig	
Perennial herb	*Iris pseudacorus*		Horticultural iris	
Perennial herb	*Cynoglossum grande*		Houndstongue	X
Perennial herb	*Phacelia imbricata*	*Phacelia imbricata* ssp. *imbricata*	Imbricate phacelia	X
Perennial herb	*Apocynum cannabinum*		Indian hemp	X
Perennial herb	*Cirsium brevistylum*		Indian thistle	X
Perennial herb	*Pedicularis densiflora*		Indian warrior	X
Perennial herb	*Vancouveria planipetala*		Inside out flower	X
Perennial herb	*Arum italicum*		Italian Lords and Ladies	
Perennial herb	*Triteleia laxa*		Ithuriel's spear	X
Perennial herb	*Eryngium aristulatum*	*Eryngium aristulatum* var. *aristulatum*	Jepson's button celery	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Tauschia kelloggii*		Kellogg's tauschia	X
Perennial herb	*Hypericum perforatum*		Klamathweed	
Perennial herb	*Calochortus uniflorus*		Large flowered star tulip	X
Perennial herb	*Lomatium macrocarpum*		Large fruited lomatium	X
Perennial herb	*Acmispon grandiflorus*		Large leaved lotus	X
Perennial herb	*Moehringia macrophylla*		Large leaved sandwort	X
Perennial herb	*Prosartes smithii*		Largeflower fairybells	X
Perennial herb	*Erigeron karvinskianus*		Latin american fleabane	
Perennial herb	*Melissa officinalis*		Lemon balm	
Perennial herb	*Lemna minuta*		Least duckweed	X
Perennial herb	*Lilium pardalinum*		Leopard lily	X
Perennial herb	*Lilium pardalinum*	*Lilium pardalinum* ssp. *pardalinum*	Leopard lily	X
Perennial herb	*Eriophyllum staechadifolium*		Lizard tail	X
Perennial herb	*Fritillaria lanceolata*	*Fritillaria lanceolata* var. *tristulis*	Marin checker lily	X
Perennial herb	*Plantago maritima*		Maritime plantain	X
Perennial herb	*Parnassia palustris*		Marsh grass of parnassus	X
Perennial herb	*Limonium californicum*		Marsh rosemary	X
Perennial herb	*Triteleia peduncularis*		Marsh tritileia	X
Perennial herb	*Toxicoscordion fontanum*		Marsh zigadenus	X
Perennial herb	*Oxalis latifolia*		Mexican oxalis	
Perennial herb	*Plantago subnuda*		Mexican plantain	X
Perennial herb	*Asclepias fascicularis*		Milkweed	X
Perennial herb	*Polygala californica*		Milkwort	X
Perennial herb	*Duchesnea indica*		Mock strawberry	
Perennial herb	*Calystegia occidentalis*	*Calystegia occidentalis* ssp. *occidentalis*	Modoc morning glory	X
Perennial herb	*Crocosmia Xcrocosmiiflora*		Monbretia	
Perennial herb	*Cirsium hydrophilum*	*Cirsium hydrophilum* var. *vaseyi*	Mt. tamalpais thistle	X
Perennial herb	*Mimulus moschatus*		Musk monkeyflower	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Hirschfeldia incana*		Mustard	
Perennial herb	*Amaryllis belladonna*		Naked Ladies	
Perennial herb	*Wyethia angustifolia*		Narrow leaved mule ears	X
Perennial herb	*Lotus tenuis*		Narrow-leaf bird's-foot trefoil	
Perennial herb	*Urtica dioica*	*Urtica dioica* ssp. *gracilis*	Nettle	X
Perennial herb		*Urtica dioica* ssp. *holosericea*	Stinging nettle	X
Perennial herb	*Anemone oregana*	*Anemone oregana* var. *oregana*	Oregon anemone	X
Perennial herb	*Leucanthemum vulgare*		Oxe eye daisy	
Perennial herb	*Symphyotrichum chilense*		Pacific aster	X
Perennial herb	*Dicentra formosa*		Pacific bleedinghearts	X
Perennial herb	*Sanicula crassicaulis*		Pacific sanicle	X
Perennial herb	*Sedum spathulifolium*		Pacific stonecrop	X
Perennial herb	*Anaphalis margaritacea*		Pearly everlasting	X
Perennial herb	*Mentha pulegium*		Pennyroyal	
Perennial herb	*Salicornia pacifica*		Pickleweed	X
Perennial herb	*Erigeron reductus*	*Erigeron reductus* var. *angustatus*	Pine erigeron	X
Perennial herb	*Hosackia pinnata*		Pinnate lotus	X
Perennial herb	*Geranium core-core*		Pink perennial cranesbill	
Perennial herb	*Conium maculatum*		Poison hemlock	
Perennial herb	*Sanicula bipinnata*		Poison sanicle	X
Perennial herb	*Lactuca virosa*		Poison wild lettuce	
Perennial herb	*Sanicula bipinnatifida*		Purple sanicle	X
Perennial herb	*Fumaria capreolata*		Ramping fumitory	
Perennial herb	*Goodyera oblongifolia*		Rattlesnake plantain	X
Perennial herb	*Arnica discoidea*		Rayless arnica	X
Perennial herb	*Clintonia andrewsiana*		Red clintonia	X
Perennial herb	*Trifolium pratense*		Red clover	
Perennial herb	*Taraxacum officinale*		Red seeded dandelion	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Kniphofia uvaria*		Redhot poker	
Perennial herb	*Lathyrus torreyi*		Redwood pea	X
Perennial herb	*Oxalis oregana*		Redwood sorrel	X
Perennial herb	*Viola sempervirens*		Redwood violet	X
Perennial herb	*Piperia transversa*		Rein orchid	X
Perennial herb	*Plantago lanceolata*		Ribwort	
Perennial herb	*Phacelia californica*		Rock phacelia	X
Perennial herb	*Hosackia rosea*		Rose flowered lotus	X
Perennial herb	*Drosanthemum floribundum*		Rosy iceplant	
Perennial herb	*Romulea rosea*	*Romulea rosea* var. *australis*	Rosy sand crocus	X
Perennial herb	*Stachys rigida*	*Stachys rigida* var. *quercetorum*	Rough hedgenettle	X
Perennial herb		*Stachys rigida* var. *rigida*	Rough hedgenettle	X
Perennial herb	*Eurybia radulina*		Roughleaf aster	X
Perennial herb	*Acmispon junceus*	*Acmispon junceus* var. *junceus*	Rush lotus	X
Perennial herb	*Baccharis glutinosa*		Salt marsh baccharis	X
Perennial herb	*Tragopogon porrifolius*		Salsify	
Perennial herb	*Erigeron foliosus*	*Erigeron foliosus* var. *franciscensis*	San francisco leafy fleabane	X
Perennial herb	*Hypericum scouleri*		Scouler's st john's wort	X
Perennial herb	*Carpobrotus chilensis*		Sea fig	
Perennial herb	*Erigeron glaucus*		Seaside daisy	X
Perennial herb	*Prunella vulgaris*	*Prunella vulgaris* var. *vulgaris*	Self heal	X
Perennial herb		*Prunella vulgaris* var. *lanceolata*	Tall Selfheal	X
Perennial herb	*Rumex acetosella*		Sheep sorrel	
Perennial herb	*Primula hendersonii*		Shooting star	X
Perennial herb	*Stachys pycnantha*		Short spike hedge nettle	X
Perennial herb	*Montia parvifolia*		Showy rock montia	X
Perennial herb	*Platanthera dilatata*	*Platanthera dilatata* var. *leucostachys*	Sierra bog orchid	X
Perennial herb	*Monardella purpurea*		Siskiyou monardella	X
Perennial herb	*Scoliopus*		Slink pod	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
	bigelovii			
Perennial herb	*Sanguisorba minor*		Small burnet	
Perennial herb	*Kopsiopsis hookeri*		Small groundcone	X
Perennial herb	*Tradescantia fluminensis*		Small leaf spiderwort	
Perennial herb	*Wyethia glabra*		Smooth mule ears	X
Perennial herb	*Calystegia purpurata*	*Calystegia purpurata* ssp. *purpurata*	Smooth western morning glory	X
Perennial herb	*Helenium puberulum*		Sneezeweed	X
Perennial herb	*Synthyris reniformis*		Snow queen	X
Perennial herb	*Chlorogalum pomeridianum*	*Chlorogalum pomeridianum* var. *pomeridianum*	Common soaproot	X
Perennial herb		*Chlorogalum pomeridianum* var. *divaricatum*	Soap plant	X
Perennial herb	*Agoseris retrorsa*		Spear leaved agoseris	X
Perennial herb	*Delphinium patens*	*Delphinium patens* ssp. *patens*	Spreading larkspur	X
Perennial herb	*Ipheion uniflorum*		Spring star	
Perennial herb	*Perideridia gairdneri*	*Perideridia gairdneri* ssp. *gairdneri*	Squaw potato	X
Perennial herb	*Lysimachia latifolia*		Starflower	X
Perennial herb	*Maianthemum stellatum*		Starry false lily of the valley	X
Perennial herb	*Drymocallis glandulosa*	*Drymocallis glandulosa* var. *glandulosa*	Sticky cinquefoil	X
Perennial herb		*Drymocallis glandulosa* var. *wrangelliana*	Sticky cinquefoil	X
Perennial herb	*Spergularia macrotheca*	*Spergularia macrotheca* var. *macrotheca*	Sticky Sand spurry	X
Perennial herb	*Ageratina adenophora*		Sticky snakeroot	
Perennial herb	*Iris foetidissima*		Stinking iris	
Perennial herb	*Hosackia stipularis*	*Hosackia stipularis* var. *stipularis*	Stipulate lotus	X
Perennial herb	*Trifolium fragiferum*		Strawberry clover	
Perennial herb	*Epipactis gigantea*		Stream orchid	X
Perennial herb	*Viola glabella*		Stream violet	X
Perennial herb	*Corallorhiza striata*		Striped coral root	X
Perennial herb	*Corallorhiza maculata*	*Corallorhiza maculata* var. *maculata*	Summer coralroot	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb		*Corallorhiza maculata* var. *occidentalis*	Summer coralroot	X
Perennial herb	*Lupinus formosus*	*Lupinus formosus* var. *formosus*	Summer lupine	X
Perennial herb	*Taraxia ovata*		Sun cup	X
Perennial herb	*Lathyrus latifolius*		Sweet pea	
Perennial herb	*Osmorhiza berteroi*		Sweetcicely	X
Perennial herb	*Castilleja foliolosa*		Texas paintbrush	X
Perennial herb	*Horkelia tenuiloba*		Thin lobed horkelia	X
Perennial herb	*Thalictrum fendleri*	*Thalictrum fendleri* var. *polycarpum*	Torrey's meadow rue	X
Perennial herb	*Turritis glabra*		Tower rockcress	X
Perennial herb	*Adenocaulon bicolor*		Trail plant	X
Perennial herb	*Sanicula tuberosa*		Turkey pea	X
Perennial herb	*Aquilegia eximia*		Vanhoutte's columbine	X
Perennial herb	*Verbena lasiostachys*	*Verbena lasiostachys* var. *scabrida*	Vervain	X
Perennial herb	*Spergularia villosa*		Villous sand spurry	
Perennial herb	*Vinca major*		Vinca	
Perennial herb	*Erysimum capitatum*		Wallflower	X
Perennial herb	*Mentha aquatica*		Water mint	
Perennial herb	*Myriophyllum spicatum*		Water milfoil	
Perennial herb	*Oenanthe sarmentosa*		Water parsley	X
Perennial herb	*Persicaria hydropiperoides*		Water pepper	X
Perennial herb	*Solidago elongata*		West coast canada goldenrod	X
Perennial herb	*Boykinia occidentalis*		Western boykinia	X
Perennial herb	*Petasites frigidus*	*Petasites frigidus* var. *palmatus*	Western coltsfoot	X
Perennial herb	*Rumex occidentalis*		Western dock	X
Perennial herb	*Euthamia occidentalis*		Western goldenrod	X
Perennial herb	*Viola ocellata*		Western heart's ease	X
Perennial herb	*Spiranthes porrifolia*		Western ladies tresses	X
Perennial herb	*Delphinium hesperium*	*Delphinium hesperium* ssp. *hesperium*	Western larkspur	X
Perennial herb	*Cicuta douglasii*		Western water hemlock	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Hydrocotyle verticillata*		Whorled marsh pennywort	X
Perennial herb	*Trifolium repens*		White clover	
Perennial herb	*Hieracium albiflorum*		White flowered hawkweed	X
Perennial herb	*Trillium ovatum*	*Trillium ovatum* ssp. *ovatum*	White flowered wakerobin	X
Perennial herb	*Marrubium vulgare*		White horehound	
Perennial herb	*Pyrola picta*		White veined shinleaf	X
Perennial herb	*Phacelia egena*		White-flowered Perennial Phacelia	X
Perennial herb	*Myosotis latifolia*		Wide leaved forget me not	
Perennial herb	*Castilleja wightii*		Wight' indian paint brush	X
Perennial herb	*Castilleja affinis*	*Castilleja affinis* ssp. *affinis*	Wight's indian paint brush	X
Perennial herb	*Dichelostemma capitatum*	*Dichelostemma capitatum* ssp. *capitatum*	Wild hyacinth	X
Perennial herb	*Triteleia hyacinthina*		Wild hyacinth	X
Perennial herb	*Fragaria vesca*		Wild strawberry	X
Perennial herb	*Dipsacus fullonum*		Wild teasel	
Perennial herb	*Epilobium ciliatum*	*Epilobium ciliatum* ssp. *ciliatum*	Willow herb	X
Perennial herb		*Epilobium ciliatum* ssp. *watsonii*	Coast fringed willow herb	X
Perennial herb	*Rumex salicifolius*		Willow leaved dock	X
Perennial herb	*Oxalis articulata*	*Oxalis articulata* ssp. *rubra*	Windowbox woodsorrel	X
Perennial herb	*Barbarea orthoceras*		Winter cress	X
Perennial herb	*Anisocarpus madioides*		Woodland madia	X
Perennial herb	*Lithophragma heterophyllum*		Woodland star	X
Perennial herb	*Angelica tomentosa*		Woolly angelica	X
Perennial herb	*Agoseris apargioides*	*Agoseris apargioides* var. *apargioides*	Coast dandelion	X
Perennial herb	*Agoseris hirsuta*		Woolly goat chicory	X
Perennial herb	*Eriophyllum lanatum*	*Eriophyllum lanatum* var. *arachnoideum*	Wooly sunflower	X
Perennial herb	*Perideridia kelloggii*		Yampah	X
Perennial herb	*Achillea millefolium*		Yarrow	X
Perennial herb	*Calochortus luteus*		Yellow mariposa	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb	*Lamiastrum galeobdolon*		Yellow archangel	
Perennial herb	*Abronia umbellata*	*Abronia umbellata* var. *umbellata*	Pink sand-verbena	X
Perennial herb	*Abronia latifolia*		Yellow sand-verbena	X
Perennial herb	*Sanicula arctopoides*		Yellow mats	X
Perennial herb	*Clinopodium douglasii*		Yerba buena	X
Perennial herb (aquatic)	*Typha latifolia*		Boradleaf cattail	X
Perennial herb (aquatic)	*Potamogeton nodosus*		Long leaved pondweed	X
Perennial herb (aquatic)	*Typha angustifolia*		Narrow leaf cattail	X
Perennial herb (aquatic)	*Alisma triviale*		Northern water plantain	X
Perennial herb (aquatic)	*Nuphar polysepala*		Rocky mountain pond-lily	X
Perennial herb (aquatic)	*Stuckenia pectinata*		Sago pondweed	X
Perennial herb (aquatic)	*Triglochin maritima*		Seaside arrow grass	X
Perennial herb (aquatic)	*Myriophyllum sibiricum*		Siberian water milfoil	X
Perennial herb (aquatic)	*Potamogeton pusillus*		Small pondweed	X
Perennial herb (aquatic)	*Triglochin concinna*		Utah arrow grass	X
Perennial herb (aquatic)	*Alisma lanceolatum*		Water plantain	
Perennial herb (aquatic)	*Nasturtium officinale*		Watercress	X
Perennial herb (aquatic)	*Ranunculus aquatilis*		Whitewater crowfoot	X
Perennial herb (bulb)	*Fritillaria affinis*		Checker lily	X
Perennial herb (bulb)	*Narcissus tazetta*		Cream narcissus	
Perennial herb (bulb)	*Narcissus pseudonarcissus*		Daffodil	
Perennial herb (bulb)	*Fritillaria liliacea*		Fragrant fritillary	X
Perennial herb (bulb)	*Allium amplectens*		Narrow leaved onion	X
Perennial herb (bulb)	*Calochortus umbellatus*		Oakland mariposa lily	X
Perennial herb (bulb)	*Allium unifolium*		One leaf onion	X
Perennial herb (bulb)	*Narcissus papyraceus*		Paperwhite narcissus	
Perennial herb (bulb)	*Allium falcifolium*		Sickle leaf onion	X
Perennial herb (bulb)	*Allium triquetrum*		White flowered onion	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Perennial herb (mycoparasitic)	*Hemitomes congestum*		Gnome plant	X
Perennial herb (parasitic)	*Kopsiopsis strobilacea*		California ground-cone	X
Perennial herb (parasitic)	*Orobanche bulbosa*		Chaparral broomrape	X
Perennial herb (parasitic)	*Orobanche uniflora*		Naked broom rape	X
Perennial herb (parasitic)	*Arceuthobium campylopodum*		Pine dwarf mistletoe	X
Perennial herb (parasitic)	*Orobanche fasciculata*		Pinyon broomrape	X
Perennial herb (rhizomatous)	*Sidalcea malviflora*	*Sidalcea malviflora* ssp. *laciniata*	Pink checkerbloom	X
Perennial herb (rhizomatous)		*Sidalcea malviflora* ssp. *malviflora*	Checker mallow	X
Perennial herb, Shrub	*Agave americana*		American century plant	
Perennial herb, Shrub	*Solanum furcatum*		Forked nightshade	
Perennial herb, Shrub	*Solanum xanti*		Nightshade	X
Perennial herb, Vine	*Vicia americana*	*Vicia americana* ssp. *americana*	American Vetch	X
Perennial herb, Vine	*Marah fabacea*		California man-root	X
Perennial herb, Vine	*Marah oregana*		Coast man-root	X
Perennial herb, Vine	*Clematis ligusticifolia*		Creek clematis	X
Perennial herb, Vine	*Dichondra donelliana*		Dichondra	X
Perennial herb, Vine	*Convolvulus arvensis*		Field bindweed	
Perennial herb, Vine	*Clematis lasiantha*		Pipestem	X
Shrub	*Corylus cornuta*	*Corylus cornuta* ssp. *californica*	Beaked hazelnut	X
Shrub	*Sambucus nigra*	*Sambucus nigra* ssp. *caerulea*	Blue elderberry	X
Shrub	*Ceanothus masonii*		Bolinas ceanothus	X
Shrub	*Helianthemum scoparium*		Broom rose	X
Shrub	*Ceanothus cuneatus*	*Ceanothus cuneatus* var. *cuneatus*	Buck brush	X
Shrub		*Ceanothus cuneatus* var. *ramulosus*	Buck brush	X
Shrub	*Dendromecon rigida*		Bush poppy	X
Shrub	*Berberis pinnata*	*Berberis pinnata* ssp. *pinnata*	California barberry	X
Shrub	*Eriogonum fasciculatum*	*Eriogonum fasciculatum* var. *foliolosum*	California buckwheat	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Shrub	*Frangula californica*	*Frangula californica* ssp. *californica*	California coffeeberry	X
Shrub	*Fremontodendron californicum*		California fremontia	X
Shrub	*Ribes californicum*		California gooseberry	X
Shrub	*Rhododendron macrophyllum*		California rose bay	X
Shrub	*Morella californica*		California wax myrtle	X
Shrub	*Rosa californica*		California wild rose	X
Shrub	*Pickeringia montana*	*Pickeringia montana* var. *montana*	Chaparral pea	X
Shrub	*Lonicera involucrata*	*Lonicera involucrata* var. *ledebourii*	Coast twinberry	X
Shrub	*Lupinus arboreus*		Coastal bush lupine	X
Shrub	*Artemisia californica*		Coastal sage brush	X
Shrub	*Arctostaphylos manzanita*	*Arctostaphylos manzanita* ssp. *manzanita*	Common manzanita	X
Shrub	*Cotoneaster franchetii*		Cotoneaster	
Shrub	*Baccharis pilularis*	*Baccharis pilularis* ssp. *consanguinea*	Coyote brush	X
Shrub		*Baccharis pilularis* ssp. *pilularis*	Coyote brush	X
Shrub	*Symphoricarpos mollis*		Creeping Snowberry	X
Shrub	*Vaccinium ovatum*		Evergreen huckleberry	X
Shrub	*Pyracantha angustifolia*		Firethorn	
Shrub	*Ribes sanguineum*	*Ribes sanguineum* var. *glutinosum*	Flowering currant	X
Shrub	*Garrya fremontii*		Fremont's silk tassel	X
Shrub	*Genista monspessulana*		French broom	
Shrub	*Lavandula stoechas*		French lavender	
Shrub	*Ceanothus gloriosus*	*Ceanothus gloriosus* var. *exaltatus*	Glory brush	X
Shrub	*Arctostaphylos sensitiva*		Glossyleaf manzanita	X
Shrub	*Ericameria arborescens*		Golden fleece	X
Shrub	*Eriophyllum confertiflorum*	*Eriophyllum confertiflorum* var. *confertiflorum*	Golden Yarrow	X
Shrub	*Ribes menziesii*		Gooseberry	X
Shrub	*Ulex europaeus*		Gorse	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Shrub	*Cistus incanus*		Hairy rockrose	
Shrub	*Erica canaliculata*		Hairy grey heather	
Shrub	*Crataegus monogyna*		Hawthorn	
Shrub	*Rubus armeniacus*		Himalayan blackberry	
Shrub	*Arctostaphylos canescens*	*Arctostaphylos canescens* ssp. *canescens*	Hoary manzanita	X
Shrub	*Melianthus major*		Honey flower	
Shrub	*Amorpha californica*	*Amorpha californica* var. *napensis*	Indigo bush	X
Shrub	*Ceanothus oliganthus*	*Ceanothus oliganthus* var. *sorediatus*	Jim brush	X
Shrub	*Quercus durata*	*Quercus durata* var. *durata*	Leather oak	X
Shrub	*Philadelphus lewisii*		Lewis' mock orange	X
Shrub	*Arctostaphylos virgata*		Marin manzanita	X
Shrub	*Cotoneaster lacteus*		Milkflower cotoneaster	
Shrub	*Ericameria ericoides*		Mock heather	X
Shrub	*Arctostaphylos montana*	*Arctostaphylos montana* ssp. *montana*	Mt. tamalpais manzanita	X
Shrub	*Ceanothus jepsonii*		Musk brush	X
Shrub	*Eriogonum nudum*	*Eriogonum nudum* var. *nudum*	Naked stemmed buckwheat	X
Shrub	*Solanum aviculare*		New zealand nightshade	
Shrub	*Physocarpus capitatus*		Ninebark	X
Shrub	*Arctostaphylos glandulosa*	*Arctostaphylos glandulosa* ssp. *cushingiana*	Non-glandular Eastwood's manzanita	X
Shrub		*Arctostaphylos glandulosa* ssp. *glandulosa*	Eastwood’s hispid Manzanita	X
Shrub	*Holodiscus discolor*		Oceanspray	X
Shrub	*Berberis nervosa*		Oregon grape	X
Shrub	*Oemleria cerasiformis*		Oso berry	X
Shrub	*Sambucus racemosa*	*Sambucus racemosa* var. *racemosa*	Pacific red elderberry	X
Shrub	*Amelanchier utahensis*		Pale leaved serviceberry	X
Shrub	*Plecostachys serpyllifolia*		Petite licorice	

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Shrub	*Lepechinia calycina*		Pitcher sage	X
Shrub	*Cytisus striatus*		Portuguese broom	
Shrub	*Echium candicans*		Pride of madeira	
Shrub	*Keckiella corymbosa*		Red beardtongue	X
Shrub	*Rhamnus crocea*		Redberry	X
Shrub	*Gaultheria shallon*		Salal	X
Shrub	*Rubus spectabilis*		Salmon berry	X
Shrub	*Cytisus scoparius*		Scotch broom	
Shrub	*Lupinus albifrons*	*Lupinus albifrons* var. *albifrons*	Silver bush lupine	X
Shrub		*Lupinus albifrons* var. *collinus*	Silver bush lupine	X
Shrub		*Lupinus albifrons* var. *douglasii*	Douglas' silver bush lupine	X
Shrub	*Symphoricarpos albus*	*Symphoricarpos albus* var. *laevigatus*	Snowberry	X
Shrub	*Rosa spithamea*		Sonoma rose	X
Shrub	*Spartium junceum*		Spanish broom	
Shrub	*Ribes divaricatum*	*Ribes divaricatum* var. *pubiflorum*	Spreading gooseberry	X
Shrub	*Mimulus aurantiacus*		Sticky monkeyflower	X
Shrub	*Rosa rubiginosa*		Sweet brier	
Shrub	*Heteromeles arbutifolia*		Toyon	X
Shrub	*Ribes victoris*		Victor's gooseberry	X
Shrub	*Ceanothus foliosus*	*Ceanothus foliosus* var. *foliosus*	Wavy leaved ceanothus	X
Shrub	*Cornus sericea*	*Cornus sericea* ssp. *occidentalis*	Western dogwood	X
Shrub		*Cornus sericea ssp. sericea*	Smooth American dogwood	X
Shrub	*Dirca occidentalis*		Western leatherwood	X
Shrub	*Rosa gymnocarpa*		Wood rose	X
Shrub	*Cotoneaster pannosus*		Woolly cotoneaster	
Shrub	*Eriodictyon californicum*		Yerba santa	X
Shrub (parasitic)	*Phoradendron bolleanum*		Bollean mistletoe	
Shrub (parasitic)	*Phoradendron leucarpum*	*Phoradendron leucarpum* ssp. *tomentosum*	Mistletoe	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Shrub (stem succulent)	*Opuntia ficus-indica*		Prickly pear cactus	
Shrub (stem succulent)	*Cistus salviifolius*		Sage leaf rockrose	
Shrub, Tree	*Quercus Xchasei*		Chase Oak	X
Shrub, Tree	*Quercus Xsubconvexa*		Quercus Xsubconvexa	X
Shrub, Vine	*Helichrysum petiolare*		Licorice plant	
Tree	*Acer macrophyllum*		Bigleaf maple	X
Tree	*Pinus muricata*		Bishop pine	X
Tree	*Acacia melanoxylon*		Blackwood acacia	
Tree	*Robinia pseudoacacia*		Black locust	
Tree	*Eucalyptus globulus*		Blue gum	
Tree	*Quercus douglasii*		Blue oak	X
Tree	*Acer negundo*		Boxelder	X
Tree	*Aesculus californica*		Buckeye	X
Tree	*Cordyline australis*		Cabbage tree	
Tree	*Umbellularia californica*		California bay	X
Tree	*Quercus kelloggii*		California black oak	X
Tree	*Torreya californica*		California nutmeg	X
Tree	*Phoenix canariensis*		Canary island date palm	
Tree	*Prunus cerasifera*		Cherry plum	
Tree	*Quercus agrifolia*	*Quercus agrifolia* var. *agrifolia*	Coast live oak	X
Tree	*Sequoia sempervirens*		Coast redwood	X
Tree	*Ficus carica*		Common fig	
Tree	*Pyrus communis*		Common pear	
Tree	*Pinus coulteri*		Coulter pine	X
Tree	*Pseudotsuga menziesii*	*Pseudotsuga menziesii* var. *menziesii*	Douglas fir	X
Tree	*Quercus chrysolepis*		Gold cup live oak	X
Tree	*Acacia longifolia*		Golden wattle	
Tree	*Acacia decurrens*		Green wattle	
Tree	*Quercus berberidifolia*		Inland scrub oak	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Tree	*Cryptomeria japonica*		Japanese cedar	
Tree	*Maytenus boaria*		Mayten	
Tree	*Arbutus menziesii*		Madrone	X
Tree	*Hesperocyparis macrocarpa*		Monterey cypress	X
Tree	*Pinus radiata*		Monterey pine	X
Tree	*Nerium oleander*		Oleander	
Tree	*Quercus Xmorehus*		Oracle oak	X
Tree	*Fraxinus latifolia*		Oregon ash	X
Tree	*Quercus garryana*	*Quercus garryana* var. *garryana*	Oregon oak	X
Tree	*Salix lasiandra*		Pacific willow	X
Tree	*Salix laevigata*		Polished willow	X
Tree	*Chamaecyparis lawsoniana*		Port orford cedar	X
Tree	*Pinus attenuata*		Scrub pine	X
Tree	*Quercus parvula*	*Quercus parvula* var. *shrevei*	Shreve's oak	X
Tree, Shrub		*Quercus parvula* var. *tamalpaisensis*	Tamalpais oak	X
Tree	*Pittosporum tenuifolium*		Tawhiwhi	
Tree	*Prunus avium*		Sweet cherry	
Tree	*Quercus lobata*		Valley oak	X
Tree	*Thuja plicata*		Western red cedar	X
Tree	*Alnus rhombifolia*		White alder	X
Tree, Shrub	*Salix lasiolepis*		Arroyo willow	X
Tree, Shrub	*Cercocarpus betuloides*	*Cercocarpus betuloides* var. *betuloides*	Birch leaf mountain mahogany	X
Tree, Shrub	*Ceanothus thyrsiflorus*		Blueblossom	X
Tree, Shrub	*Buddleja davidii*		Butterfly bush	
Tree, Shrub	*Ligustrum ovalifolium*		California privet	
Tree, Shrub	*Adenostoma fasciculatum*		Chamise	X
Tree, Shrub	*Garrya elliptica*		Coast silk tassel	X
Tree, Shrub	*Salix sitchensis*		Coulter Willow	X
Tree, Shrub	*Ligustrum lucidum*		Glossy privet	
Tree, Shrub	*Chrysolepis chrysophylla*	*Chrysolepis chrysophylla* var. *chrysophylla*	Golden chinquapin	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Tree, Shrub		*Chrysolepis chrysophylla* var. *minor*	Bush chinquapin	X
Tree, Shrub	*Ilex aquifolium*		Holly	
Tree, Shrub	*Quercus wislizeni*	*Quercus wislizeni* var. *frutescens*	Live oak	X
Tree, Shrub		*Quercus wislizeni* var. *wislizeni*	Interior live oak	X
Tree, Shrub	*Myoporum laetum*		Lollypop tree	
Tree, Shrub	*Olea europaea*		Olive	
Tree, Shrub	*Alnus rubra*		Red alder	X
Tree, Shrub	*Hesperocyparis sargentii*		Sargent cypress	X
Tree, Shrub	*Salix scouleriana*		Scouler willow	X
Tree, Shrub	*Acacia dealbata*		Silver wattle	
Tree, Shrub	*Acacia verticillata*		Star acacia	
Tree, Shrub	*Notholithocarpus densiflorus*	*Notholithocarpus densiflorus* var. *densiflorus*	Tanoak	X
Tree, Shrub	*Ceanothus velutinus*		Tobacco brush, snowbrush	X
Tree, Shrub	*Pittosporum undulatum*		Victorian box	
Tree, Shrub	*Acacia retinodes*		Water watttle	
Tree, Shrub	*Rhododendron occidentale*		Western azalea	X
Tree, Shrub	*Euonymus occidentalis*		Western burning bush	X
Vine	*Asparagus asparagoides*		African asparagus fern	
Vine	*Lathyrus angulatus*		Angled pea vine	
Vine	*Hedera canariensis*		Canary ivy	
Vine	*Clematis vitalba*		Old man's beard	
Vine	*Vicia hassei*		Hasse's vetch	X
Vine, Shrub	*Rubus ursinus*		California blackberry	X
Vine, Shrub	*Aristolochia californica*		California pipevine	X
Vine, Shrub	*Galium porrigens*		Climbing bedstraw	X
Vine, Shrub	*Hedera helix*		English ivy	
Vine, Shrub	*Galium porrigens*	*Galium porrigens* var. *porrigens*	Graceful bedstraw	X
Vine, Shrub	*Whipplea modesta*		Modesty	X
Vine, Shrub	*Lonicera hispidula*		Pink honeysuckle	X

Life Form	Species Name	Subspecies or Variety Found on Mt. Tam	Common Name	Native
Vine, Shrub	*Toxicodendron diversilobum*		Poison oak	X
Vine, Shrub	*Rubus parviflorus*		Thimbleberry	X

APPENDIX 6. RARE, THREATENED, AND ENDANGERED PLANT SPECIES OF MT. TAM

Rank Code	Rank Description
1A	Plants Presumed Extirpated in California and Either Rare or Extinct Elsewhere
1B.1	Plants Rare, Threatened, or Endangered in California and Elsewhere- Seriously threatened in California
1B.2	Plants Rare, Threatened, or Endangered in California and Elsewhere- Moderately threatened in California
1B.3	Plants Rare, Threatened, or Endangered in California and Elsewhere- Not very threatened in California
2A	Plants Presumed Extirpated in California, But Common Elsewhere
2B.1	Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere- Seriously threatened in California
2B.2	Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere- Moderately threatened in California
2B.3	Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere- Not very threatened in California
3**	Plants About Which More Information is Needed - A Review List
4.1	Plants of Limited Distribution - A Watch List- Seriously threatened in California
4.2	Plants of Limited Distribution - A Watch List- Moderately threatened in California
4.3	Plants of Limited Distribution - A Watch List- Not very threatened in California

Information taken from *CNPS.org*

**Rank 3 is excluded from this list

Scientific Name	Rank Code
Amorpha californica var. *napensis*	1B.2
Amsinckia lunaris	1B.2
Arabis blepharophylla	4.3
Arctostaphylos montana ssp. *montana*	1B.3
Arctostaphylos virgata	1B.2
Aspidotis carlotta-halliae	4.2
Astragalus breweri	4.2
Calamagrostis ophitidis	4.3
Calandrinia breweri	4.2
Calochortus umbellatus	4.2
Calochortus uniflorus	4.2
Calystegia collina ssp. *oxyphylla*	4.2
Castilleja ambigua ssp. *ambigua*	4.2
Ceanothus gloriosus var. *exaltatus*	4.3
Ceanothus masonii	1B.2
Chloropyron maritimum ssp. *palustre*	1B.2
Cirsium hydrophilum var. *vaseyi*	1B.2

Scientific Name	Rank Code
Dirca occidentalis	1B.2
Elymus californicus	4.3
Eriogonum luteolum var. *caninum*	1B.2
Erysimum franciscanum	4.2
Fritillaria lanceolata var. *tristulis*	1B.1
Fritillaria liliacea	1B.2
Hesperocyparis macrocarpa	1B.2
Hesperolinon congestum	1B.1
Horkelia tenuiloba	1B.2
Hosackia gracilis	4.2
Iris longipetala	4.2
Kopsiopsis hookeri	2B.3
Leptosiphon acicularis	4.2
Leptosiphon grandiflorus	4.2
Lessingia micradenia var. *micradenia*	1B.2
Navarretia rosulata	1B.2
Perideridia gairdneri ssp. *gairdneri*	4.2
Pinus radiata	1B.1
Pleuropogon hooverianus	1B.1
Pleuropogon refractus	4.2
Quercus parvula var. *tamalpaisensis*	1B.3
Stebbinsoseris decipiens	1B.2
Streptanthus batrachopus	1B.3
Streptanthus glandulosus ssp. *pulchellus*	1B.2
Toxicoscordion fontanum	4.2

APPENDIX 7. LIKELY EXTIRPATED PLANT SPECIES OF MT. TAM

The following is a list of plant believed to be extirpated from the One Tam area of focus.

Scientific Name	Common Name
Achyrachaena mollis	Blow wives
Agrostis microphylla	Little leaf bentgrass
Apiastrum angustifolium	Wild celery
Arabis eschscholtziana	Eschscholtz's hairy rockcress
Asclepias speciosa	Showy milkweed
Astragalus pycnostachyus	Marsh milk vetch
Blechnum spicant	Deer fern
Callitriche fassettii	Fassett's water starwort
Callitriche marginata	Winged water starwort
Callitriche palustris	Vernal water-starwort
Callitriche trochlearis	Water starwort
Carex cusickii	Cusick's sedge
Circaea alpina ssp. *pacifica*	Pacific enchanter's nightshade
Cirsium andrewsii	Franciscan thistle
Clarkia purpurea ssp. *viminea*	Large godetia
Collomia grandiflora	Large flowered collomia
Cornus nuttallii	Mountain dogwood
Cryptantha micromeres	Small flowered cryptantha
Cryptantha muricata	Prickly cryptantha
Cryptantha torreyana	Torrey's cryptantha
Cypripedium californicum	California lady's slipper
Datisca glomerata	Durango root
Deinandra corymbosa	Coastal tarweed
Epilobium hallianum	Hall's willowherb
Equisetum laevigatum	Smooth scouring rush
Eryngium aristulatum var. *aristulatum*	Jepson's button celery
Eschscholzia caespitosa	Tufted eschscholzia
Euphorbia crenulata	Chinesecaps
Festuca octoflora	Sixweeks grass
Galium trifidum	Three petaled bedstraw
Geranium bicknellii	Bicknell's geranium
Geranium carolinianum	Carolina geranium
Pseudognaphalium stramineum	Cottonbatting plant
Helenium bigelovii	Bigelow's sneezeweed
Heliotropium curassavicum var. *oculatum*	Seaside heliotrope
Holocarpha macradenia	Santa Cruz tarplant

Scientific Name	Common Name
Lagophylla ramosissima	Common hareleaf
Lathyrus jepsonii var. *californicus*	California tule pea
Lewisia rediviva	Bitter root
Limnanthes douglasii	Common meadow foam
Lythrum californicum	Common loosestrife
Micropus amphibolus	Mt. Diablo cottonweed
Microseris paludosa	Marsh scorzonella
Paxistima myrsinites	Oregon boxwood
Penstemon heterophyllus ssp. *purdyi*	Purdy's foothill penstemon
Pentachaeta alsinoides	Tiny pygmy daisy
Pentachaeta bellidiflora	White rayed pentachaeta
Phacelia suaveolens	Sweet scented phacelia
Pityopus californicus	Pinefoot
Plagiobothrys glaber	Hairless popcorn flower
Pleuropogon hooverianus	North coast semaphore grass
Pleuropogon refractus	Nodding semaphore grass
Potentilla rivalis var. *millegrana*	Brook cinquefoil
Prunus subcordata	Sierra plum
Prunus virginiana var. *demissa*	Western choke cherry
Quercus dumosa	Scrub oak
Ranunculus flammula var. *ovalis*	Greater creeping spearwort
Ranunculus lobbii	Lobb's aquatic buttercup
Ranunculus orthorhynchus var. *bloomeri*	Bloomer's buttercup
Ribes malvaceum	Chaparral currant
Ribes victoris	Victor's gooseberry
Sceptridium multifidum	Leather grape-fern
Sidalcea hickmanii ssp. *viridis*	Marin checkerbloom
Sisyrinchium californicum	California golden eyed grass
Tetrapteron graciliflorum	Hill sun cup
Torreyochloa pallida var. *pauciflora*	Mannagrass
Trifolium amoenum	Showy Indian clover
Viola pedunculata	California golden violet

APPENDIX 8. MAMMAL SPECIES OF MT. TAM

Life Form	Scientific Name	Common Name	Native
Bats	*Antrozous pallidus*	Pallid bat	X
Bats	*Corynorhinus townsendii*	Townsend's big-eared bat	X
Bats	*Eptesicus fuscus*	Big brown bat	X
Bats	*Lasionycteris noctivagans*	Silver-haired bat	X
Bats	*Lasiurus blossevillii*	Western red bat	X
Bats	*Lasiurus cinereus*	Hoary bat	X
Bats	*Myotis californicus*	California myotis	X
Bats	*Myotis thysanodes*	Fringed myotis	X
Bats	*Myotis volans*	Long-legged myotis	X
Bats	*Myotis yumanensis*	Yuma myotis	X
Bats	*Tadarida brasiliensis*	Brazilian (Mexican) free-tailed bat	X
Carnivores	*Canis latrans*	Coyote	X
Carnivores	*Lontra canadensis*	North American river otter	X
Carnivores	*Lynx rufus*	Bobcat	X
Carnivores	*Mephitis mephitis*	Striped skunk	X
Carnivores	*Mustela frenata*	Long-tailed weasel	X
Carnivores	*Procyon lotor*	Northern raccoon	X
Carnivores	*Puma concolor*	Puma (cougar, mountain lion)	X
Carnivores	*Spilogale gracilis*	Western spotted skunk	X
Carnivores	*Taxidea taxus*	American badger	X
Carnivores	*Urocyon cinereoargenteus*	Gray fox	X
Hoofed Mammals	*Bos taurus*	Cow	
Hoofed Mammals	*Odocoileus hemionus*	Black-tailed (mule) deer	X
Insectivores	*Neurotrichus gibbsii*	American shrew-mole	X
Insectivores	*Scapanus latimanus*	Broad-footed mole	X
Insectivores	*Sorex trowbridgii*	Trowbridge's shrew	X
Insectivores	*Sorex vagrans*	Vagrant shrew	X
Marsupials	*Didelphis virginiana*	Virginia opossum	
Rabbits and Rodents	*Lepus californicus*	Black-tailed jackrabbit	X
Rabbits and Rodents	*Microtus californicus*	California vole	X
Rabbits and Rodents	*Mus musculus*	House mouse	
Rabbits and Rodents	*Neotamias sonomae*	Sonoma chipmunk	X

Life Form	Scientific Name	Common Name	Native
Rabbits and Rodents	*Neotoma fuscipes*	Dusky-footed woodrat	X
Rabbits and Rodents	*Peromyscus maniculatus*	Deer mouse	X
Rabbits and Rodents	*Rattus rattus*	Black rat	
Rabbits and Rodents	*Reithrodontomys megalotis*	Western harvest mouse	X
Rabbits and Rodents	*Sciurus griseus*	Western gray squirrel	X
Rabbits and Rodents	*Sciurus niger*	Eastern fox squirrel	
Rabbits and Rodents	*Sylvilagus bachmani*	Brush rabbit	X
Rabbits and Rodents	*Thomomys bottae*	Botta's pocket gopher	X

APPENDIX 9. BIRD SPECIES OF MT. TAM

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Blackbirds and Allies	*Euphagus cyanocephalus*	Brewer's Blackbird	Uncommon	X
Blackbirds and Allies	*Molothrus ater*	Brown-headed Cowbird	Uncommon	X
Blackbirds and Allies	*Icterus bullockii*	Bullock's Oriole	Uncommon	X
Blackbirds and Allies	*Icterus cucullatus*	Hooded Oriole	Irregular/ accidental visitor	X
Blackbirds and Allies	*Agelaius phoeniceus*	Red-winged BlackBird	Common	X
Blackbirds and Allies	*Sturnella neglecta*	Western Meadowlark	Uncommon	X
Cardinals, Grosbeaks, and Allies	*Pheucticus melanocephalus*	Black-headed Grosbeak	Common	X
Cardinals, Grosbeaks, and Allies	*Passerina amoena*	Lazuli Bunting	Uncommon	X
Cardinals, Grosbeaks, and Allies	*Piranga ludoviciana*	Western Tanager	Uncommon	X
Chickadees, Titmice, and Bushtits	*Psaltriparus minimus*	Bushtit	Common	X
Chickadees, Titmice, and Bushtits	*Poecile rufescens*	Chesnut-backed Chickadee	Common	X
Chickadees, Titmice, and Bushtits	*Baeolophus inornatus*	Oak Titmouse	Common	X
Cranes and Rails	*Fulica americana*	American Coot	Common	X
Cranes and Rails	*Laterallus jamaicensis* ssp. *coturniculus*	California Black Rail	Rare	X
Cranes and Rails	*Rallus obsoletus* ssp. *obsoletus*	California Ridgway's Rail	Rare	X
Cranes and Rails	*Gallinula galeata*	Common Gallinule	Rare	X
Cranes and Rails	*Porzana carolina*	Sora	Uncommon	X
Cranes and Rails	*Rallus limicola*	Virginia Rail	Uncommon	X
Dippers	*Cinclus mexicanus*	American Dipper	Irregular/ accidental visitor	X
Ducks, Geese, and Swans	*Anas americana*	American Wigeon	Uncommon	X
Ducks, Geese, and Swans	*Bucephala islandica*	Barrow's Goldeneye	Irregular/ accidental visitor	X
Ducks, Geese, and Swans	*Bucephala albeola*	Bufflehead	Uncommon	X
Ducks, Geese, and Swans	*Branta canadensis*	Canada Goose	Common	X
Ducks, Geese, and Swans	*Aythya valisineria*	Canvasback	Uncommon	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Ducks, Geese, and Swans	*Anas cyanoptera*	Cinnamon Teal	Uncommon	X
Ducks, Geese, and Swans	*Bucephala clangula*	Common Goldeneye	Uncommon	X
Ducks, Geese, and Swans	*Mergus merganser*	Common Merganser	Common	X
Ducks, Geese, and Swans	*Anas strepera*	Gadwall	Uncommon	X
Ducks, Geese, and Swans	*Aythya marila*	Greater Scaup	Uncommon	X
Ducks, Geese, and Swans	*Anas crecca*	Green-winged Teal	Uncommon	X
Ducks, Geese, and Swans	*Lophodytes cucullatus*	Hooded Merganser	Uncommon	X
Ducks, Geese, and Swans	*Aythya affinis*	Lesser Scaup	Uncommon	X
Ducks, Geese, and Swans	*Anas platyrhynchos*	Mallard	Common	X
Ducks, Geese, and Swans	*Anas acuta*	Northern Pintail	Uncommon	X
Ducks, Geese, and Swans	*Anas clypeata*	Northern Shoveler	Uncommon	X
Ducks, Geese, and Swans	*Aythya collaris*	Ring-necked Duck	Uncommon	X
Ducks, Geese, and Swans	*Oxyura jamaicensis*	Ruddy Duck	Uncommon	X
Ducks, Geese, and Swans	*Aix sponsa*	Wood Duck	Rare	X
Finches and Allies	*Spinus tristis*	American Goldfinch	Uncommon	X
Finches and Allies	*Carpodacus mexicanus*	House Finch	Common	X
Finches and Allies	*Spinus lawrencei*	Lawrence's Goldfinch	Irregular/ accidental visitor	X
Finches and Allies	*Spinus psaltria*	Lesser Goldfinch	Uncommon	X
Finches and Allies	*Spinus pinus*	Pine Siskin	Uncommon	X
Finches and Allies	*Carpodacus purpureus*	Purple Finch	Common	X
Finches and Allies	*Loxia curvirostra*	Red Crossbill	Uncommon	X
Gnatcatchers	*Polioptila caerulea*	Blue-gray Gnatcatcher	Uncommon	X
Goatsuckers	*Phalaenoptilus nuttallii*	Common Poorwill	Uncommon	X
Grebes	*Aechmophorus clarkii*	Clark's Grebe	Rare	X
Grebes	*Podiceps nigricollis*	Eared Grebe	Uncommon	X
Grebes	*Podilymbus podiceps*	Pied-billed Grebe	Common	X
Grebes	*Aechmophorus occidentalis*	Western Grebe	Common	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Grouse, Quail, and Allies	*Callipepla californica*	California Quail	Common	X
Grouse, Quail, and Allies	*Meleagris gallopavo*	Wild Turkey	Common	
Gulls and Terns	*Larus californicus*	California Gull	Rare	X
Gulls and Terns	*Hydroprogne caspia*	Caspian Tern	Common	X
Gulls and Terns	*Sterna hirundo*	Common Tern	Irregular/ accidental visitor	X
Gulls and Terns	*Sterna forsteri*	Forster's Tern	Uncommon	X
Gulls and Terns	*Larus glaucescens*	Glaucous-winged Gull	Rare	X
Gulls and Terns	*Larus argentatus*	Herring Gull	Rare	X
Gulls and Terns	*Larus delawarensis*	Ring-billed Gull	Common	X
Gulls and Terns	*Larus occidentalis*	Western Gull	Rare	X
Herons and Allies	*Ardea herodias*	Great Blue Heron	Common	X
Herons and Allies	*Ardea alba*	Great Egret	Common	X
Herons and Allies	*Butorides virescens*	Green Heron	Uncommon	X
Herons and Allies	*Egretta thula*	Snowy Egret	Common	X
Jays, Magpies, and Crows	*Corvus brachyrhynchos*	American Crow	Common	X
Jays, Magpies, and Crows	*Corvus corax*	Common Raven	Common	X
Jays, Magpies, and Crows	*Cyanocitta stelleri*	Steller's Jay	Common	X
Jays, Magpies, and Crows	*Aphelocoma californica*	Western Scrub-Jay	Common	X
Kingfishers	*Megaceryle alcyon*	Belted Kingfisher	Common	X
Kinglets	*Regulus satrapa*	Golden-crowned Kinglet	Uncommon	X
Kinglets	*Regulus calendula*	Ruby-crowned Kinglet	Common	X
Larks	*Eremophila alpestris*	Horned Lark	Uncommon	X
Loons	*Gavia immer*	Common Loon	Irregular/ accidental visitor	X
Loons	*Gavia pacifica*	Pacific Loon	Irregular/ accidental visitor	X
MockingBirds and Thrashers	*Toxostoma redivivum*	California Thrasher	Rare	X
MockingBirds and Thrashers	*Mimus polyglottos*	Northern Mockingbird	Uncommon	X
New World Sparrows and Allies	*Artemisiospiza belli*	Bell's Sparrow	Rare	X
New World Sparrows and Allies	*Spizella atrogularis*	Black-chinned sparrow	Rare	X
New World Sparrows and Allies	*Melozone crissalis*	California Towhee	Common	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
New World Sparrows and Allies	*Spizella passerina*	Chipping Sparrow	Uncommon	X
New World Sparrows and Allies	*Junco hyemalis*	Dark-eyed Junco	Common	X
New World Sparrows and Allies	*Passerella iliaca*	Fox Sparrow	Common	X
New World Sparrows and Allies	*Zonotrichia atricapilla*	Golden-crowned Sparrow	Common	X
New World Sparrows and Allies	*Ammodramus savannarum*	Grasshopper Sparrow	Rare	X
New World Sparrows and Allies	*Pipilo chlorurus*	Green-tailed Towhee	Irregular/ accidental visitor	X
New World Sparrows and Allies	*Chondestes grammacus*	Lark Sparrow	Uncommon	X
New World Sparrows and Allies	*Melospiza lincolnii*	Lincoln's Sparrow	Rare	X
New World Sparrows and Allies	*Aimophila ruficeps*	Rufous-crowned Sparrow	Rare	X
New World Sparrows and Allies	*Passerculus sandwichensis*	Savannah Sparrow	Uncommon	X
New World Sparrows and Allies	*Melospiza melodia*	Song Sparrow	Common	X
New World Sparrows and Allies	*Pipilo maculatus*	Spotted Towhee	Common	X
New World Sparrows and Allies	*Zonotrichia leucophrys*	White-crowned Sparrow	Common	X
New World Sparrows and Allies	*Zonotrichia albicollis*	White-throated Sparrow	Rare	X
Nuthatches and Creepers	*Certhia americana*	Brown Creeper	Common	X
Nuthatches and Creepers	*Sitta pygmaea*	Pygmy Nuthatch	Uncommon	X
Nuthatches and Creepers	*Sitta canadensis*	Red-breasted Nuthatch	Common	X
Nuthatches and Creepers	*Sitta carolinensis*	White-breasted Nuthatch	Uncommon	X
Old World Sparrows	*Passer domesticus*	House Sparrow	Uncommon	
Owls	*Tyto alba*	Barn Owl	Common	X
Owls	*Strix varia*	Barred Owl	Rare	X
Owls	*Bubo virginianus*	Great Horned Owl	Common	X
Owls	*Asio otus*	Long-eared Owl	Uncommon	X
Owls	*Glaucidium gnoma*	Northern Pygmy-Owl	Rare	X
Owls	*Aegolius acadicus*	Northern Saw-whet Owl	Rare	X
Owls	*Strix occidentalis* ssp. *caurina*	Northern Spotted Owl	Uncommon	X
Owls	*Megascops kennicottii*	Western Screech-Owl	Uncommon	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Pelicans and Allies	*Pelecanus erythrorhynchos*	American White Pelican	Rare	X
Pelicans and Allies	*Phalacrocorax penicillatus*	Brandt's Cormorant	Irregular/ accidental visitor	X
Pelicans and Allies	*Pelecanus occidentalis*	Brown Pelican	Irregular/ accidental visitor	X
Pelicans and Allies	*Phalacrocorax auritus*	Double-crested Cormorant	Common	X
Pelicans and Allies	*Phalacrocorax pelagicus*	Pelagic Cormorant	Irregular/ accidental visitor	X
Pigeons and Doves	*Patagioenas fasciata*	Band-tailed Pigeon	Common	X
Pigeons and Doves	*Zenaida macroura*	Mourning Dove	Common	X
ShoreBirds	*Haematopus bachmani*	Black Oystercatcher	Irregular/ accidental visitor	X
ShoreBirds	*Himantopus mexicanus*	Black-necked Stilt	Uncommon	X
ShoreBirds	*Tringa melanoleuca*	Greater Yellowlegs	Uncommon	X
ShoreBirds	*Charadrius vociferus*	Killdeer	Common	X
ShoreBirds	*Actitis macularius*	Spotted Sandpiper	Uncommon	X
ShoreBirds	*Gallinago delicata*	Wilson's Snipe	Uncommon	X
Shrikes	*Lanius ludovicianus*	Loggerhead Shrike	Rare	X
Starlings and Allies	*Sturnus vulgaris*	European Starling	Common	
Swallows	*Riparia riparia*	Bank Swallow	Irregular/ accidental visitor	X
Swallows	*Hirundo rustica*	Barn Swallow	Common	X
Swallows	*Petrochelidon pyrrhonota*	Cliff Swallow	Common	X
Swallows	*Stelgidopteryx serripennis*	Northern Rough-winged Swallow	Uncommon	X
Swallows	*Progne subis*	Purple Martin	Uncommon	X
Swallows	*Tachycineta bicolor*	Tree Swallow	Common	X
Swallows	*Tachycineta thalassina*	Violet-green Swallow	Common	X
Swifts and Hummingbirds	*Selasphorus sasin*	Allen's Hummingbird	Common	X
Swifts and Hummingbirds	*Calypte anna*	Anna's Hummingbird	Common	X
Swifts and Hummingbirds	*Chaetura vauxi*	Vaux's Swift	Uncommon	X
Swifts and Hummingbirds	*Aeronautes saxatalis*	White-throated Swift	Rare	X
Thrushes	*Turdus migratorius*	American Robin	Common	X
Thrushes	*Catharus guttatus*	Hermit Thrush	Common	X
Thrushes	*Catharus ustulatus*	Swainson's Thrush	Common	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Thrushes	*Myadestes townsendi*	Townsend's Solitaire	Rare	X
Thrushes	*Ixoreus naevius*	Varied Thrush	Common	X
Thrushes	*Sialia mexicana*	Western Bluebird	Common	X
Tyrant Flycatchers	*Myiarchus cinerascens*	Ash-throated Flycatcher	Uncommon	X
Tyrant Flycatchers	*Sayornis nigricans*	Black Phoebe	Common	X
Tyrant Flycatchers	*Contopus cooperi*	Olive-sided Flycatcher	Uncommon	X
Tyrant Flycatchers	*Empidonax difficilis*	Pacific-slope Flycatcher	Common	X
Tyrant Flycatchers	*Sayornis saya*	Say's Phoebe	Uncommon	X
Tyrant Flycatchers	*Tyrannus verticalis*	Western Kingbird	Rare	X
Tyrant Flycatchers	*Contopus sordidulus*	Western Wood-Pewee	Common	X
Vireos	*Vireo cassinii*	Cassin's Vireo	Uncommon	X
Vireos	*Vireo huttoni*	Hutton's Vireo	Common	X
Vireos	*Vireo gilvus*	Warbling Vireo	Common	X
Vultures, Hawks, and Falcons	*Falco sparverius*	American Kestrel	Common	X
Vultures, Hawks, and Falcons	*Haliaeetus leucocephalus*	Bald Eagle	Uncommon	X
Vultures, Hawks, and Falcons	*Buteo platypterus*	Broad-winged Hawk	Rare	X
Vultures, Hawks, and Falcons	*Accipiter cooperii*	Cooper's Hawk	Uncommon	X
Vultures, Hawks, and Falcons	*Aquila chrysaetos*	Golden Eagle	Rare	X
Vultures, Hawks, and Falcons	*Falco columbarius*	Merlin	Rare	X
Vultures, Hawks, and Falcons	*Circus cyaneus*	Northern Harrier	Uncommon	X
Vultures, Hawks, and Falcons	*Pandion haliaetus*	Osprey	Common	X
Vultures, Hawks, and Falcons	*Falco peregrinus*	Peregrine Falcon	Rare	X
Vultures, Hawks, and Falcons	*Falco mexicanus*	Prairie Falcon	Rare	X
Vultures, Hawks, and Falcons	*Buteo lineatus*	Red-shouldered Hawk	Common	X
Vultures, Hawks, and Falcons	*Buteo jamaicensis*	Red-tailed Hawk	Common	X
Vultures, Hawks, and Falcons	*Buteo lagopus*	Rough-legged Hawk	Irregular/ accidental visitor	X
Vultures, Hawks, and Falcons	*Accipiter striatus*	Sharp-shinned Hawk	Common	X
Vultures, Hawks, and Falcons	*Cathartes aura*	Turkey Vulture	Common	X

Life Form	Scientific Name	Common Name	Occurrence Within One Tam Area of Focus	Native
Vultures, Hawks, and Falcons	*Elanus leucurus*	White-tailed Kite	Common	X
Waxwings	*Bombycilla cedrorum*	Cedar Waxwing	Common	X
Wood-warblers	*Setophaga nigrescens*	Black-throated Gray Warbler	Rare	X
Wood-warblers	*Setophaga occidentalis*	Hermit Warbler	Rare	X
Wood-warblers	*Geothlypis tolmiei*	MacGillivray's Warbler	Uncommon	X
Wood-warblers	*Oreothlypis celata*	Orange-crowned Warbler	Common	X
Wood-warblers	*Setophaga townsendi*	Townsend's Warbler	Common	X
Wood-warblers	*Cardellina pusilla*	Wilson's Warbler	Common	X
Wood-warblers	*Setophaga petechia*	Yellow Warbler	Common	X
Wood-warblers	*Setophaga coronata*	Yellow-rumped Warbler	Common	X
Woodpeckers	*Melanerpes formicivorus*	Acorn Woodpecker	Common	X
Woodpeckers	*Picoides pubescens*	Downy Woodpecker	Common	X
Woodpeckers	*Picoides villosus*	Hairy Woodpecker	Common	X
Woodpeckers	*Colaptes auratus*	Northern Flicker	Common	X
Woodpeckers	*Picoides nuttallii*	Nuttall's Woodpecker	Common	X
Woodpeckers	*Dryocopus pileatus*	Pileated Woodpecker	Uncommon	X
Woodpeckers	*Sphyrapicus ruber*	Red-breasted Sapsucker	Common	X
Wrens	*Thryomanes bewickii*	Bewick's Wren	Common	X
Wrens	*Troglodytes aedon*	House Wren	Uncommon	X
Wrens	*Cistothorus palustris*	Marsh Wren	Uncommon	X
Wrens	*Troglodytes pacificus*	Pacific Wren	Common	X
Wrens	*Salpinctes obsoletus*	Rock Wren	Rare	X
Wrentits	*Chamaea fasciata*	Wrentit	Common	X

APPENDIX 10. AMPHIBIAN AND REPTILE SPECIES OF MT. TAM

Scientific Name	Common Name	Native
Lithobates catesbeianus	American bullfrog	
Pseudacris sierra	Sierran treefrog (Pacific treefrog)	X
Rana boylii	Foothill yellow-legged frog	X
Rana draytonii	California red-legged frog	X
Taricha granulosa	Rough-skinned newt	X
Taricha torosa ssp. *torosa*	Coast Range newt	X
Aneides lugubris	Arboreal salamander	X
Batrachoseps attenuatus	California slender salamander	X
Dicamptodon ensatus	California giant salamander	X
Ensatina eschscholtzii	Ensatina	X
Ensatina eschscholtzii ssp. *xanthoptica*	Yellow-eyed ensatina	X
Anaxyrus boreas ssp. *halophilus*	California toad	X
Elgaria coerulea ssp. *coerulea*	San Francisco alligator lizard	X
Elgaria multicarinata ssp. *multicarinata*	California alligator lizard	X
Plestiodon skiltonianus ssp. *skiltonianus*	Skilton's skink	X
Sceloporus occidentalis ssp. *bocourtii*	Coast Range fence lizard	X
Charina bottae	Northern rubber boa	X
Coluber constrictor ssp. *mormon*	Western yellow-bellied racer	X
Crotalus oreganus ssp. *oreganus*	Northern Pacific rattlesnake	X
Diadophis punctatus ssp. *amabilis*	Pacific ring-necked snake	X
Lampropeltis getula ssp. *californiae*	California kingsnake	X
Pituophis catenifer ssp. *catenifer*	Pacific gopher snake	X
Thamnophis atratus	Aquatic gartersnake	X
Thamnophis elegans ssp. *terrestris*	Coast gartersnake	X
Thamnophis sirtalis ssp. *infernalis*	California red-sided gartersnake	X
Actinemys marmorata	Pacific pond turtle	X
Pseudemys concinna	River cooter	
Trachemys decussata	Cuban dlider	
Trachemys scripta ssp. *elegans*	Red-eared slider	

APPENDIX 11. FISH SPECIES OF MT. TAM

Scientific Name	Common Name	Native
Acanthogobius flavimanus	Yellowfin goby	
Carassius auratus	Goldfish	
Catostomus occidentalis	Sacramento sucker	X
Cottus aleuticus	Coastrange sculpin	X
Cottus asper	Prickly sculpin	X
Cottus gulosus	Riffle sculpin	X
Cyprinus carpio	Common carp	
Entosphenus tridentatus	Pacific lamprey	X
Gambusia affinis	Western mosquitofish	
Gasterosteus aculeatus	Threespine stickleback	X
Hesperoleucus symmetricus	California/ Tomales roach	X
Ictalurus punctatus	Channel catfish	
Lepomis cyanellus	Green sunfish	
Lepomis macrochirus	Bluegill	
Lepomis microlophus	Redear sunfish	
Leptocottus armatus	Pacific staghorn sculpin	X
Micropterus dolomieu	Smallmouth bass	
Micropterus punctulatus	Spotted bass	
Micropterus salmoides	Largemouth bass	
Morone saxatilis	Striped bass	
Notemigonus crysoleucas	Golden shiner	
Oncorhynchus kisutch	Coho salmon	X
Oncorhynchus mykiss	Steelhead trout	X
Platichthys stellatus	Starry flounder	X
Pomoxis annularis	White crappie	
Pomoxis nigromaculatus	Black crappie	