EARLY DETECTION BEYOND BOUNDARIES

Rachel Kesel, Conservation Management Specialist

rkesel@onetam.org

David Greenberger, Assistant Conservation Management Specialist

dgreenberger@onetam.org

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Cover photo: An early detection surveyor records an invasive grass on a smartphone device at Cascade Canyon Preserve in Marin County, California.
Photo: Lieven Leroy

ACKNOWLEDGMENTS

Working on Mount Tamalpais comes with many advantages, not the least of which is the collegiality among staff working together to manage the land. We would like to thank the multitude of people who make this work possible.

The One Tam Early Detection subgroup members, past and present, set the course for the surveys and analysis. Andrea Williams, Eric Wrubel, Pete Frye, Tom Reyes, and Catey Ritchie—you made your mark on Tam. Teams of staff work with these leaders to collect the valuable data analyzed here. Even more staff work year-round to manage invasive plants on the mountain.

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EXECUTIVE SUMMARY

The four agencies entrusted with caring for Mt. Tamalpais' tens of thousands acres of open space consider invasive plant management a key part of their missions to protect the mountain's iconic landscapes, and the plants and animals that call them home.

Because invasive plant populations do not stop at property lines, in 2016 the One Tam collaborative joined these four agencies in partnership with the nonprofit Golden Gate National Parks Conservancy to create a coordinated Early Detection Rapid Response (EDRR) program.

This report synthesizes early detection efforts from 2014 to 2018—which spans the EDRR program's lead-up, inception, and first years. It includes details about the program's organization, methodology, and results. It also offers a deeper analysis of species distributions and of survey and treatment efforts. Detailed strategies for addressing widespread weeds are covered in Appendix C.

PROGRAM STRUCTURE AND KEY COMPONENTS

One Tam's EDRR goals are to identify priority invasive species, treat high-priority patches, and share data across jurisdictions and with the public. Differences in individual agency protocols and widely varying organizational capacities meant that the One Tam EDRR program had to build on shared priorities to unite its partners around realistic invasive plant management goals. In its first four years, the program was able to:

- **Establish Priority One and Two lists** of 62 out of 200 known potential invasive species based on population size, number, and/or proximity of other populations on nearby lands (Appendix A).
- **Coordinate surveys** of the mountain's 338 miles of roads and trails (to be repeated every three years) focused on areas of high visitation and ecological value using a flexible survey structure based on seasonality, habitat type, and staff capacity.
- **Employ flexible staffing models** to fill in gaps in existing agency teams to create a holistic invasive species survey and rapid response treatment program for the entire mountain.
- **Treat small weed patches when feasible** and use best management practices to prevent spreading weeds from one area to another.
- **Collect, standardize, and share data** using the publicly accessible, cloud-based Calflora Observer Pro mobile app, including important population characteristics and measures of labor/effort (Appendix F), with data carefully quality controlled.
- **Leverage the power of the One Tam partnership** to allow a non-land-owning entity to thread together separate agency EDRR work, coordinate multiple crews across jurisdictional boundaries, and create the One Tam EDRR team to support agency efforts as needed (and vice versa).

RESULTS AND LESSONS LEARNED

The initial survey dataset provided a cross-boundary perspective that helped identify shared needs. It also revealed that Priority One species constitute just 1% of the total area surveyed, indicating that these species are meaningful early detection targets. While some Priority One species were found to be more widespread than expected, declining levels of the year-to-year control needed for several of these species shows that rapid response is working.

Several specific lessons have also been learned from implementing the One Tam EDRR protocol (Page 28).

1. **Shared goals must be disseminated, reiterated, and revisited for successful implementation.**
2. **A pilot season to test and adapt the protocol proved highly beneficial.**
3. **The protocol, particularly the species list, must remain flexible in order to meet EDRR's fundamental purpose of locating and treating important weed populations.**
4. **Rapid Response requires contact with high priority invasive plant material and so practices that reduce the inadvertent spread of these species are critical.**
5. **Rapid Response to new detections of Priority One species requires reserving time in the schedule to ensure capacity to treat them promptly.**

Accomplishments to date include:

5,993 gross acres mapped

- Priority One (61 acres/724 patches)
- Priority Two (5,932 acres/15,000 patches)

462 miles of roads/trails and 28 miles of creeks/drainages surveyed (including repeats)

782 hours treating Priority One species and **12,145 hours treating Priority Two** species in 2019

57% of gross acres of Priority One species managed (as of 2019)

WHERE DO WE GO FROM HERE?

Lessons from the One Tam EDRR program's first years will help shape its future. This ambitious effort to coordinate four separate agencies—working both independently and together across the landscape—has yielded significant benefits. In particular, having a cross-jurisdictional team that understands and supports its partner's needs has been key to the program's success.

Complete integration of collective priorities into a mountain-wide management program is the next challenge. In particular, defining detailed, landscape-level treatment strategies to ensure successful weed control or eradication is a must. With a proven approach to working across boundaries, and new data for planning in hand, staffing and funding can now be scaled up to treat all Priority One weeds. The priority species lists will also need to be periodically reevaluated as new weeds emerge and as agency priorities evolve.

EDRR is grounded in the idea that early intervention prevents much bigger problems later on. Investments to sustain these early gains lead to even longer-term economic and resource management benefits. Indeed, the potential of a comprehensive program like this to protect Mt. Tamalpais' renowned biodiversity and increase its resilience to the impacts of climate change mean that these are early investments well worth making.

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LIST OF ACRONYMS

BMPs – Best Management Practices

Cal-IPC – California Invasive Plant Council

CDFA – California Department of Food and Agriculture

EDRR – Early Detection Rapid Response

GIS – Geographic Information System

MCP – Marin County Parks and Open Space District

MMWD – Marin Municipal Water District

NPS – National Park Service

WHIPPET – Weed Heuristics: Invasive Population Prioritization for Eradication Tool

GLOSSARY OF TERMS

Calflora Database – A public database with a subscription system which enables organizations engaged in land management to track weed infestations and treatments over time. Data from this report are collected and stored in the Calflora Database.

Calflora group – A subset of users and data pertaining to a specific agency's jurisdiction in this case.

Calflora history stack – Refers to a set of records describing a specific area of a mapped weed species through time.

Calflora record – Refers to a unique plant observation in the Calflora Database. A record is a collection of data for a specific species at a specific point in time.

Cal-IPC Inventory – The Cal-IPC Inventory is a categorization of invasive plants that threaten California's natural areas based on an assessment of the ecological impacts of each plant.

High: Species that have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure.

Moderate: Species that have substantial and apparent (but not severe) ecological impacts on physical processes, plant and animal communities, and vegetation structure.

Limited: Species that are invasive, but whose ecological impacts are minor on a statewide level or there was not enough information to justify a higher score.

Patch – In the WHIPPET prioritization, a patch refers to the original observation data, which has some limitations and often overlaps. The typical mapping standard in the region is a 20-meter inter-patch distance.

Population – In the WHIPPET prioritization, a population refers to the patch level observation data that was buffered by 30 meters and dissolved into larger areas more closely representing species populations.

Primary survey – The initial EDRR survey of the One Tam road and trail network is referred to as the primary survey in this report. Surveyors collected this data from 2014 to 2018. The primary survey provides One Tam with a baseline weed assessment for the 23 Priority One species, as well as enhanced information about the 39 Priority Two species.

Priority One species – A true early detection species in the Mt. Tamalpais region. These 23 taxa occur only in low numbers or not at all.

Priority Two species – Widespread weeds mapped as part of the early detection protocol to catch new populations. These 39 taxa are part of existing management goals.

Region – The region in this paper refers to the 52,000-acre area of focus for the One Tam collaborative. It is also referred to as the Mt. Tamalpais region.

State Parks – Herein, this refers to Mt. Tamalpais State Park.

Surveillance – Continued monitoring of a population with no aboveground plants. Five years of surveillance may indicate extirpation, depending on the species history at the site and seed life or reproductive strategy.

INTRODUCTION

Invasive species, broadly defined, are those that are non-native to an area or ecosystem and cause environmental harm, economic harm, or harm to human health (Executive Order 13112, Feb. 1999). Widely recognized as stressors of natural habitats (Simberloff et al. 2008), invasive species are implicated in native biodiversity loss, ecosystem dysfunction, and fuel buildup, as well as degradations to recreational access and property values. In 2006, the California Invasive Plant Council found that control costs for invasive plants exceeded $82 million in California annually (California Invasive Plant Council 2006). More recently, a report from Washington found that "without prevention and control, invasive species could have a total impact of $1.3 billion dollars annually" in that state (Community Attributes, Inc. 2017). Conservation and stewardship programs often emphasize the removal of invasive plants—by addressing infestations, land managers protect the iconic characteristics of California wildlands and increase the resilience of native species and ecosystems to the impacts of climate change (California Department of Fish and Wildlife 2015).

While many widespread invasive plant species have already made an indelible mark on California, the trend in invasive plant management toward an Early Detection Rapid Response (EDRR) model aims to prevent new introductions from becoming widespread. EDRR enables the discovery of incipient patches of invasive plants—and the quick implementation of management actions—through a system of surveying for likely species in areas prone to invasion. These areas include roads, trails, visitor use areas such as parking lots and campgrounds, and employee use areas including offices and tool sheds. Areas impacted by construction, maintenance, or restoration also require surveying for new invasive plants. Repeated disturbance, the introduction of new soil or plant material, and the movement of people, vehicles, pets, or livestock make these areas common points of entry and establishment for new plant species. When paired with a robust invasive species prevention program, EDRR proves a cost-effective approach to invasive species management (Kaiser and Burnett 2010).

By focusing on the early side of the invasion curve (Figure 1), One Tam positions its invasive plant management programs for success. While public land managers must address widespread weeds to protect natural resources, commodities, and visitor access, the movement towards early detection and prevention strategies offers the most hope as land management costs escalate and traditional tools come into question over emissions or exposure levels.

PURPOSE

This report synthesizes findings from early detection data collection efforts on Mt. Tamalpais in Marin County, California, from 2014 to 2018. Data collection methods and results are presented here, as well as deeper analysis in the discussion section, including investigations of species distributions and survey and treatment effort. Strategies for addressing detections of widespread weeds found during the course of EDRR appear in Appendix C.

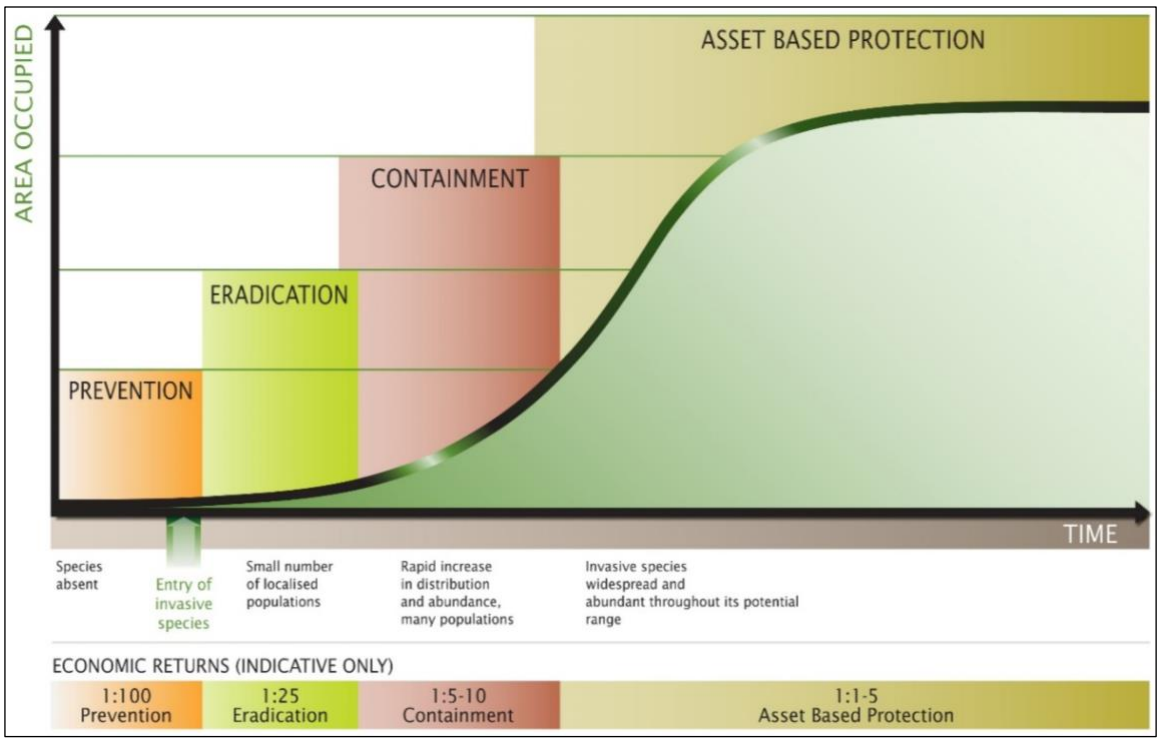

Figure 1. Generalized invasion curve showing actions appropriate to each stage (Agriculture Victoria 2017).

SETTING

Situated north of San Francisco in Marin County, California, the public lands of Mt. Tamalpais cover nearly 40,000 acres. With over 750 native plant species and 250 native animal species, Mt. Tamalpais is a critical refuge for biodiversity in the San Francisco Bay Area. Habitats present on the mountain include towering coast redwood forests, sweeping grasslands, rare serpentine barrens and chaparral, as well as thousands of acres of oak woodland, mixed hardwoods, coniferous forests, riparian systems, wet meadows, and marshlands.

THE **MT. TAMALPAIS REGION** DESCRIBES THE 53,000-ACRE FOCUS AREA OF ONE TAM, WHICH CONTAINS APPROXIMATELY 40,000 ACRES OF PUBLIC OPEN SPACE MANAGED BY THE PARTNERS OF THE COLLABORATIVE.

Through the One Tam collaborative, four agencies manage Mt. Tamalpais in partnership with the non-profit Golden Gate National Parks Conservancy (Figure 2). The National Park Service stewards approximately 8,600 acres in the Golden Gate National Recreation Area and Muir Woods National Monument. The California Department of Parks and Recreation (State Parks) manages approximately 6,400 acres of Mount Tamalpais State Park, which surrounds Muir Woods and reaches the mountain's highest peak. The Marin Municipal Water District (MMWD) provides drinking water to residents and businesses from an 18,800-acre watershed ranging from south of the peak to several miles north. The Marin County Open Space District manages approximately 5,600 acres in several preserves along the eastern and northern edges of these larger land holdings.

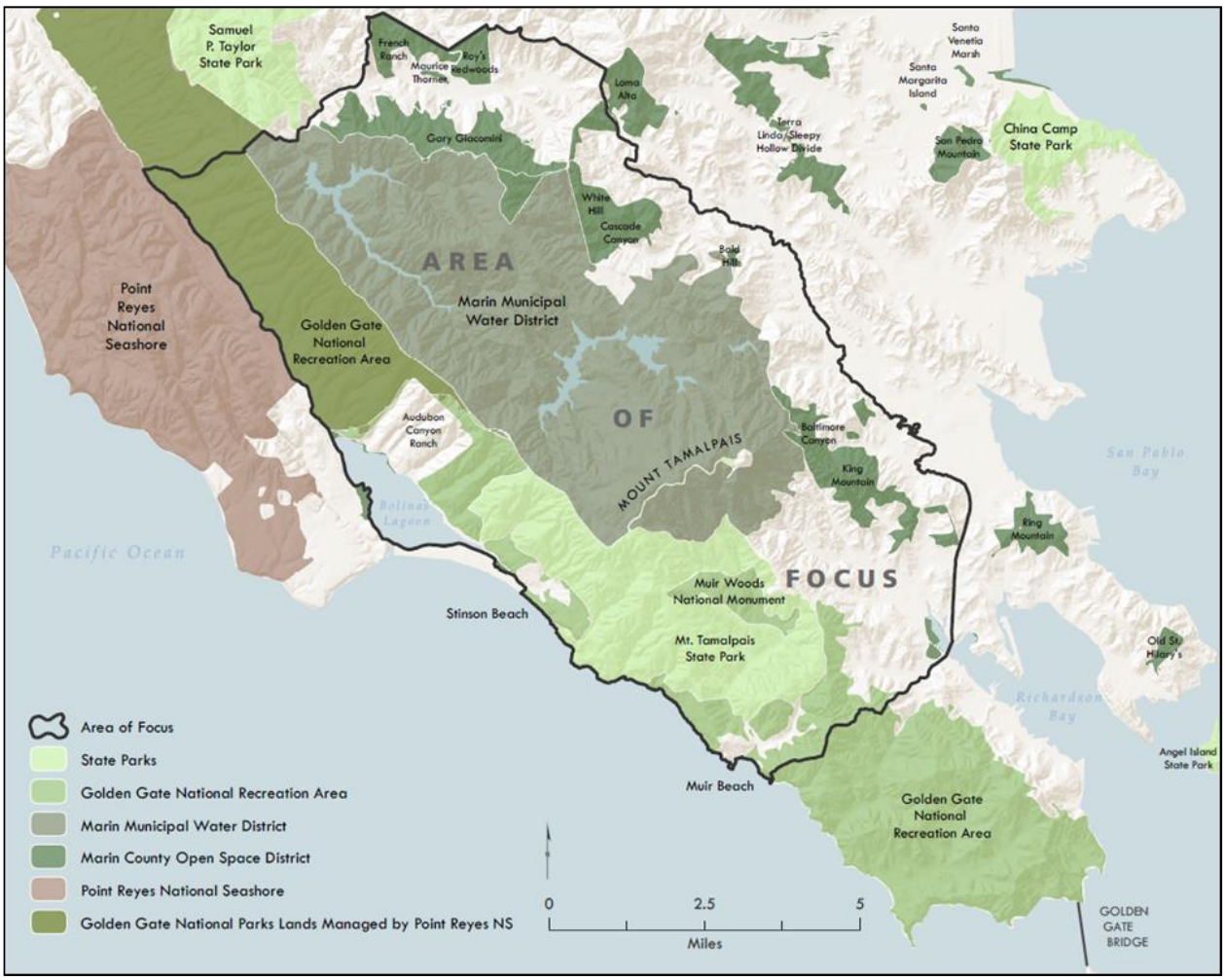

Figure 2. Four public agencies and a non-profit steward the lands of Mt. Tamalpais in Marin County, California. Together they form the One Tam collaborative. The Area of Focus in this map is also referred to as the Mt. Tamalpais region.

Each One Tam agency manages invasive plants to benefit species diversity, ecosystem function, visitor access, and fuels reduction. Significant investments are made to control invasive plants throughout the region. These efforts pre-date the One Tam collaborative. The partners identified invasive plant management as an early area for collaboration following the formation of One Tam. By partnering up, the agencies are able to apply a regional understanding of species distributions to management actions, with the intention of improving efficiency and control over time.

Invasive plant populations often spill from one agency's land onto the next, creating a need for coordinated management. One Tam partners actively address invasive plants through a collaborative EDRR program and agency-driven invasive plant management programs. The collaborative EDRR program began field surveys in 2016, though some partners had existing programs prior to the collaborative. The National Park Service (NPS) and Marin County Open Space District (MCP) have well-established EDRR programs, while State Parks and MMWD lack the internal capacity to perform early detection surveys. By hiring a team of ecologists through the Golden Gate National Parks Conservancy, the collaborative is able to fill the gaps and survey the entire road

and trail network of the Mt. Tamalpais region. Just as land management challenges extend beyond the boundaries of each agency, the skills and working relationships of partner staff have value beyond Mt. Tamalpais. Cross-jurisdictional work does not completely stop at the One Tam boundary drawn around the focus area. One Tam's collaborative model enables EDRR staff to perform high-priority riparian surveys in nearby Lagunitas Creek—a salmonid-bearing stream threatened by the invasive Japanese knotweed—despite its lying outside the Mt. Tamalpais region. The data collected through these efforts beyond the region proper are not presented here, except when they inform the prioritization scheme in Appendix C.

Since the initiation of the collaborative EDRR program in 2016, One Tam has aimed to

- identify priority invasive species at cost-efficient stages for treatment,
- treat high-priority patches,
- and share data across jurisdictions to facilitate prioritization of future work.

The guiding tenet of the program is to provide comprehensive EDRR service across the Mt. Tamalpais region.

This work requires consistency in data collection standards, but it does not require identical staffing structures or protocols. For example, NPS and MCP EDRR teams range far beyond Mt. Tamalpais and typically survey for more species than the Parks Conservancy EDRR team. Data collection attributes overlap sufficiently to allow for the analysis presented in this report, though some teams collect additional information. The One Tam protocol builds on shared management priorities and helps to unite partners around realistic and achievable goals for invasive plant management.

In addition to sharing data across agency jurisdictions within the collaborative, One Tam recognizes the importance of publishing data to a wider audience. This is primarily facilitated using the publicly accessible Calflora Database as the central repository for data storage. Calflora's Weed Manager system allows agencies to record detailed treatment and assessment data while showing subsets of information to public users. Other end-users include the Marin-Sonoma Weed Management Area and adjacent landowners, as well as researchers and the interested public.

METHODS AND PROGRAM DESIGN

One Tam agencies have well-developed policy documents to guide vegetation management. Within those existing frameworks, agency vegetation ecologists and environmental scientists develop collaborative goals within a One Tam body known as the Science Working Group, which also has participation from agency wildlife ecologists. An early iteration of this working group led the initial development of the collaborative EDRR program, and later formed an Early Detection Subgroup to refine the program over time.

With regional invasive plant management leaders on board from the outset of the program, One Tam developed a collaborative protocol to fit the needs of all partners. In 2016, One Tam's Conservation Management program piloted a protocol based on the NPS EDRR standards (Williams et al. 2009). The team formalized its protocol with notable deviations from NPS on the species list and using staff rather than volunteers. Staffing models vary slightly among the agencies (Figure 3).

STAFFING FOR EDRR SURVEYS

NPS: One permanent lead and one 10-month intern
MCP: One nine-month seasonal technician
Redwood Creek Collaborative: One restoration technician for three weeks
Parks Conservancy: Two permanent staff and two six-month seasonal technicians

Figure 3. Staffing models vary across EDRR teams.

Three components are key to any EDRR protocol:

- Species list
- Survey geography
- Mapping standards

SPECIES LIST

In the planning phase for the One Tam EDRR program, the Science Working Group vetted a list of 200 invasive plants found in or near Marin County. Of that total, managers selected species that at least one agency would actively manage if detected. The group settled on a target list of 60 species, sorted into two ranks—Priority One and Priority Two (Appendix A). Over the following years, evolving priorities led the group to take one species off the list while adding three others, for a total of 62 species at the time of this writing. Formal review of the list occurs on a three-year cycle. Emergency additions can be added outside of the review cycle as needed.

The Science Working Group found quick consensus when creating the Priority One list, which includes highly invasive species

- with few populations and low gross area in the Mt. Tamalpais region, or
- not known on Mt. Tamalpais but found nearby in Marin or neighboring counties.

Several Priority One species were known to be invasive in nearby counties with similar habitat types as Mt. Tamalpais, indicating a need for vigilance. Finding and promptly managing the 23 species on the Priority One list was the primary goal of the One Tam EDRR program.

PRIORITY ONE: SPECIES ASSUMED TO BE NEW TO THE MT. TAMALPAIS REGION AND SMALL IN GROSS AREA, OR ABSENT BUT LIKELY TO BE INTRODUCED.

The resources invested in training surveyors for plant identification and months of field time presented an opportunity to collect important data on a separate group of more widespread weed species. While these species could not be considered new threats to Mt. Tamalpais, augmented data and detection of unknown small patches were of interest to agency ecologists. This Priority Two list includes 39 widely distributed invasive species management targets. The team only included widespread weeds that at least one agency would manage in the mapping effort. While there are extensive opportunities for invasive plant management on most public lands, this realistic approach rendered a manageable list of species to survey.

PRIORITY TWO: WIDESPREAD WEED SPECIES MAPPED DURING THE COURSE OF EDRR SURVEYS. AT LEAST ONE AGENCY WOULD TREAT THESE SPECIES, IF DETECTED.

For many areas on Mt. Tamalpais, the initial EDRR survey effort was the first chance to map the species list in detail. In other areas, restoration teams had already collected years of assessment and treatment data. All existing distribution data is presented together in this analysis to provide a comprehensive picture of weed distributions.

The collaborative set a goal to treat every population of Priority One species detected in the Mt. Tamalpais region. Meanwhile, new detections of Priority Two species are vetted by vegetation management leads for integration into existing work plans as is feasible.

GEOGRAPHY

In alignment with NPS and MCP EDRR programs, the One Tam collaborative aimed to survey the entire road and trail network of the Mt. Tamalpais region. The roads and trails shown in Figure 4 are the routes the collaborative aims to survey on a three-year cycle. Early in this effort, teams focused surveys on areas of high public or staff visitation and high ecological value. Prioritizing these time-intensive, weedy stretches left a backlog of trails with minimal weeds to survey in 2018. Future three-year cycles will institute a more balanced spread, which will allow for more predictability around the time required for surveying and data management.

As the team gained experience, it added infrastructure areas to the survey work plan, including picnic areas, campgrounds, parking lots, water tanks, dam faces, and buildings. NPS, with a robust in-house EDRR program in place, directed the added capacity of the Parks Conservancy team toward riparian corridors. Thus, on NPS lands, the team surveyed creeks and gulches in addition to a limited subset of roads and trails.

Road and trail survey structure varied slightly by work group. The Parks Conservancy EDRR team used two surveyors with one person looking on each side of the trail. Some teams used only one surveyor covering both sides. Routes were often completed as loops or through-hikes, though parking logistics required many out-and-back surveys. Out-and-backs allowed a surveyor to see vegetation from more than one vantage point, often revealing hidden occurrences. Time limitations prohibited staff from doing out-and-backs on every route. When feasible, staff performed repeat surveys from the opposite direction of the original survey. To document survey area, surveyors ran

tracklogs on GPS devices, which were imported into ArcGIS for quality control and analysis.

Staff repeat some roads or trails in the same year, based on several factors. Marin County Parks surveys their roads and trails twice in a year to ensure that staff have multiple opportunities to detect species. Given additional resources, repeating all roads and trails would be ideal for all EDRR teams. Some exceptions could be made for trails with no detections, particularly non-system trails.

Detectability varies by species and time of year. Most surveys took place from March to September. While managers staggered surveys according to habitat—forests in early to mid-spring, grasslands in late spring and early summer, riparian systems in summer—repeat surveys presented a more thorough approach. The Parks Conservancy team prioritized repeats on MCP lands, early season forest surveys, and surveys known to have high priority weeds or those with variable detectability windows.

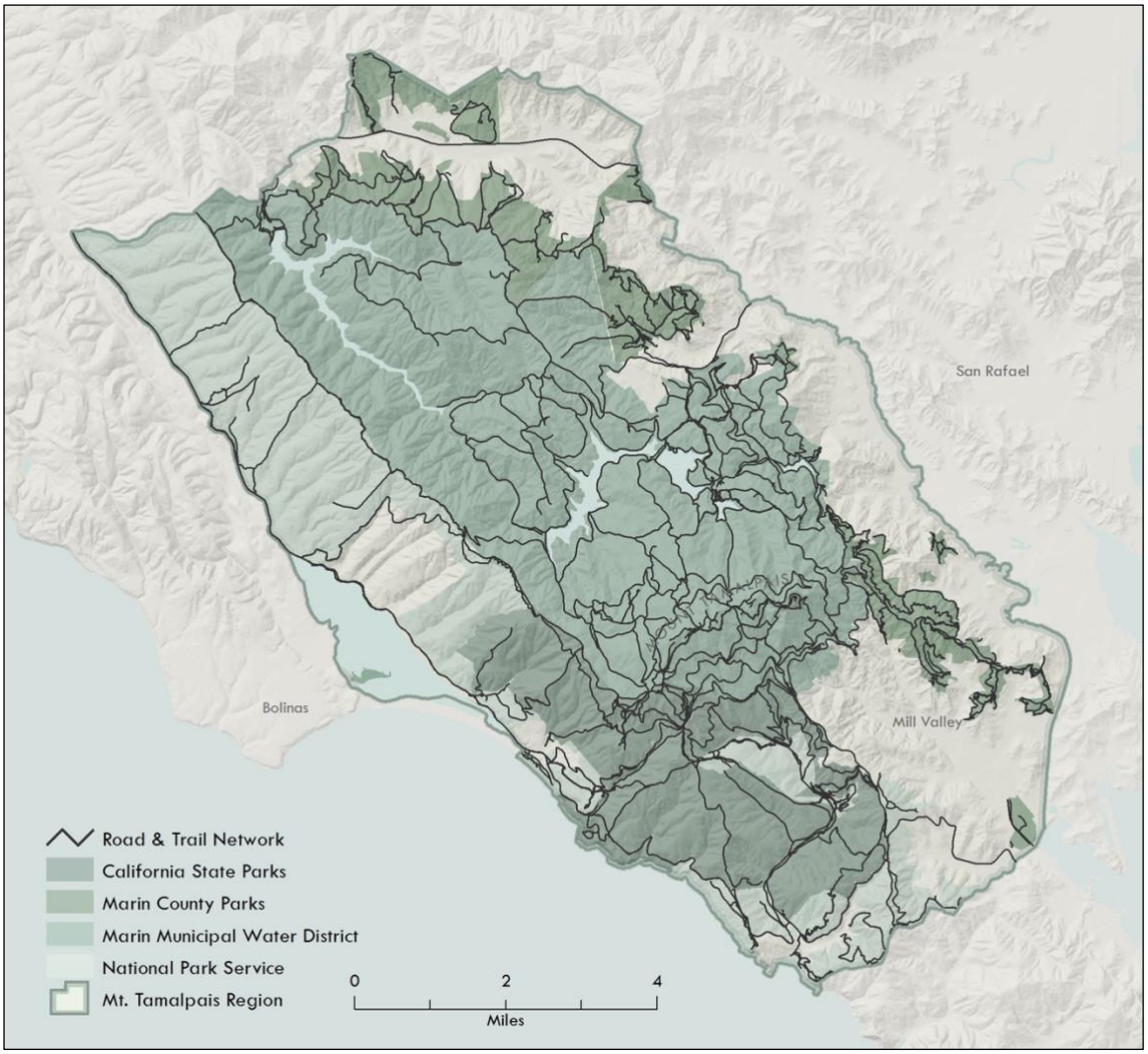

Figure 4. The road and trail network in the Mt. Tamalpais region.

Traversing 40,000 acres required significant travel time. For the Parks Conservancy team that covers the entire region, the ability to start and end work in a variety of locations allowed for critical efficiency. Staff carefully planned routes with phenology and logistics in mind, but some driving redundancy and overlap proved unavoidable. The team tracked travel time on their MMWD surveys in Calflora as a representative subset of the total effort. Time for surveys was measured from the time the survey team parked to when they drove away. This time included brushing boots and tools after the survey.

MAPPING STANDARDS

In order to compare data collected by several teams over several years, the creation of mapping standards was critical to the formation of the One Tam EDRR program. The team developed reporting metrics as goals for the program, and worked backwards from those to coordinate data collection forms and standards. By aligning attribute information and other protocol elements, One Tam ensured sufficient data compatibility to support the analysis presented here.

Surveyors mapped all detections of Priority One species with polygons around each patch. For any patch of a Priority Two species over 100 square meters, surveyors took a point with a radius, which was later converted to a polygon by the Calflora system. Because these points with radii were often incomplete representations, a standardized note was added to the record, stating "Point or polygon does not represent full population." This prevented misinterpretation by data consumers who were not familiar with the populations themselves. The protocol employed a minimum mapping unit of 1 square meter and an inter-patch distance of 20 meters (Figure 5).

While spatial data for species locations provided critical information, the characteristics of invasive plant populations also factor into management decisions. Data attributes included biological characteristics and labor effort information. A full list of data collection fields and domains is found in Appendix F.

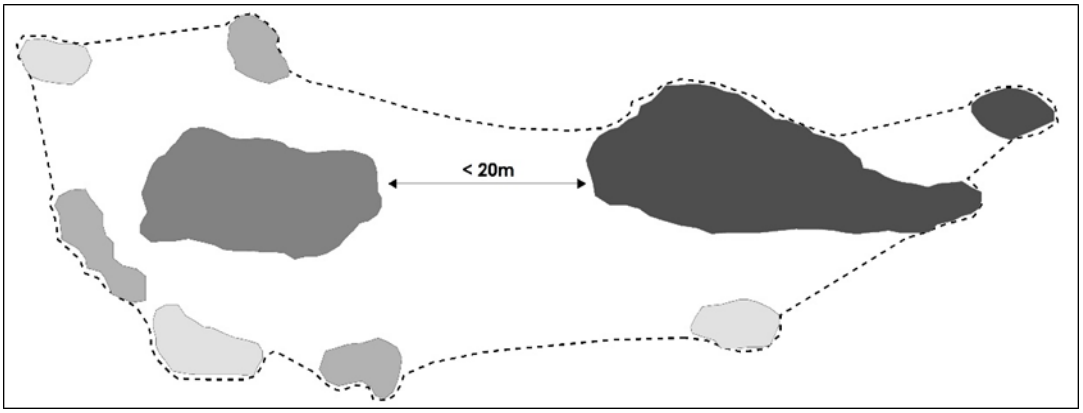

Figure 5. Patches of the same species within 20 meters of each other are mapped together as a single polygon (dotted line), despite differences in density. Adapted from Williams et al. 2009.

DATA COLLECTION

Data was collected in the field using the Calflora Database (Calflora) mobile application, Observer Pro. Data was stored in the cloud-based Weed Manager system, a subscription service of Calflora. Staff performed quality control checks on each record before making the data public and viewable by agency staff.

All data collection efforts require a balance between office time and field time. The Parks Conservancy EDRR team ensured the delivery of high-quality data by maintaining a ratio of 4:1 for field to office time. One office day per week allowed for upkeep on many crucial tasks, including logistical planning, data preparation, and tool and gear maintenance. Staff spent a significant amount of time performing quality control checks on data before making it publicly available on calflora.org.

DATA ANALYSIS

Most data analysis in this report required exporting spatial data from Calflora. After exporting, points and lines were buffered to their radii to generate polygons using ArcGIS. Point and line records which lacked a radius were assigned a value of 1 square meter for gross area if one or more plants were noted in the attribute data. Another GIS exercise dissolved overlapping polygons of the same species to determine gross area and number of patches.

Treatment statistics were calculated by taking the acreage of treatment records from 2017-2020 as a percentage of gross acreage, both overall and by species. Treatment records logged prior to 2017 were excluded because invasive species patches require a follow-up regime to be considered under management.

Time data were also stored in Calflora. Custom reports within that system were used to generate some time statistics for this report. Other time statistics were calculated in Microsoft Excel. The Parks Conservancy EDRR team tracked travel time and data management hours for MMWD surveys. That data is presented here as a representative subset of the total effort.

PREVENTION

Because surveyors routinely interact with high-priority weeds, One Tam EDRR teams implemented best management practices around the potential spread of seeds, propagules, and pathogens. The team employed rigorous hygiene protocols for cleaning boots, equipment, and vehicles at regular intervals. These protocols draw from the expertise and guidance of science-based organizations including the California Invasive Plant Council (2012). Furthermore, the timing of treatments and disposal of material always integrated prevention practices. While putting new invasive species biomass into plastic bags for disposal into landfills may seem unsustainable at face value, early and comprehensive intervention can prevent the need for a decade of return trips in motor vehicles and the use of heavier-handed tools and techniques with their own impacts.

WHAT-TO-TREAT CHEAT SHEET

DO TREAT IF

- Patch <100m2,
- AND is at least 20m from another patch of the same species,
- AND the treatment can be completed in 10 minutes,
- AND the amount of weeds to carry away is manageable.

DO NOT TREAT IF

- Patch >100m2,
- OR patch <100m2 but near more patches of same species,
  - For example, if you find a 1 square meter patch of *Ehrharta erecta* every 21m, it is not feasible to treat
- OR patch requires >10 minutes to remove,
- OR amount of plant biomass that must be hauled away is prohibitive.

EXCEPTIONS

- For Priority One species, it may be prudent to push these numerical boundaries. If you find a Priority One patch that will take 30 minutes to remove but it's ready to seed and it is unlikely anyone else will be able to treat it in time, initiate treatment.
- It's sometimes justifiable to treat just a portion of a large patch of a Priority One species, such as to push the patch edge out of a creek or trail corridor.

WHEN-TO-BAG GUIDELINES

- Plants with reproductive propagules should be bagged.
- Many grasses and asters can mature to reproductive viability even after being pulled out of the ground. Bag plants from these two families even if they're only flowering.

Figure 6. Parks Conservancy staff use a cheat sheet to decide what patches to treat during surveys.

As the One Tam collaborative worked to prevent the spread of invasive plants, it thoughtfully implemented and propagated a culture of prevention. Through simple but thorough hygiene efforts, workers reduced their potential to be vectors themselves. Additional strategies include the following:

- Work and travel 'clean to weedy'
- Work on outliers first—both in the season and in the workday
- Start clean, end clean
- Source certified weed-free mulch

TREATMENT

While some early detection teams within the collaborative separate monitoring from treatment, the Parks Conservancy and MCP teams performed treatments during surveys. Treatments implemented during surveys required good judgment about which patches to target. To make these decisions, staff started with a 10-minute rule of thumb: if treatment would take longer than 10 minutes, the patch was left untreated. For help with these judgment calls, Parks Conservancy staff developed a cheat sheet (Figure 6).

Parks Conservancy EDRR staff also performed treatments on days dedicated to management rather than surveys. Most of those treatment days address Priority One species. The team built regular time into its schedule for rapid response to new Priority One detections. If no new detections of Priority One species occurred, staff folded in on agency-led treatment of Priority Two species. Maintaining rapid response capacity was a critical component to overall success of the program.

Staffing resources can fluctuate at most organizations, sometimes abruptly. Partnership was a key element of the success of the EDRR effort. With the ability to work across jurisdictional boundaries, the Parks Conservancy team could move to areas lacking resources, particularly for rapid response. Similarly, partners stepped up to help each other by allocating staff and contractors to the effort when treatment needs exceeded the Parks Conservancy team capacity (Figure 7).

STAFFING FOR INVASIVE PLANT TREATMENT

MMWD: Program lead, volunteer coordinator, three seasonal aides, several contractors, volunteers

MCP: Program lead, six seasonal technicians, volunteer coordinator, volunteers, contractors

NPS: Habitat Restoration Team with two program leads, two interns, contractors, volunteers

Redwood Creek Collaborative: Program lead, crew lead, three technicians, contractors

State Parks: Program lead, field lead, several contractors, volunteers

Parks Conservancy: Three program leads, two seasonal staff, two volunteer coordinators, six interns, volunteers

Figure 7. Staffing models vary across treatment teams.

RESULTS

SPECIES DETECTED

At the outset of the collaborative EDRR effort, 15 Priority One species were known to occur within the Mt. Tamalpais region (Table 1). Many of these occurrences were single locations along Highway 1, documented by the NPS early detection team or the NPS Habitat Restoration Team. During the primary survey, teams detected the first populations of *Bromus tectorum* and *Elymus caput-medusae*. Six species remain undetected by surveyors on public lands in the Mt. Tamalpais region to date.

INVASIVE PLANT POPULATIONS

Priority One species occupy 724 patches across 61 gross acres in the Mt. Tamalpais region. *Clematis vitalba* and *Bromus tectorum* comprise 26.7 acres or 44% of this total. Species population areas range from 0.00025 acres (*Stipa tenuissima*) to 6.2 acres (*Bromus tectorum*). The mode for patch area for all species is 0.00025 acres (1 square meter). Net area of Priority One species totaled 8.04 acres.

Species	Patches	Gross Acres	Known prior to 2016	Detected since 2016
Aegilops triuncialis	41	6.25	X	X
Ailanthus altissima	0	0		
Albizia lophantha	0	0		
Arctotheca calendula	0	0		
Brachypodium sylvaticum	0	0		
Bromus tectorum	45	13.43		X
Buddleja davidii	1	< 0.01	X	
Carex pendula	106	1.42	X	X
Centaurea calcitrapa	95	2.60	X	X
Clematis vitalba	225	13.27	X	X
Cytisus striatus	1	< 0.01	X	
Dittrichia graveolens	100	8.64	X	X
Elymus caput-medusae	22	2.80		X
Fallopia japonica	0	0		
Hypericum grandifolium	9	0.92	X	X
Iris pseudacorus	17	0.61	X	X
Maytenus boaria	5	5.57	X	
Sesbania punicea	0	0		
Solanum aviculare	34	0.59	X	X
Stipa manicata	8	5.00	X	X
Stipa miliacea	12	0.06	X	X
Stipa tenuissima	1	< 0.01	X	X
Ulex europaeus	2	0.15	X	

Table 1. Priority One detections in the Mt. Tamalpais region on partner land.

The 39 widespread weeds on the Priority Two list cover 5,932 gross acres in the Mount Tamalpais region. Combined with the Priority One species, the total mapped acreage of Priority One and Priority Two species reaches 5,993 gross acres. Priority One species comprise 1% of this total. French broom acreage reaches 3,710 gross acres, or 63% of total weed acres (Figure 8).

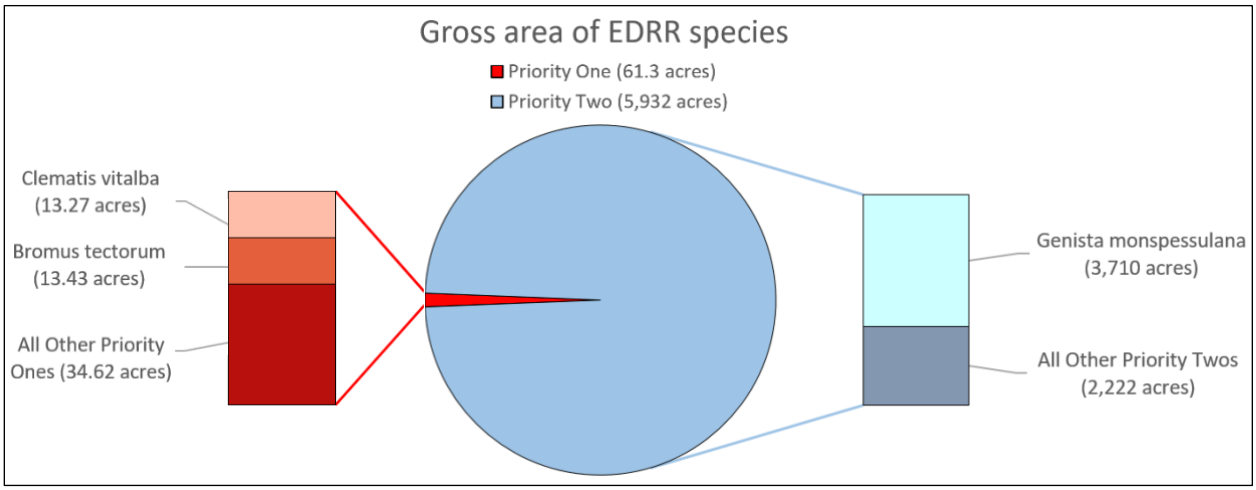

Figure 8. Gross area breakdown of EDRR species.

PRIORITY ONE SPECIES CONSTITUTE JUST 1% OF TOTAL WEED AREA IN THE MT. TAMALPAIS REGION, INDICATING THAT THESE SPECIES ARE MEANINGFUL EARLY DETECTION TARGETS.

MILES SURVEYED

EDRR teams surveyed a total of 462 miles of roads and trails in the Mt Tamalpais region from 2014 to 2018. This mileage includes repeated segments of some roads and trails—172 miles were repeated during the survey. The team also surveyed 28 miles of creeks and drainages, all on state and federal parklands.

SURVEY LABOR EFFORT

The EDRR survey of 462 road and trail miles required approximately 1,550 hours of on-the-ground survey effort. Parks Conservancy staff completed 1,372 hours of this total.

TREATMENT LABOR EFFORT

Staff, contractors, and volunteers spent 782 hours treating Priority One Species in 2019 in contrast with over 12,000 hours treating Priority Two species. More treatment hours are spent on Priority Two species because they inhabit far more acreage than Priority Ones.

DISCUSSION

The primary survey of the road and trail network occurred from 2014 through 2018 (Figure 9). National Park Service and Marin County Parks teams surveyed in 2014 and 2015, while the Parks Conservancy team formed in 2016. Redwood Creek staff performed surveys in 2018. In future years, the full survey of the network will occur every three years.

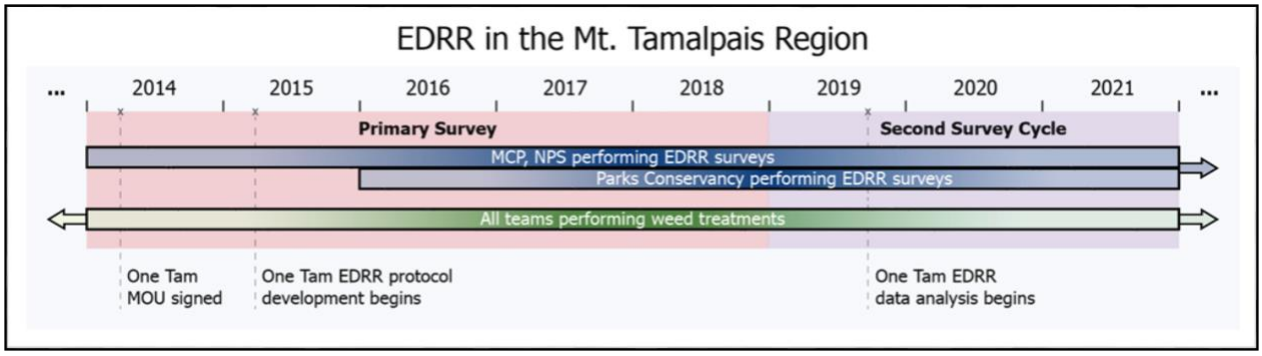

Figure 9. EDRR timeline in the Mt. Tamalpais region.

PRIMARY SURVEY: THE INITIAL MAPPING OF THE ONE TAM ROAD AND TRAIL NETWORK IS REFERRED TO AS THE PRIMARY SURVEY IN THIS REPORT. SURVEYORS COLLECTED THIS DATA FROM 2014 TO 2018. THE PRIMARY SURVEY PROVIDES ONE TAM WITH A BASELINE ASSESSMENT FOR THE 23 PRIORITY ONE SPECIES, AS WELL AS ENHANCED INFORMATION ABOUT 39 PRIORITY TWO SPECIES.

POPULATIONS

Priority One species occur in 724 patches over 61.32 gross acres in the Mt. Tamalpais region. Mean patch size is 0.09 gross acres. Several species—*Bromus tectorum, Clematis vitalba, Maytenus boaria,* and *Stipa manicata*—have a single large patch skewing mean patch size upward. Ten of the 16 Priority One species detected have a maximum patch size of less than 1 gross acre (Appendix B).

While most species on the Priority One list have few populations and a small gross area within the region, a handful were found to be more widespread than expected. *Clematis vitalba* was known to occur along Redwood Creek prior to the primary survey. Mapping by early detection surveyors and treatment crews shows that this species occurs over approximately 13 gross acres. This indicates that the species was not detected early in the invasion curve, but is fairly well established. On the other hand, the species makes an excellent Priority One target in all other creeks and drainages within the region, where it remains undetected to date.

Bromus tectorum presents another challenge to the concept of a Priority One species. Surveryors have mapped over 13 gross acres of this species. The distribution and gross acreage of *Bromus tectorum* indicate that the species has been on Mount Tamalpais for many years. Similarly, *Aegilops triuncialis* occupies over six gross acres in several patches, from East Peak to West Ridgecrest Boulevard to Carson Ridge. This distribution and total gross area indicate that the species is well-established. All populations of both species are under management, as is consistent with goals for Priority One species.

An early detection species list created at a landscape scale is not always functional at a smaller scale, such as by watershed or by work site. The One Tam list appears to function well for the Mt. Tamalpais region, though it is clear that some Priority One species can no longer be considered early detections at the landscape scale.

THE WATCHLIST

Surveyors have yet to detect several species on the Priority One list: *Ailanthus altissima, Albizia lophantha, Arctotheca calendula, Brachypodium sylvaticum,* and *Sesbania punicea*. *Fallopia japonica* occurs within the Mt. Tamalpais region on private land, and just outside the region on public land. By keeping these species on the list, Parks Conservancy surveyors ensure strive to not let incipient patches go overlooked.

DATASET

There are over 15,000 distinctly mapped patches of weeds in the Calflora dataset for Priority Two species. Significant gaps in data management are revealed by this data analysis. Calflora offers a technique known as history stacking through which records of a species mapped repeatedly in a location can be linked over time. This should allow for easier data analysis. A GIS exercise to dissolve overlapping polygons (including points and lines buffered by their radii) of the same species indicates that the number of history stacks should be closer to 11,000 than 15,000. These same challenges prevent the calculation of net acreage for Priority Two species.

The challenge of annual grasses – Bromus tectorum and Aegilops triuncialis

Bromus tectorum in Mount Tamalpais State Park. Photo: Josh Nuzzo/One Tam

Aegilops triuncialis (barbed goatgrass) and *Bromus tectorum* (cheatgrass) have been known to occur in Marin County for decades, but were added to the Priority One list because of their scarcity in the Mt. Tamalpais region. One Tam land managers knew of barbed goatgrass patches on the mountain, but cheatgrass was initially added as a watchlist plant.

The addition paid off—early in the 2016 survey season, Parks Conservancy staff detected cheatgrass for the first time at a heavily disturbed MMWD site near West Peak. Soon thereafter, the team spotted an infestation on State Parks land at Forbes Bench. New patches have been detected every year since. Barbed goatgrass can also lurk undetected. Staff spotted one new patch while driving along Bolinas-Fairfax Road—one of the mountain's most trafficked routes.

Managing annual grasses presents a formidable challenge to land managers. Cheatgrass is exceptionally difficult to identify before it flowers, and barbed goatgrass blends in with its surroundings seamlessly. In warm conditions, cheatgrass can progress from flower to fruit in one week. Seeds of both species are highly mobile and easily shatter from dry florets when handled. Low detectability, seed mobility, and a narrow treatment window frustrate efforts to curb the spread of these two Priority One plants.

An extra word of caution is warranted for cheatgrass in particular. In 2017, a single cheatgrass plant appeared in a rutted trail bed infested with barbed goatgrass. Because the One Tam team had mowed both species in various sites the year prior, they assume they accidentally moved the seed on their mowers or clothing from one site to the other. This movement occurred despite copious attention to hygiene for equipment, boots, and clothing. The intrepid seedling was mapped and removed, and the species hasn't been seen at the site since.

MILES SURVEYED

The Mt. Tamalpais region has approximately 290 miles of fire roads and trails on agency land, as well as 48 miles of surface streets (Figure 10). Staff aim to survey these 338 miles of roads and trails every three years (Appendix E).

However, three major roads that run through agency land—Panoramic Highway, Highway 1, and Bolinas-Fairfax Road—are unsafe to survey in most cases because of vehicle traffic. Those segments total 36 miles, which EDRR teams chip away at when the opportunity arises. In 2017, One Tam took advantage of landslide-induced road closures to survey 8 miles of Highway 1. The team also surveys roadside pullouts for weeds as a proxy for the road itself. NPS EDRR teams have also surveyed stretches of Highway 1 and the western reach of Bolinas-Fairfax Road.

Sir Francis Drake Boulevard is not included in these calculations. Some important invasive plant populations occur along this thoroughfare. While the land on either side is

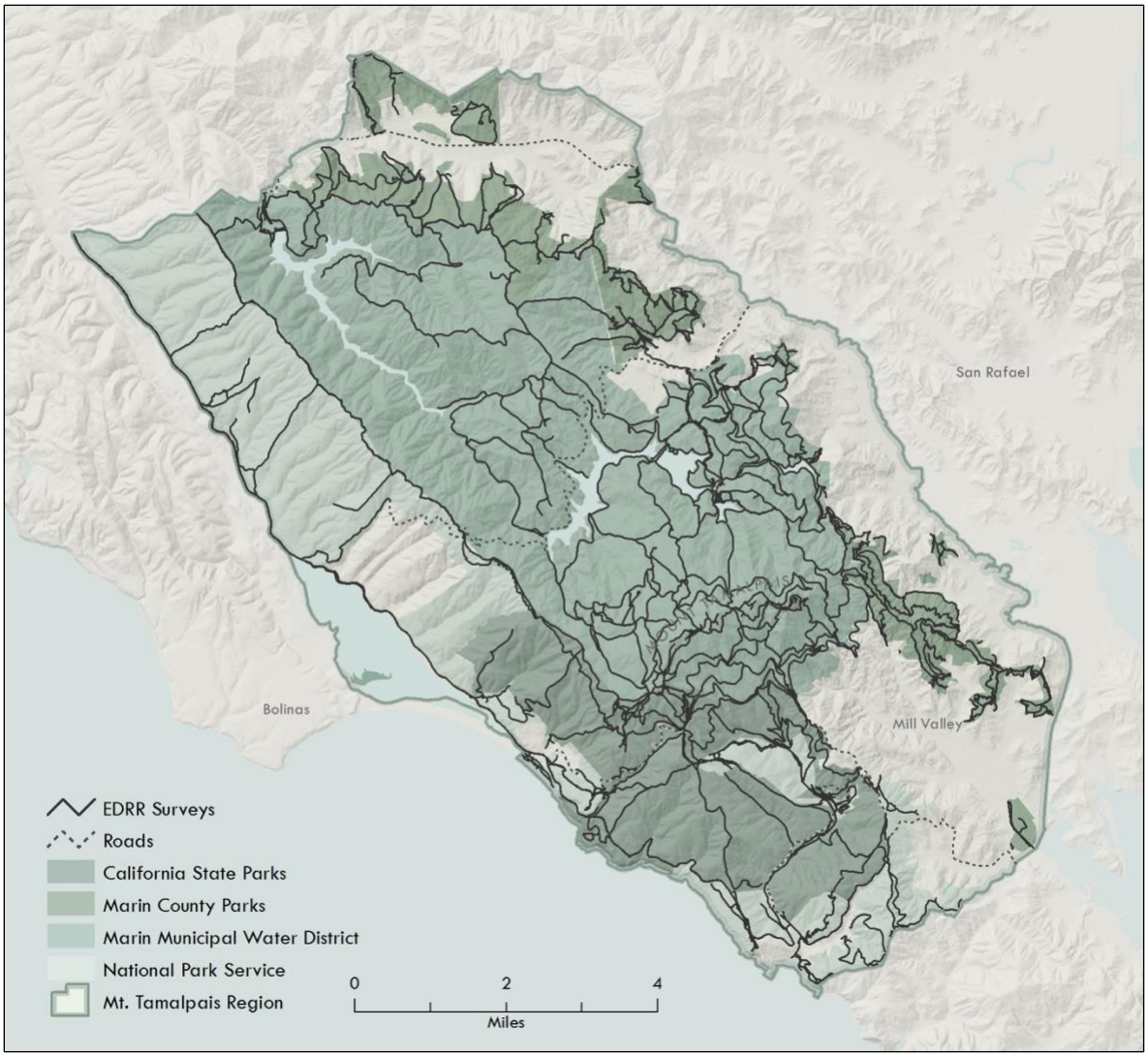

Figure 10: Roads and trails surveyed by agency and Parks Conservancy staff.

not contiguously owned by One Tam partner agencies, some MCP preserves border the road. Paths paralleling the road in these areas have been surveyed—this mileage is included in the analysis.

SURVEY LABOR EFFORT

Four teams survey for early detection species on Mt. Tamalpais. As the teams got to know each other, staff developed collaborative training days between Parks Conservancy, MCP, Redwood Creek, and MMWD surveyors. These trainings provided valuable calibration on data collection standards. While MMWD does not have an early detection survey team, their staff joined the training to inform plant ID and opportunistic mapping. NPS EDRR staff start several weeks later than the other agencies, preventing their inclusion in the collaborative training thus far.

Teams communicate about survey geography in the winter before each survey season. Labor tracking for each team is variable. Most of the information about time and cost comes from the Parks Conservancy EDRR team, which surveys the highest number of miles in the Mt. Tamalpais region each year.

While staff do not track the time invested in onboarding, safety training, or protocol development, existing metrics provide a snapshot of the level of effort required to implement a robust EDRR program. The Parks Conservancy EDRR team spent 5,580 field and office hours on the primary survey.

Parks Conservancy EDRR staff track travel time and data management time on their MMWD surveys in Calflora's Work Session Entry application. The results from MMWD surveys indicate that 1.3 hours of travel time and 1.3 hours of data management time are required for each mile surveyed. This time includes setting up devices for surveys as well as planning survey geography.

The total cost of the Parks Conservancy crew of four staff for the primary survey was approximately $170,000 for wages. This total only accounts for Parks Conservancy staff time from March to mid-August from 2016 through 2018. Like the total number of hours above, the total assumes that three Parks Conservancy staff work approximately half of their hours on early detection surveys, while the manager surveys approximately one third of the total time. The number includes minimal treatments on surveys only. NPS, Redwood Creek, and MCP staff time are not included.

Total cost for rapid response was not fully captured in the Calflora data for the primary survey. At least 1,600 hours were spent on Priority One treatments from 2015 through 2018. Assuming a staff cost of $21/hour, the total cost of Priority One rapid response reaches at least $33,600. These data have gaps for significant species including *Aegilops triuncialis*, which is heavily managed by MMWD, and *Clematis vitalba* by NPS.

Furthermore, this number does not include rapid response to new outlier patches of Priority Two species.

Riparian Challenges – Fallopia japonica

Known as one of the costliest invasive species in the world, *Fallopia japonica* (Japanese knotweed) poses a significant threat to critical salmonid habitat in Marin County. Listed by the California Department of Food and Agriculture as an A-rated weed, Japanese knotweed is a high priority for management throughout the state. County agricultural commissioners have the authority to require treatment with this designation.

Japanese knotweed begins to flower in a stretch of Lagunitas Creek in Mount Tamalpais State Park in 2019. Photo: David Greenberger/One Tam

State Parks and NPS lands along Lagunitas Creek host federally endangered Coho salmon (*Oncorhynchus kisutch*) and federally threatened steelhead trout (*O. mykiss*). The juveniles of these species eat insects that fall off vegetation overhanging the banks of the creek. Japanese knotweed does not host native, coevolved insects, and has the demonstrated ability to displace many of the native herbaceous plants that sprawl over the banks of the creek.

For ecologists charged with managing Lagunitas Creek, the potential for this well-documented invasive to displace native creekside vegetation requires rapid response. While public land managers have undertaken treatment of Japanese knotweed, significant unmanaged portions remain on private lands upstream. In order to engage the community that owns these source populations, One Tam partners have joined forces with the Marin County Agriculture Office, University of California Cooperative Extension, and Marin County Resource Conservation District. Known as the Marin Knotweed Action Team, the partnership's current goal is to eradicate Japanese knotweed from the Lagunitas Creek Watershed. Over 60 private properties allowed treatment of their Japanese knotweed patches in 2019.

Meanwhile, NPS and State Parks completed a third year of survey and treatment on 8 miles of Lagunitas Creek in 2019. Eleven surveyors spent 584 hours (including travel time) on the survey, detecting 1,467 stems across 175 patches. Two contract crews spent three days (approximately $5,400) treating patches found, flagged, and mapped by surveyors. Between 2017 and 2018, NPS staff recorded a 92% reduction in number of stems post-treatment (Bobbi Simpson, pers. comm., Sep. 25, 2019).

RIPARIAN SYSTEMS

Streams act as vectors for invasive plants, sweeping propagules down watersheds. While some trails parallel creeks (Redwood Creek Trail, Cataract Trail, Steep Ravine Trail), many creeks and drainages flow far from the road and trail network. The opportunity to survey a subset of riparian corridors for NPS and State Parks has enriched the dataset by augmenting understanding of species including *Ageratina adenophora, Ehrharta erecta, Hedera* spp. and *Carex pendula*. Absence data for species like *Clematis vitalba* in Mt. Tamalpais drainages outside of Redwood Creek also has value. Many of the species on the Priority One list, including *Fallopia japonica, Clematis vitalba,* and *Sesbania punicea,* would mostly occur in riparian or wetland environments in this region rather than trailside.

Riparian systems introduce significant obstacles to survey work, including complicated terrain, dense vegetation, and increased hazard potential. Thus, these surveys are far

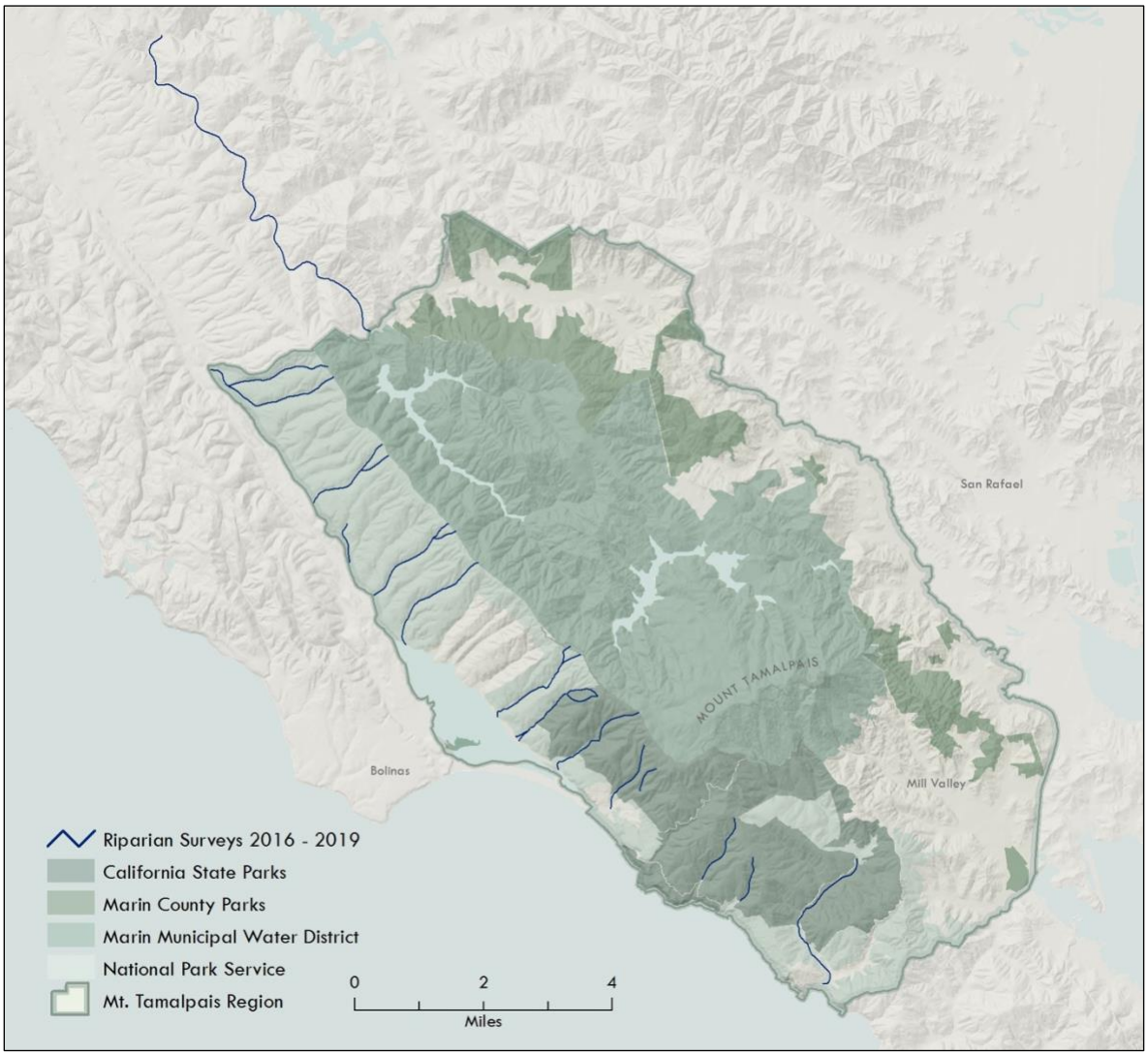

Figure 11: Creeks and drainages surveyed by Parks Conservancy staff.

slower to complete than their road and trail analogs. The team spent 184 hours in drainages to complete 22 miles of riparian surveys off Bolinas Ridge. Total riparian mileage within the region from 2016-2018 comes to 27.7 miles (Figure 11). This effort required 233 hours. In addition to the riparian surveys conducted within the Mt. Tamalpais region, the Parks Conservancy EDRR team surveyed Lagunitas Creek on state and federal parklands just outside the Mt. Tamalpais region to the north.

One Tam has not set a goal for which or how many streams to survey, or a return interval. At present, riparian surveys are largely relegated to NPS lands, with some also performed on State Parks. Unless trails follow creeks on MMWD or MCP lands, riparian areas on those properties remain unsurveyed to date. This leaves a data gap for several Priority One species in the eastern and northern ends of the Mt. Tamalpais region, excepting Lagunitas Creek.

TREATMENT

Priority One Treatments

Priority One treatment data reveal a declining level of required effort year to year for several species, demonstrating that rapid response is having a positive impact. *Solanum aviculare* treatments dropped from 8 hours in 2016 to 3.4 hours in 2019. Along the same lines, *Carex pendula* dropped from 38 hours in 2016 to 8 hours in 2019. Treatment time on *Centaurea calcitrapa* has dropped from a high of 118 hours in 2017 to 8 hours in 2019 with 100% of mapped patches revisited each year. While treatment effort on some species is decreasing, *Aegilops triuncialis* treatment hovers around 240 hours per year. This sustained level of effort suggests that while eradication remains elusive, *A. triuncialis* is somewhat controlled. A deeper dive into the data reveals that at least three new patches were mapped during the primary survey. While the density or area of older patches may be reducing under treatment, the species continues to spread in total dispersion within the region, if limitedly.

Bromus tectorum treatments have escalated from zero hours in 2015 to 375 hours with the discovery of patches near West Peak and Forbes Bench, as well as a 6-acre patch on the eastern edge of MMWD land. New detections of *B. tectorum* have been made into 2019, indicating that this cryptic species may not yet be fully mapped.

As of 2019, several Priority One species remain incompletely treated, despite the goal to treat all patches every year. *Clematis vitalba* (9.95 acres untreated), *Maytenus boaria* (5.55 acres untreated), and *Stipa manicata* (5 acres untreated) require management if that goal is to be met. As of 2019, 57% of Priority One gross acreage is under management.

For species like *Clematis vitalba* and *Bromus tectorum,* treatment costs will continue to rise until all patches are under control. The possibility of eradication for these species wanes with each year that patches go unmanaged. Given that eradication is the stated goal, these species may warrant down-listing over time. It is recommended that staff re-evaluate these two species at the end of the 2021 survey season. If gross acreage continues to climb, the goal should shift from eradication to containment.

Centaurea calcitrapa Management – A Win for Grasslands

The sweeping Ridgecrest grasslands are threatened by starthistle invasion. Photo: Allison Titus/One Tam

A close cousin to the widespread *Centaurea solstitialis* (yellow starthistle), *Centaurea calcitrapa* (purple starthistle) is known for its encroachment from disturbance into grasslands. Initial patches crop up along roads and parking lots along with trailsides where they compromise visitor experience with stiff, calf-high spines. This Priority One species occurs sporadically within the Mt. Tamalpais region, with notable populations on West Ridgecrest Boulevard and at the MMWD sludge pond.

Low frequency across the expansive grasslands of West Ridgecrest Boulevard requires a yearly 8-mile survey to locate small patches along trails and the road itself. In addition to detecting these one-off occurrences, the Parks Conservancy EDRR team leads the removal of three patches with dozens to hundreds of plants. In three years, the team has successfully reduced one patch to surveillance status, with zero plants detected in the past two seasons.

Collaboration on West Ridgecrest Boulevard, where the boundaries of State Parks, NPS, and MMWD meet (Figure 12), has proven critical to the efficacy of purple starthistle treatment. Unconstrained by agency boundaries, Parks Conservancy staff work efficiently across the landscape. Thus far, having one team underpin the treatment of purple starthistle along these boundaries has ensured that every known patch receives treatment each year.

Where the two species grow together, pairing rapid response to purple starthistle with the existing management of yellow starthistle also increases efficiency. Several work groups manage yellow starthistle along West Ridgecrest Boulevard. State Parks contractors start the season with a chemical treatment of the largest patches on their land. Parks Conservancy EDRR staff survey for purple starthistle and lead contractors on manual removal for both species. Staff from the One Tam Restoration group and One Tam Youth and Community Engagement group bring volunteers to pull yellow starthistle. MMWD staff and contractors dedicate time as well. Together, these efforts ensured that every patch detected in 2019 received treatment.

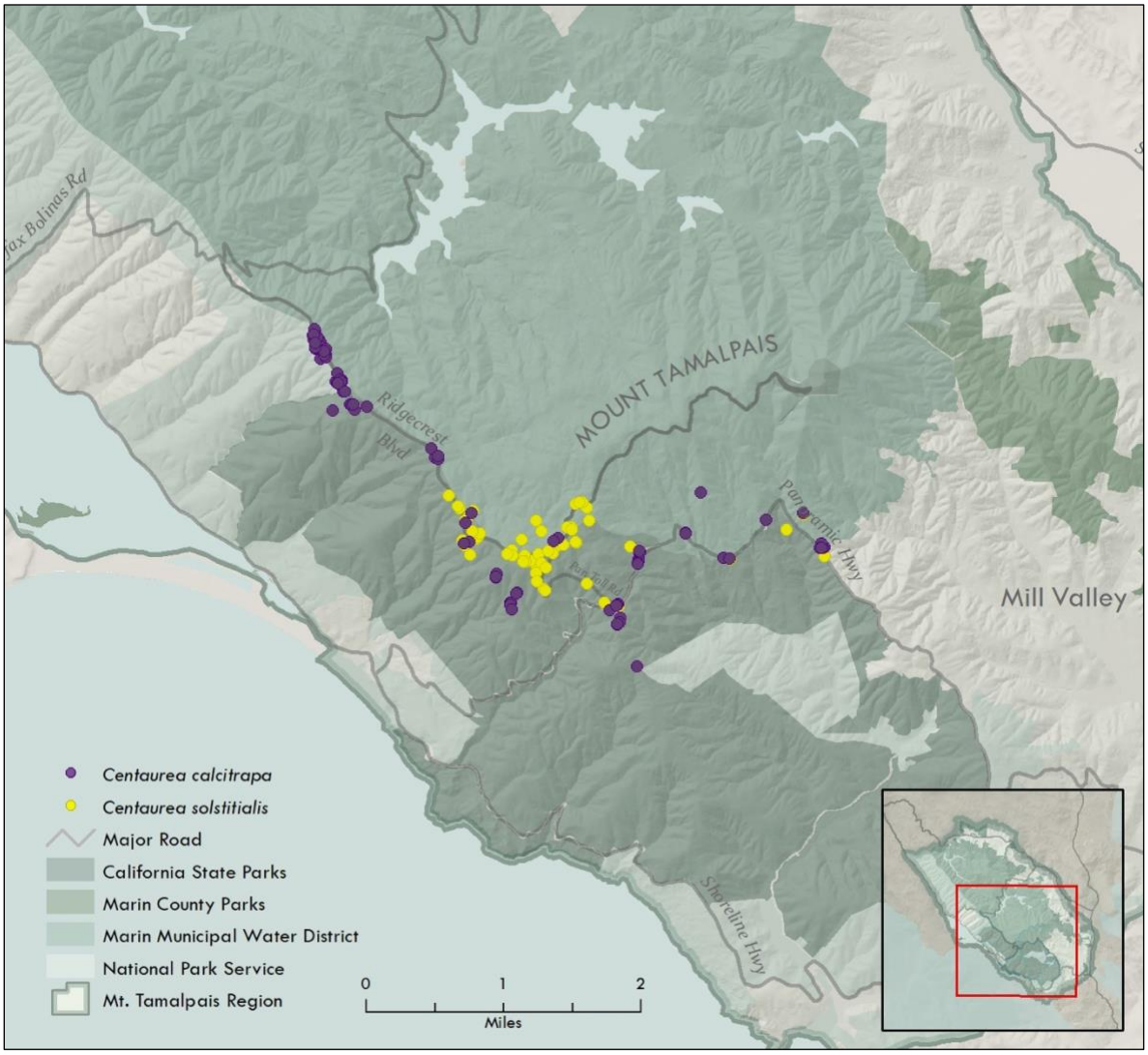

Figure 12. Purple starthistle and yellow starthistle co-occur in an area where multiple agency boundaries converge. This offers a critical opportunity for collaboration.

Year-to-year comparisons of treatment time and acreage data are complicated by the discovery of new patches. Treatments can be successfully reducing patches of a species as other factors, like dispersal or new introductions, cause gross acres to rise. While one might expect treatment costs or effort to decline year on year as a result of successful treatment, this assumes the species is fully mapped. For species like *Centaurea calcitrapa* this expectation aligns with the data. On the other hand, *Bromus tectorum* treatment success should be measured at a patch scale rather than the landscape scale.

Acquisition of new properties also creates data analysis challenges. For example, the time spent treating *Dittrichia graveolens* remained stable at approximately 16 hours per season from 2016 to 2018 but spiked to 36 hours in 2019 as a large patch at MCP's newly acquired Sky Ranch came under management.

Priority Two Treatments

In 2019, One Tam partners spent over 12,000 hours on treatments of Priority Two species. French broom eclipses the rest of the list with over 9,000 hours of management. If all broom species are lumped, this number climbs to 9,500. *Ehrharta erecta*, the species with the next highest labor investment, follows far behind with 650 hours of management. Some *Ehrharta erecta* work performed by contractors may not be entered into Calflora.

Staff spend far less time on Priority One species, but the proportion of Priority Two species under management (2,240 gross acres) is only 38%. While many of these treatment choices surely represent valuable resource protection, some warrant further prioritization at the landscape scale. Treating 100% of Priority One species may require a reduction of effort on some Priority Two populations.

STAFF, CONTRACTORS, AND VOLUNTEERS SPENT 792 HOURS TREATING PRIORITY ONE SPECIES IN 2019, COMPARED TO 12,145 HOURS ON PRIORITY TWO SPECIES. THIS DIFFERENCE CAN BE ATTRIBUTED TO THE LOW NUMBER OF PRIORITY ONE POPULATIONS.

PRIORITIZATION

While One Tam aims to treat all detections of Priority One species, the approach to Priority Two species has progressed by species or by site. The primary survey generated a valuable dataset for prioritizing across boundaries. Parks Conservancy staff applied the WHIPPET model (Weed Heuristics: Invasive Population Prioritization for Eradication Tool) to 32 species on the Priority Two list as part of this analysis (Skurka Darin et al. 2011). Those results are documented in Appendix C, along with distribution maps of those species. Seven species were excluded from that analysis either because they were not mapped during the survey or because the taxa were not covered by the model at the time of the analysis. Populations of those species in the Mt. Tamalpais region are described in Appendix D.

LESSONS LEARNED

Implementation of the EDRR protocol has taught One Tam several valuable lessons.

1. **Shared goals must be disseminated, reiterated, and revisited for successful implementation.**

   The goal to treat all patches of Priority One species each year was conceived by the Early Detection subgroup and forwarded to an early iteration of the Science Working Group. Two types of communication gaps prevent this goal from being fully realized as of early 2020. First, this goal was not thoroughly shared with agency vegetation management staff who were not regular participants in the One Tam decision-making process. This prevents the institutional awareness and buy-in necessary for success. Second, several staff transitions have occurred at the operational level at which annual treatment decisions are made. Goal sharing with new staff has been incomplete. Also, several positions remain vacant. The Early Detection subgroup lost all agency members during 2018 and 2019. By summer of 2020, all of those positions will be staffed again.

   To address these communication gaps, Parks Conservancy staff will update the Science Working Group on the findings in this report. Staff will seek guidance on how to revisit the goal to treat all Priority One patches every year, as well as the inclusion of new hires into One Tam processes.

2. **Datasets may present analytic challenges proportional to their complexity.**

   Surveyors collect and manage data for the One Tam EDRR program using the Calflora Database. Implementation of the program included significant investment in the Calflora platform to enhance its tools toward collaborative use. As agency staff entered a new data system, efforts were made to import legacy datasets to support analysis over time. Imported data, which appear to lack quality control checks, caused significant challenges during the analysis for this report.

   Use of the history stacking function remains low for both imports and data collected within the Calflora suite of applications. This function creates a relationship between records of the same patch of a single species. Recording the same patch year on year or multiple times a year to document treatment effort complicates analysis of invasive plant data. The Calflora history stacking function attempts to smooth this challenge. Data from 2018 and 2019 incorporates history stacking more comprehensively than data collected prior to those years.

   Every data management system has limitations. The export of data from the Calflora Database as relates to the history stacking function proved very challenging during the report period. Parks Conservancy staff and Calflora staff debriefed on the challenges. Calflora staff have made some improvements as of the writing of this report.

3. **A pilot season to test the protocol proved highly beneficial.**

Staff untangled several imperfections in the first year of data collection, including how best to plan survey routes and several access considerations. These logistical elements are compounded in partnership by the need to coordinate with many individuals from organizations with varying policies for field work and access. Systems for logistics deserve adequate attention to develop efficiencies.

Following the pilot season, further adjustments were made as needed. By the second year the team had more fluency in Calflora and began to develop better internal systems for preparing data for the field. The implementation of data quality control checks and the implementation of history stacking became more routine by the end of the 2017 season. Staff also modified their GPS equipment each year of the primary survey.

4. **The protocol, particularly the species list, must remain flexible in order to meet EDRR's fundamental purpose of locating and treating important weed populations.**

   By the third year of the primary survey, the Early Detection subgroup had removed one species from the list and added three new ones. These shifts impact data comparisons. Integrating riparian and infrastructure areas into the program has progressed in an ad hoc fashion thus far. It is recommended that the team address these needs when considering other protocol revisions between the 2021 and 2022 field seasons.

5. **Rapid Response requires contact with high priority invasive plant material, which may be spread by survey or treatment staff.**

   Rigorous best management practices (BMPs) should be a routine element of any early detection program. BMPs provided by the California Invasive Plant Council (2012) offered One Tam a solid starting point.

6. **Rapid Response to new detections of Priority One species requires reserving time in the schedule to ensure capacity to treat them.**

   To ensure that there is capacity to respond to new detections, the team should maintain a realistic calendar of activities. Each year, the team has found new populations of Priority One populations. Holding a day or two a month open for Rapid Response in spring and early summer is critical to ensuring new detections of can be treated. If no new detections are found, the reserved time can be used for additional surveys or to support treatments of Priority Two species.

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List of Appendices

Appendix A. Early Detection Species List

PRIORITY ONE

Species	CDFA Rating	Cal-IPC Rating
Aegilops triuncialis	-	High
Ailanthus altissima	C	Moderate
Albizia lophantha	-	-
Arctotheca calendula	A	Moderate
Brachypodium sylvaticum	-	Moderate
Bromus tectorum	C	High
Buddleja davidii	-	Watchlist
Carex pendula	-	Watchlist
Centaurea calcitrapa	-	Moderate
Clematis vitalba	A	Moderate
Cytisus striatus	B	Moderate
Dittrichia graveolens	-	Moderate
Elymus caput-medusae	-	High
Fallopia japonica	A	Moderate
Hypericum grandifolium	-	Watchlist
Iris pseudacorus	B	Limited
Maytenus boaria	-	Watchlist
Sesbania punicea	-	High
Solanum aviculare	-	Watchlist
Stipa manicata	-	Limited
Stipa miliacea var. *miliacea*	-	Limited
Stipa tenuissima	-	Watchlist
Ulex europaeus	-	High

PRIORITY TWO

Species	CDFA Rating	Cal-IPC Rating
Acacia melanoxylon	-	Limited
Ageratina adenophora	-	Moderate
Arctotheca prostrata	-	Moderate
Calendula arvensis	-	-
Centaurea solstitialis	-	High
Cortaderia jubata	-	High
Cortaderia selloana	-	High
Cotoneaster franchetii	-	Moderate
Cotoneaster lacteus	-	Moderate
Cotoneaster pannosus	-	Moderate
Crataegus monogyna	-	Limited
Cytisus scoparius	B	High
Delairea odorata	-	High
Digitalis purpurea	-	Limited
Dipsacus fullonum	-	Moderate
Ehrharta erecta	-	Moderate
Eucalyptus globulus	-	Limited
Euphorbia oblongata	-	Limited
Festuca arundinacea	-	Moderate
Foeniculum vulgare	-	Moderate
Genista monspessulana	-	High
Hedera canariensis	-	High
Hedera helix	-	High
Helichrysum petiolare	-	Limited
Hypericum perforatum	-	Limited
Ilex aquifolium	-	Limited
Lathyrus latifolius	-	-
Leucanthemum vulgare	-	Moderate
Ligustrum lucidum	-	Limited
Pennisetum clandestinum	-	Limited
Phalaris aquatica	-	Moderate
Pittosporum crassifolium	-	-
Pyracantha angustifolia	-	Limited
Romulea rosea var. *australis*	-	Watchlist
Rubus armeniacus	-	High
Rytidosperma caespitosum	-	Watchlist
Rytidosperma penicillatum	-	Limited
Spartium junceum	-	High
Tradescantia fluminensis	-	-

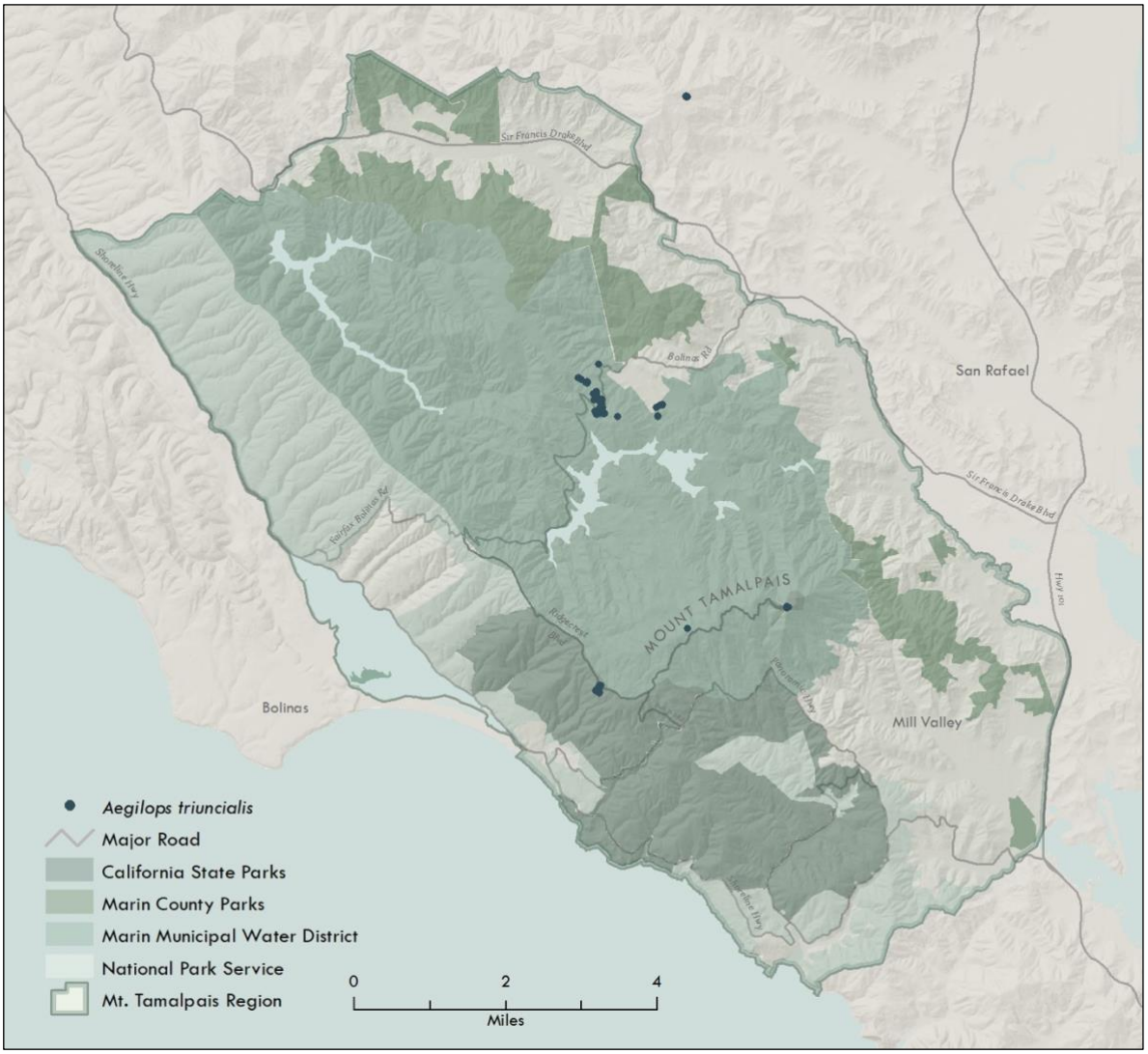
Appendix B. Priority One Species Accounts

AEGILOPS TRIUNCIALIS

Family: Poaceae
Cal-IPC Rating: High

Among the many invasive annual grasses on Mt. Tamalpais, *Aegilops triuncialis* (barbed goatgrass) deserves special consideration for its propensity to invade serpentine soil, including barrens and grasslands that host rare plants. Stiff and rich in silicates, barbed goatgrass also poses challenges to ranchers and private landowners inasmuch as livestock will not eat it, and at times find it injurious.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
41	6.25	0.14	100%

Barbed goatgrass occurs in several populations from East Peak to Hangglider Point along the mountain's primary ridgeline. The East Peak population has been significantly reduced with treatment. That population is not in prime grassland habitat but is rather in a disturbed area near a parking lot with limited suitable habitat. Additional populations on Carson Ridge and at Bullfrog Quarry (MMWD) are much larger and older. Substantial populations occur north of the Mt. Tamalpais region on public and private land.

All known patches of barbed goatgrass are under management within the Mt. Tamalpais region, however differentiating one annual grass from a sea of other annual grasses is a challenge for treatment crews. Despite significant treatment effort, gross area for this species has remained stable throughout the primary survey period.

AILANTHUS ALTISSIMA

Family: Simaroubaceae
Cal-IPC Rating: Moderate

Intentionally planted around the state as an ornamental, *Ailanthus altissima* (tree-of-heaven) grows quickly, particularly in riparian habitats. This species, which ranges in size from sprawling shrub to stately tree can spread via seed or vegetative growth. A tenacious resprouter when cut, tree-of-heaven is notably challenging to control once established.

Regional Distribution

Tree-of-heaven is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

ALBIZIA LOPHANTHA

Family: Fabaceae
Cal-IPC Rating: Watch

Albizia lophantha (stinkbean) can grow in dense stands, especially in moist habitats such as lakeshores or creeksides. With a highly regular growth habit and stiff, hard branches, these patches prove challenging to remove once established. Voluminous production of thick-coated seeds creates a significant seedbank, which necessitates follow-up management once parent trees are removed.

Paraserianthes lophantha is a synonym.

Regional Distribution

Stinkbean is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

Priority One Table of Contents

ARCTOTHECA CALENDULA

Family: Asteraceae
Cal-IPC Rating: Moderate

Like many invasive plants in California, *Arctotheca calendula* (fertile capeweed) is used in horticulture and landscaping. This plant can spread by seed or stolons and can rapidly establish as a mat-forming groundcover.

Regional Distribution

Fertile capeweed is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

Several records in the Calflora Database seemingly indicate the presence of fertile capeweed in Marin County. However, upon inspection, many of these records appear to actually be *A. prostrata* (sterile capeweed). The two taxa were once considered the same species before a taxonomic split was implemented, leaving a residue of confusion in the dataset.

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BRACHYPODIUM SYLVATICUM

Family: Poaceae
Cal-IPC Rating: Moderate

In California, *Brachypodium sylvaticum* (slender false brome) is only known in San Mateo and Santa Clara counties, where efforts to eradicate this perennial bunchgrass have faced considerable challenges. One Tam considers slender false brome a watchlist species because suitable habitat exists in the Mt. Tamalpais region.

Regional Distribution

Slender false brome is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

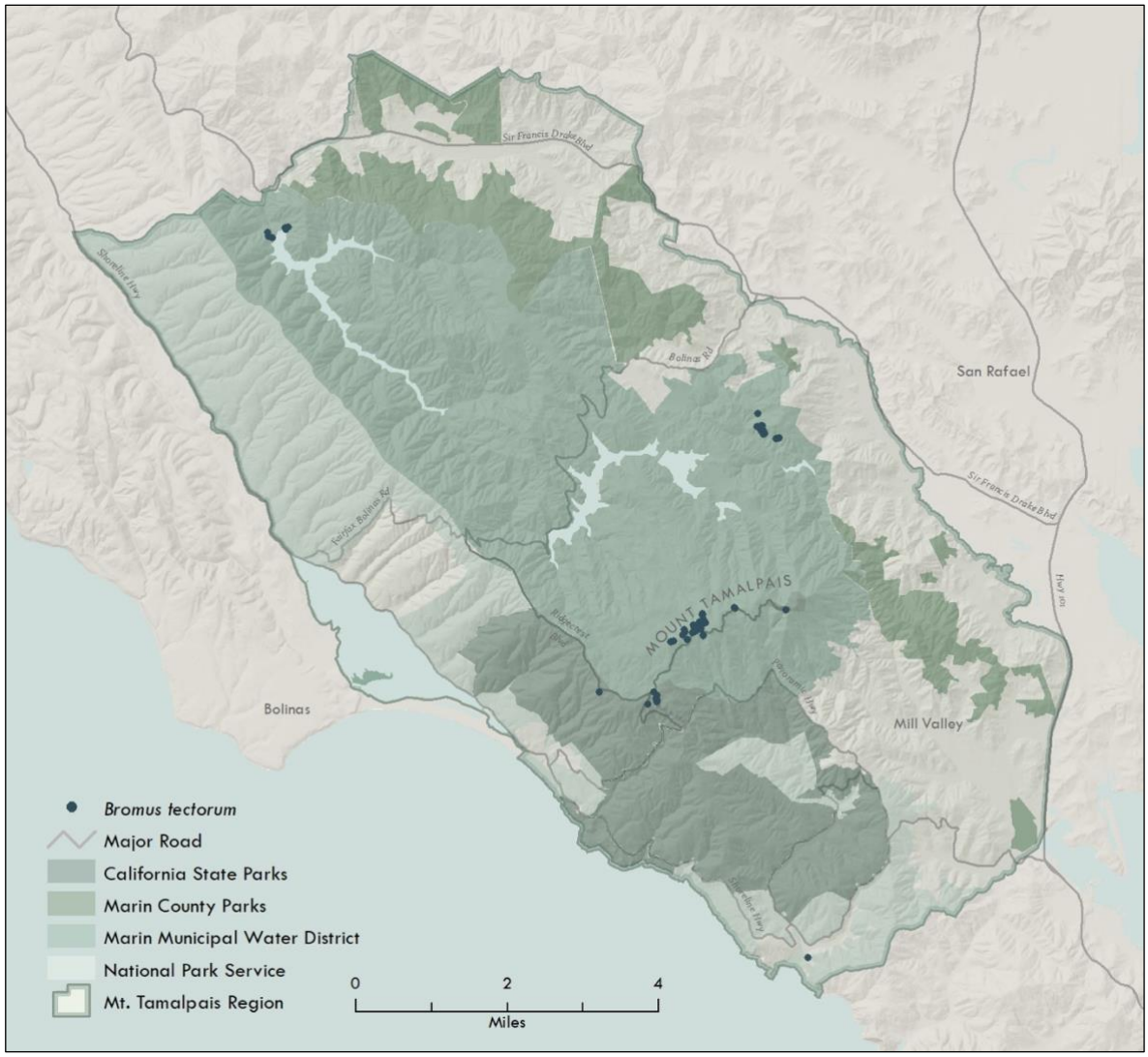
Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

BROMUS TECTORUM

Family: Poaceae
Cal IPC Rating: High

Considered a formidable invasive plant throughout much of the American West, *Bromus tectorum* (cheatgrass) has significant impacts on fragile desert communities where it alters the movement and intensity of fire. On Mt. Tamalpais this annual grass grows primarily on gravelly, disturbed soils—including rare serpentine barren habitat. The concern that a fire on the mountain may spread this species to other sensitive habitats also factors into its prioritization. Slight and cryptic, this species evades the eye of many surveyors until they have had a chance to see it *in situ*.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
45	13.43	0.05	99.9%

Cheatgrass occurs in three clusters in the Mt. Tamalpais region. The Ridgecrest patches occur from a pullout near the top of the mountain to a large stand at West Peak and down to Forbes Bench on State Parks land. A single plant at Hangglider Point (West Ridgecrest Boulevard) was detected and removed in 2017. No further detections of this species have been made at that location since that time. The largest occurrence of cheatgrass occurs at Yolanda Trail on MMWD land. Despite spanning several acres, this population was first detected in 2018. Additional patches occur on the face of Peters Dam, also on MMWD property.

Treatment limitations on MMWD property challenge management of this species. While staff annually attempt a propane flaming strategy at West Peak, weather conditions often confound the effort, relegating options to time-intensive hand removal. Most of this species' gross area occurs on MMWD land.

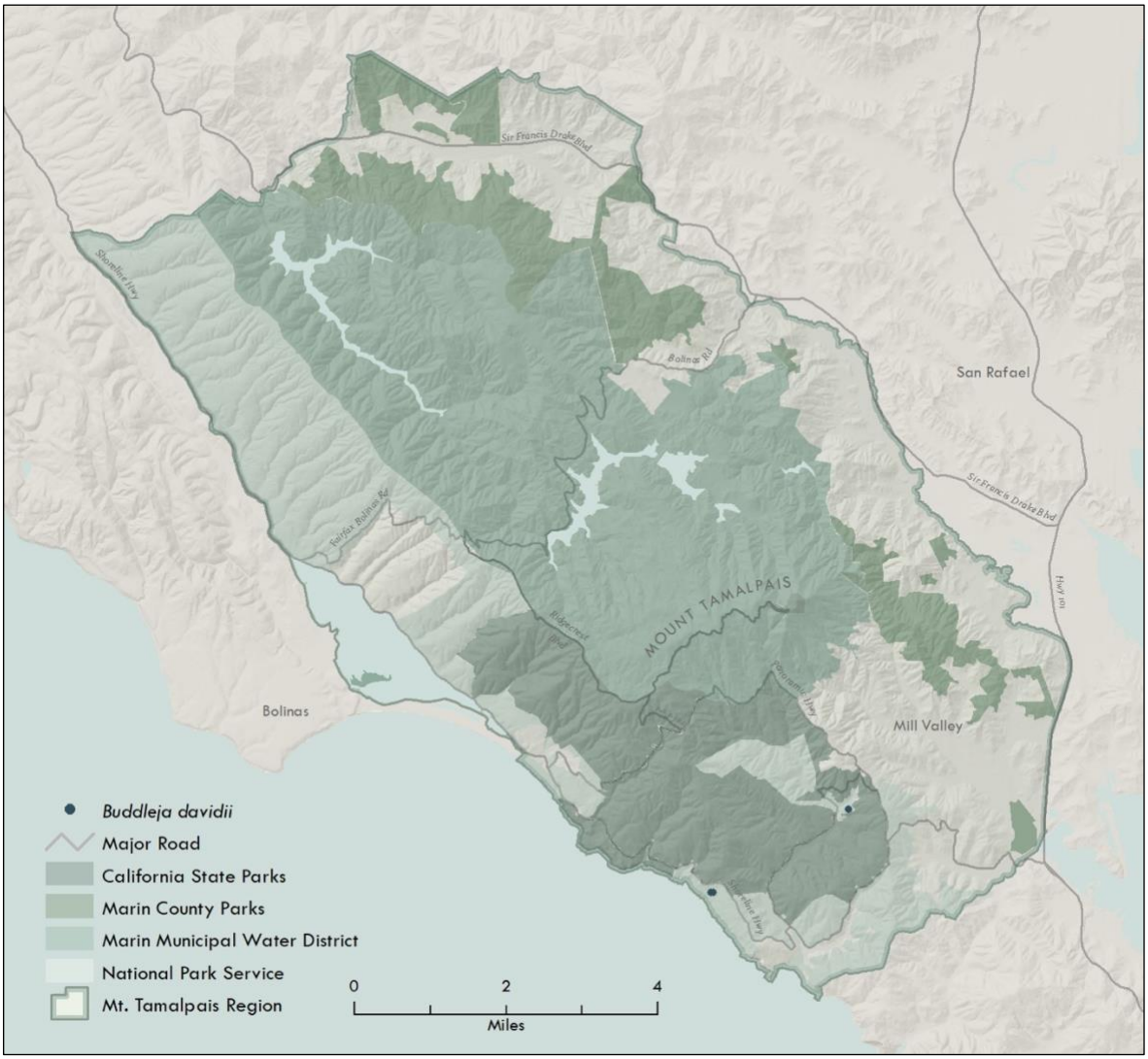
Given that cheatgrass currently exists in many large, well-distributed patches within the area of focus, and that new patches continue to be detected each year, it is likely that eradication is no longer a feasible goal. One Tam will revisit the prioritization and management strategy for this species in fall of 2021 when the EDRR species list comes under review.

BUDDLEJA DAVIDII

Family: Scrophulariaceae
Cal-IPC Rating: Watch

A popular ornamental with an appealing common name, *Buddleja davidii* (butterfly bush) can spread from gardens into wildlands. This leggy shrub can sprout from vegetative material or germinate from seed. Areas adjacent to landscaped gardens and riparian areas are the habitats most at risk from this species on Mt. Tamalpais.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
1	< 0.01	< 0.01	100%

This species has only been detected once on public land in the Mt. Tamalpais region. That occurrence, by the Muir Beach parking lot, was removed several years ago and has not been seen there since. Additional patches have been mapped on private residential land, but those are excluded from this analysis and the acreage totals above since they are not subject to management by One Tam agencies.

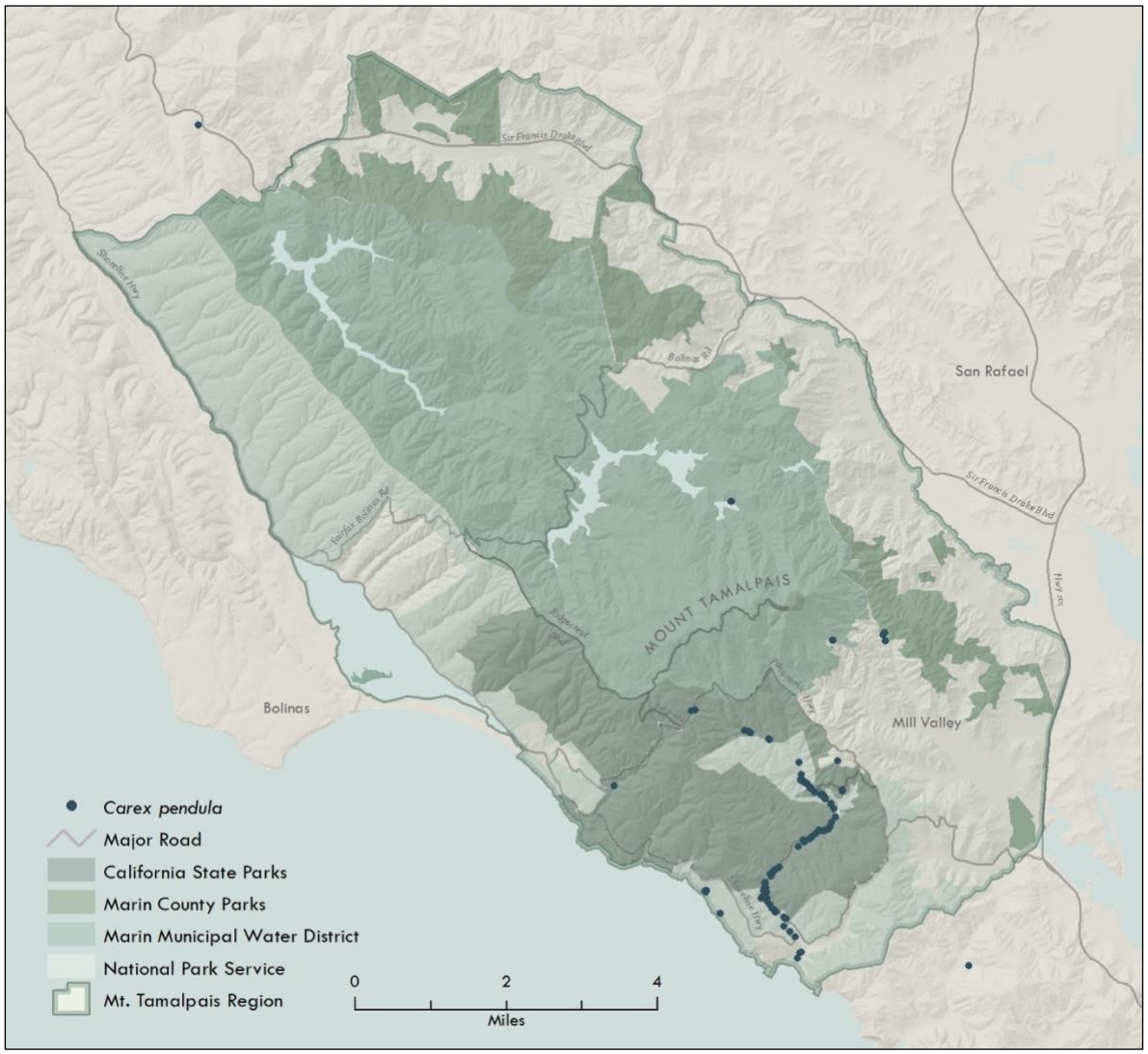
Priority One Table of Contents

CAREX PENDULA

Family: Cyperaceae
Cal-IPC Rating: Watch

Carex pendula (hanging sedge) is an impressively large perennial that forms dense tussocked stands in wet habitats. It spreads primarily via prodigious production of seeds, which in riparian settings are swept downstream to find purchase on banks and sandbars. Hanging sedge is also known to grow in high-value regions, including salmonid-bearing streams, California red-legged frog habitat, and deep redwood forest.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
106	1.42	0.06	47.3%

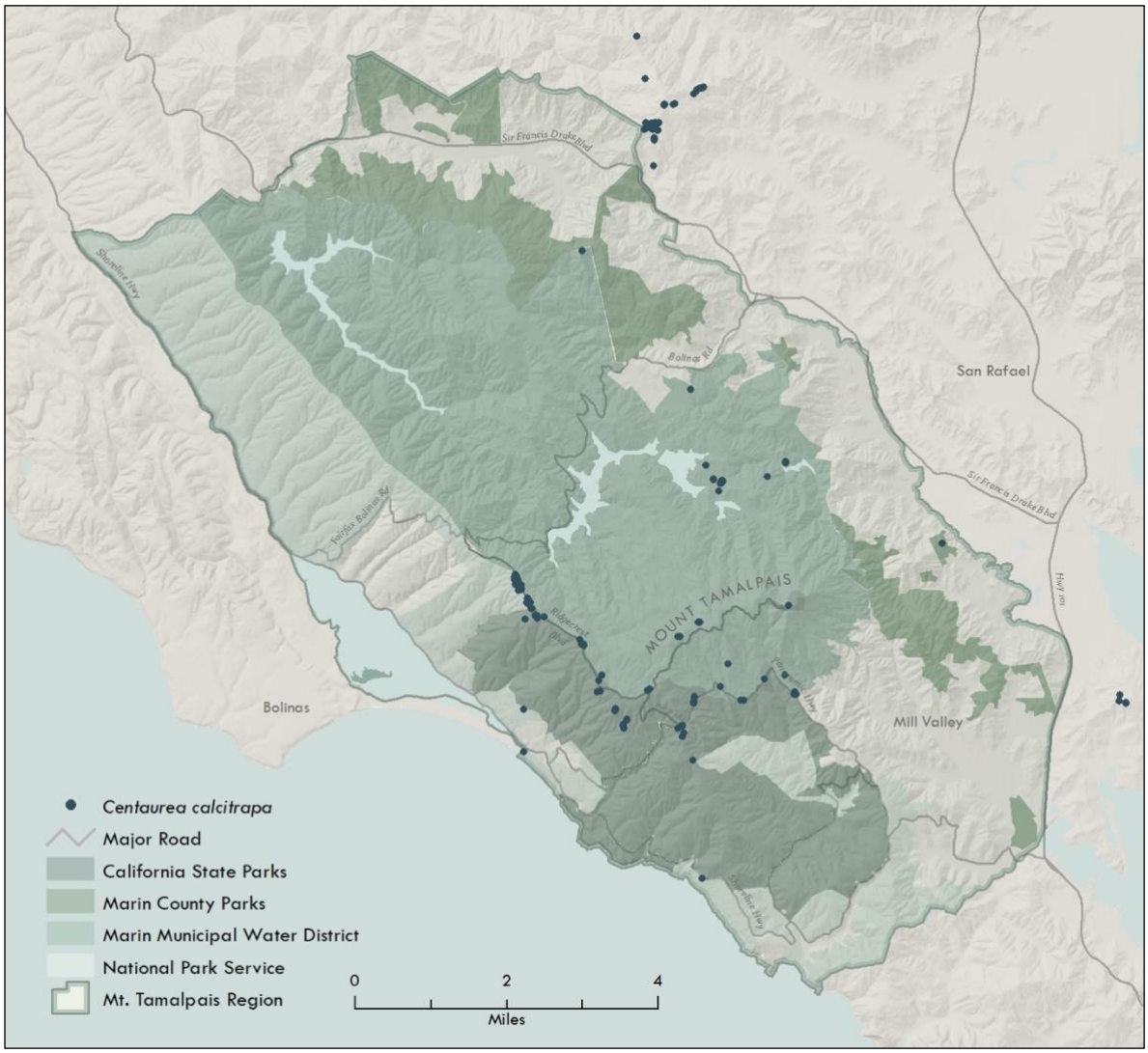
Hanging sedge occurs along several reaches of Redwood Creek as well as in coastal seeps and forests. The species is also known from Lagunitas Creek north of the Mt. Tamalpais region on land managed by One Tam partners. One of the largest patches in the region spans the borderline between MCP and the township of Mill Valley. Uphill patches on the MCP side are under management, but the bulk remains untreated on Mill Valley land.

CENTAUREA CALCITRAPA

Family: Asteraceae
Cal-IPC Rating: Moderate

Centaurea calcitrapa (purple starthistle) occurs in sunny areas of high disturbance, including roadsides, parking lots, campgrounds, and overgrazed pastures. This species, whose duration ranges from annual to biennial to weakly perennial, favors compacted soils. In a genus of plants known to be invasive in California, purple starthistle outperforms related species found in the Mt. Tamalpais region in having the stiffest spines. Left unmanaged, this trail-follower can significantly impact visitor experience in summer and fall months.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
95	2.60	0.03	100%

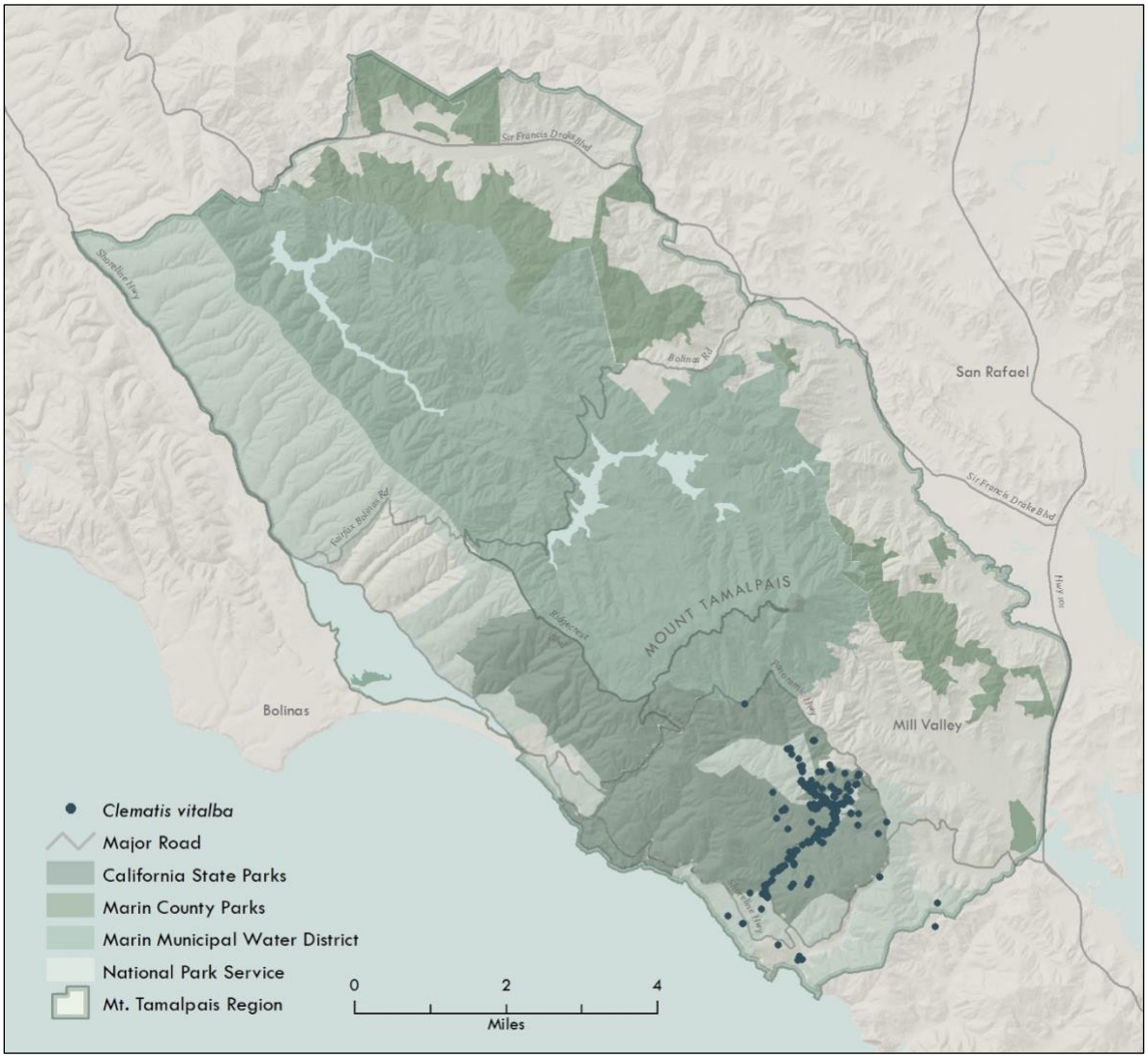
Purple starthistle occurs in three main areas inside the Mt. Tamalpais region: the West Ridgecrest grasslands, Panoramic Highway, and MMWD's lakes region. All patches are under management. Old records in Calflora show plants on the east side of the area of focus which appear to have been managed or initially misidentified, as they no longer occur. Significant populations exist just north of the region in pastures with cattle and horses.

CLEMATIS VITALBA

Family: Ranunculaceae
Cal-IPC Rating: Moderate

A woody riparian vine with native relatives in the same genus, *Clematis vitalba* (old man's beard), was misidentified for several years within the Mt. Tamalpais region. Old man's beard is stout enough to climb up and over the canopies of full-grown trees, where it spreads its feathery seeds on the wind. Hanging shoots that contact the soil can reroot, and plant fragments that wash downstream may also become established.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
225	13.27	4.8	25%

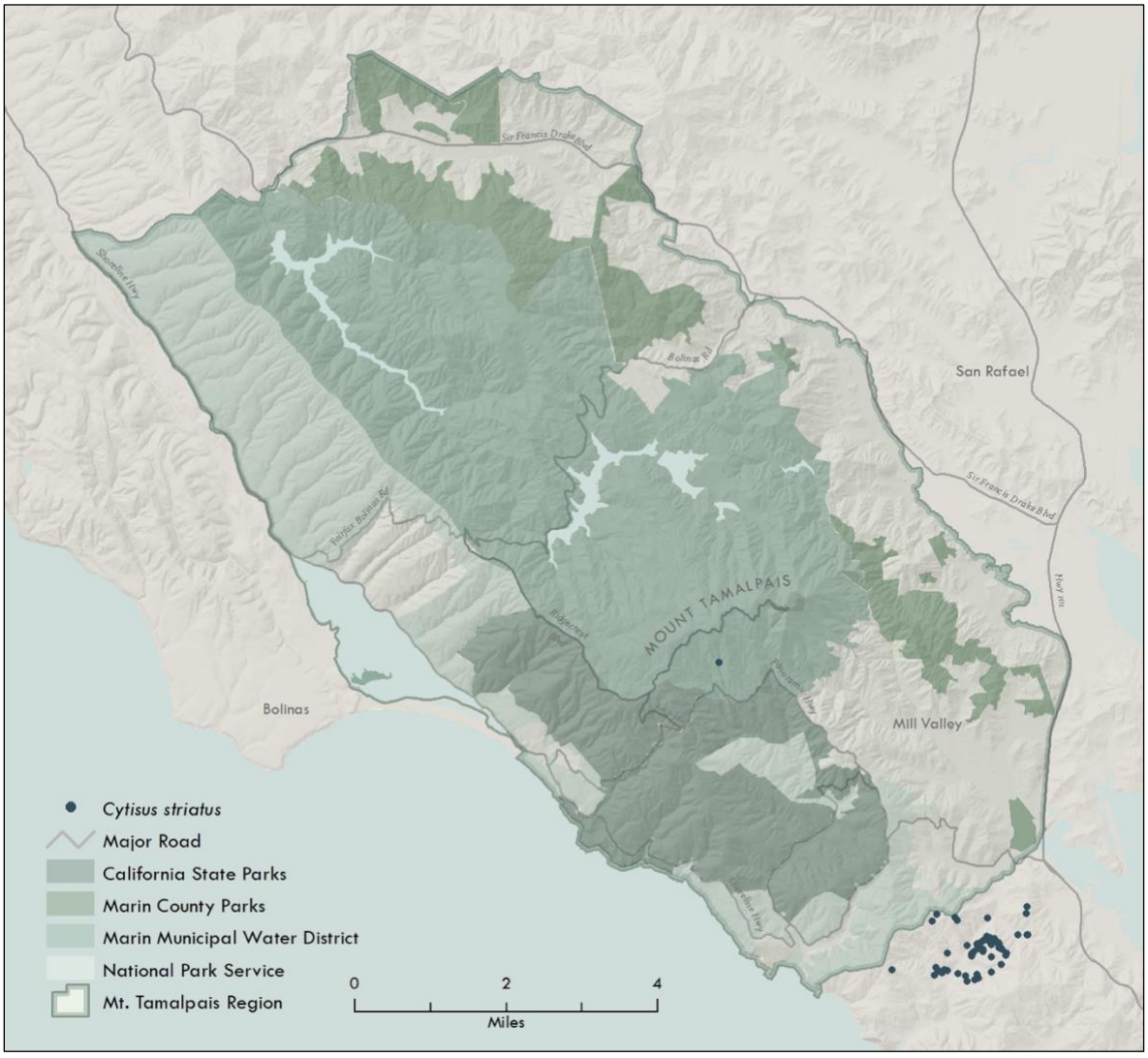
Old man's beard occurs in the Redwood Creek Watershed in the southwestern quadrant of the region. It also occurs over Coyote Ridge into the Tennessee Valley Watershed. One Tam staff recorded occurrences north of the region as well, on NPS lands along Lagunitas Creek.

CYTISUS STRIATUS

Family: Fabaceae
Cal-IPC Rating: Moderate

Bright, conspicuous flowers make *Cytisus striatus* (Portuguese broom) a striking ornamental shrub. Surveyors have spotted specimens in gardens bordering public lands during late spring and summer when mature plants become a blaze of yellow. Like other brooms, Portuguese broom functions as a nitrogen fixer and has long-lived seeds. The Calflora dataset includes some misidentified patches of *Cytisus scoparius*, which have been ferreted out of this account.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
1	< 0.01	< 0.01	100%

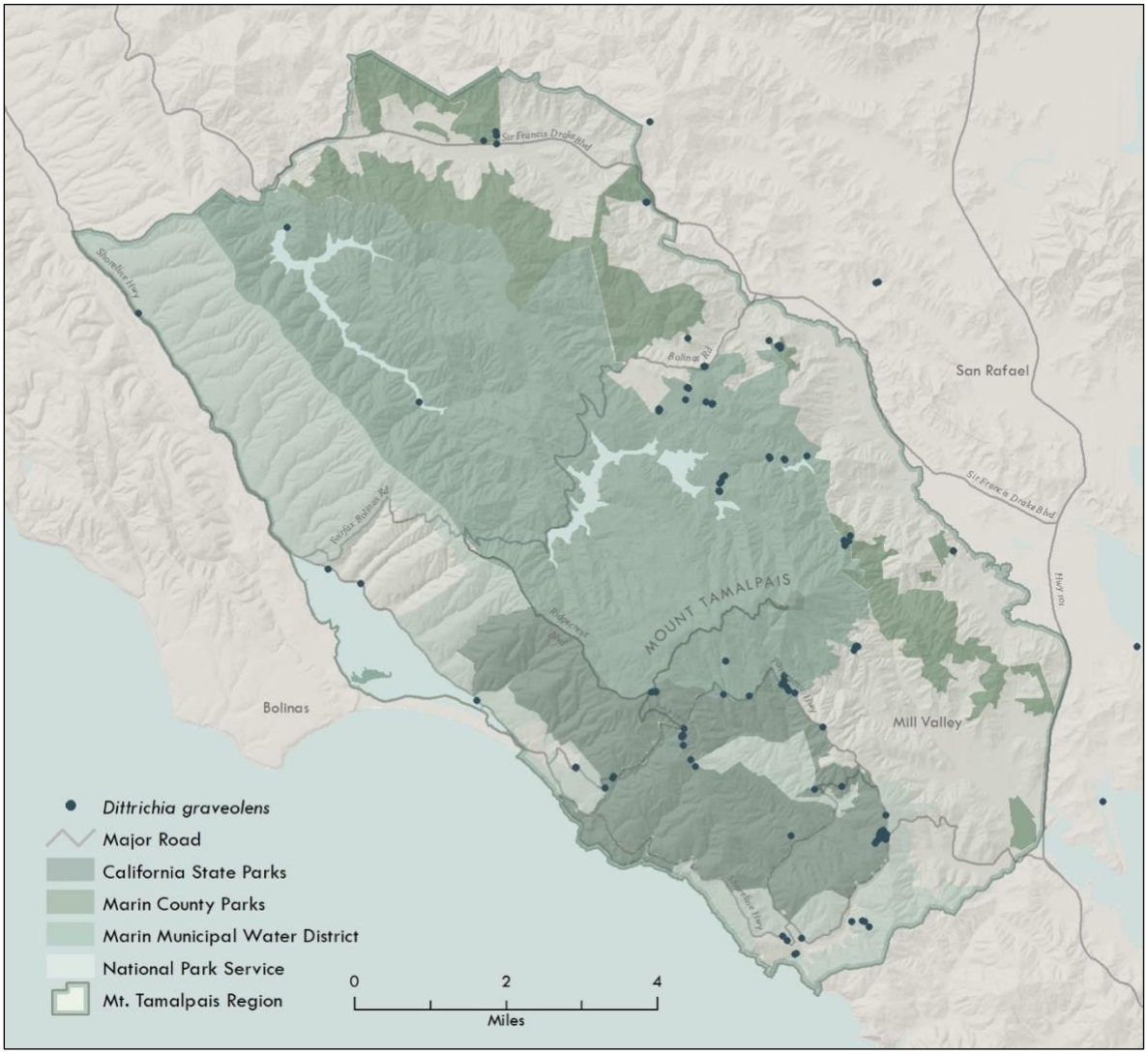
Although Portuguese broom is known within the Mt. Tamalpais region, only one of a handful of patches occurs on public land. A small patch on MMWD land was properly identified and removed in 2014. At least one plant occurs on private land near Muir Beach. This species is more widespread in the Marin Headlands to the south.

DITTRICHIA GRAVEOLENS

Family: Asteraceae
Cal-IPC Rating: Moderate

Dittrichia graveolens (stinkwort) lives up to its pejorative common name with a pungent camphor odor. Some people develop contact dermatitis from handling the resinous plants, and the scent lingers where it touches. A devotee of the disturbed trailside habitat niche, this species can impact visitor experiences.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
100	8.64	0.04	77.8%

Stinkwort has expanded significantly in the Bay Area in the past 10 years. The sticky, feathery seeds both move on vehicles and blow around in their wakes, leading to trenchant establishment along the Highway 101 corridor in Marin. As vehicles traverse the public lands of Mt. Tamalpais, more and more roadside populations have become established there, too.

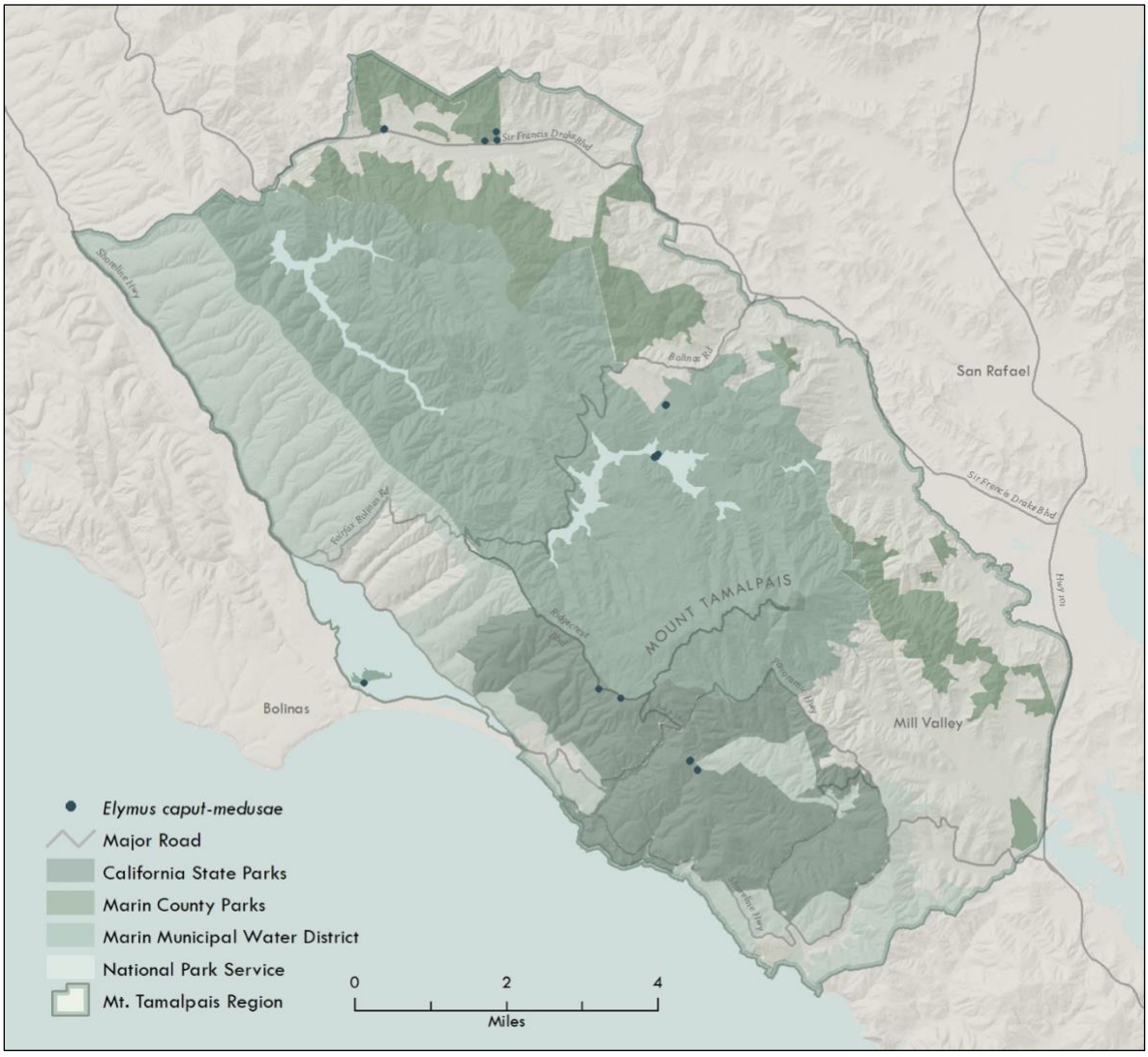
As a noted disturbance-follower, this species also occurs in landslide soil piles, rock and material depots, parking lots, and infrastructure areas like water tanks. The majority of this species is under management with exceptions on MCP lands with heavily impacted roadways on or near Sir Francis Drake Boulevard.

ELYMUS CAPUT-MEDUSAE

Family: Poaceae
Cal-IPC Rating: High

Elymus caput-medusae (medusahead) has a strong association with livestock and pastures in parts of the Bay Area. Another Mediterranean annual grass, medusahead stands out among its Priority One analogues in its ability to create thick, persistent thatch. The species' impacts on forage lands led to the development of a *Medusahead Management Guide for the Western States* (Kyser et al. 2014).

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
22	2.8	1.95	13.3%

In the Mt. Tamalpais region, the species has a significant population cluster along Sir Francis Drake Boulevard, part of which sits on private land or rights of way. Smaller patches occur at Sky Oaks Meadow and Bon Tempe Dam on MMWD land. Four small patches occur on State Parks land near disturbed roadside grasslands. One patch occurs next to a construction stockpile of imported rock.

Taeniatherum caput-medusae is a synonym. Nomenclature changes should be considered when compiling data from Calflora—some records remain logged under this old name.

Kyser, G. B., J. M. DiTomaso, K. W. Davies, J. S. Davy, and B. S. Smith. 2014. Medusahead Management Guide for the Western States. University of California, Weed Research and Information Center, Davis. Available at: wric.ucdavis.edu (accessed 19 February 2020).

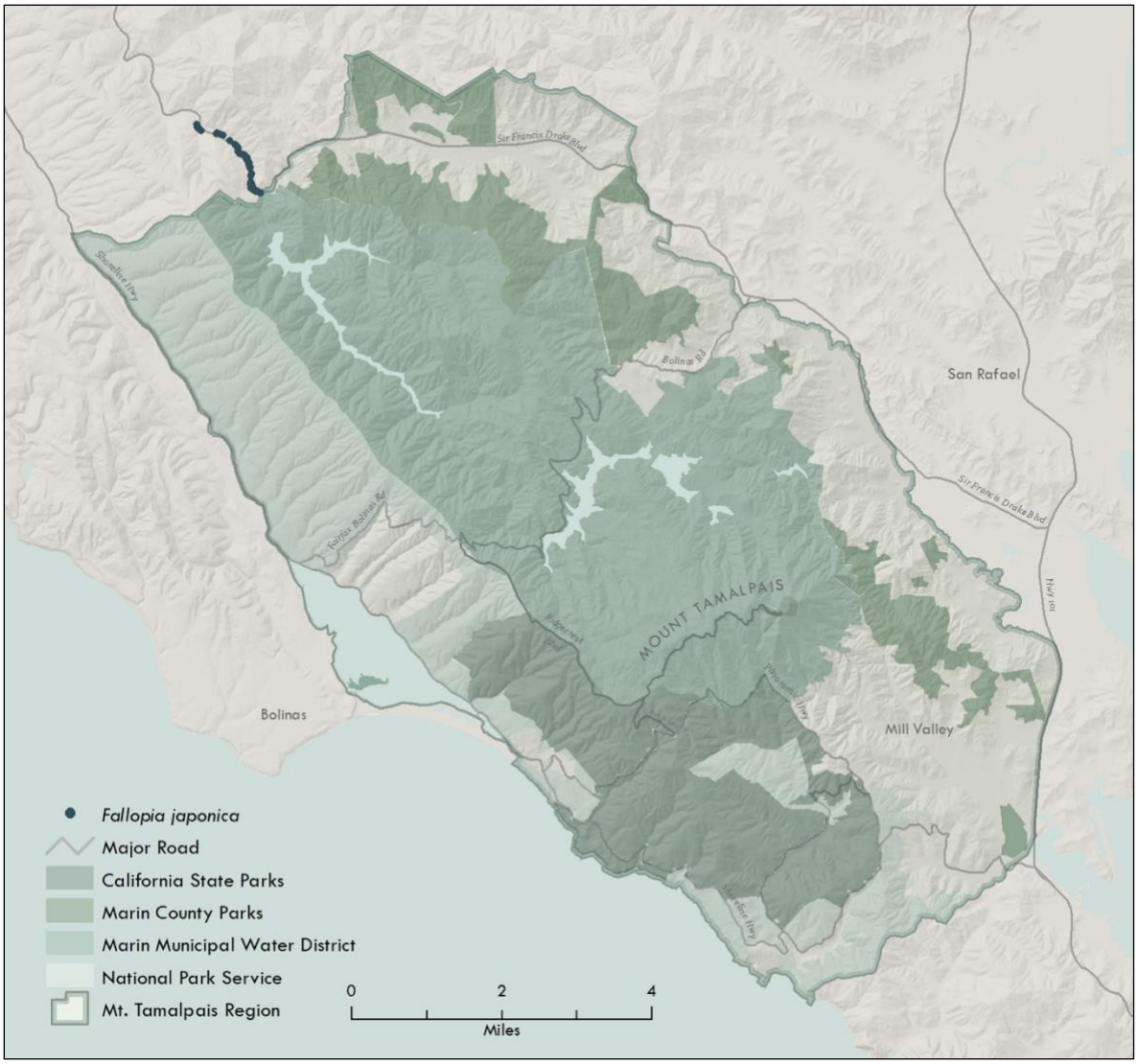
FALLOPIA JAPONICA

Family: Polygonaceae
Cal-IPC Rating: Moderate

Fallopia japonica (Japanese knotweed) stands out as a priority invasive species worldwide for its impacts to both wildlands and infrastructure, dually able to form monocultures in riparian environments and compromise building foundations in urban and residential areas.

A vigorous perennial herb, Japanese knotweed spreads not through seeds but through physical breakage and dispersal. Its creekside affinity provides ideal conditions for downstream movement of scoured rhizomes or stem node material. Japanese knotweed and related species appear to have escaped from cultivation for ornamental purposes.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

In the Mt. Tamalpais region, Japanese knotweed only occurs on private land—however, public land occurrences appear immediately north in Samuel P. Taylor State Park and the Golden Gate National Recreation Area. All Marin populations occur within the Lagunitas Creek watershed. Populations on public land are under management. The collaborative group known as the Marin Knotweed Action Team, led by University of California Cooperative Extension and Marin County Agricultural Department, works to address populations on private land. As of 2019, over 60 private properties are also under management.

The rhizomatous nature of Japanese knotweed limits management approaches to either chemical treatment or full removal of all plant and soil material in an infested area. It is reputed that many or most populations of Japanese knotweed are sexually sterile—to that end, One Tam staff collected seeds from mature plants in 2019 for analysis. Viability tests indicated that 0% of the seeds were viable.

Reynoutria japonica is a synonym.

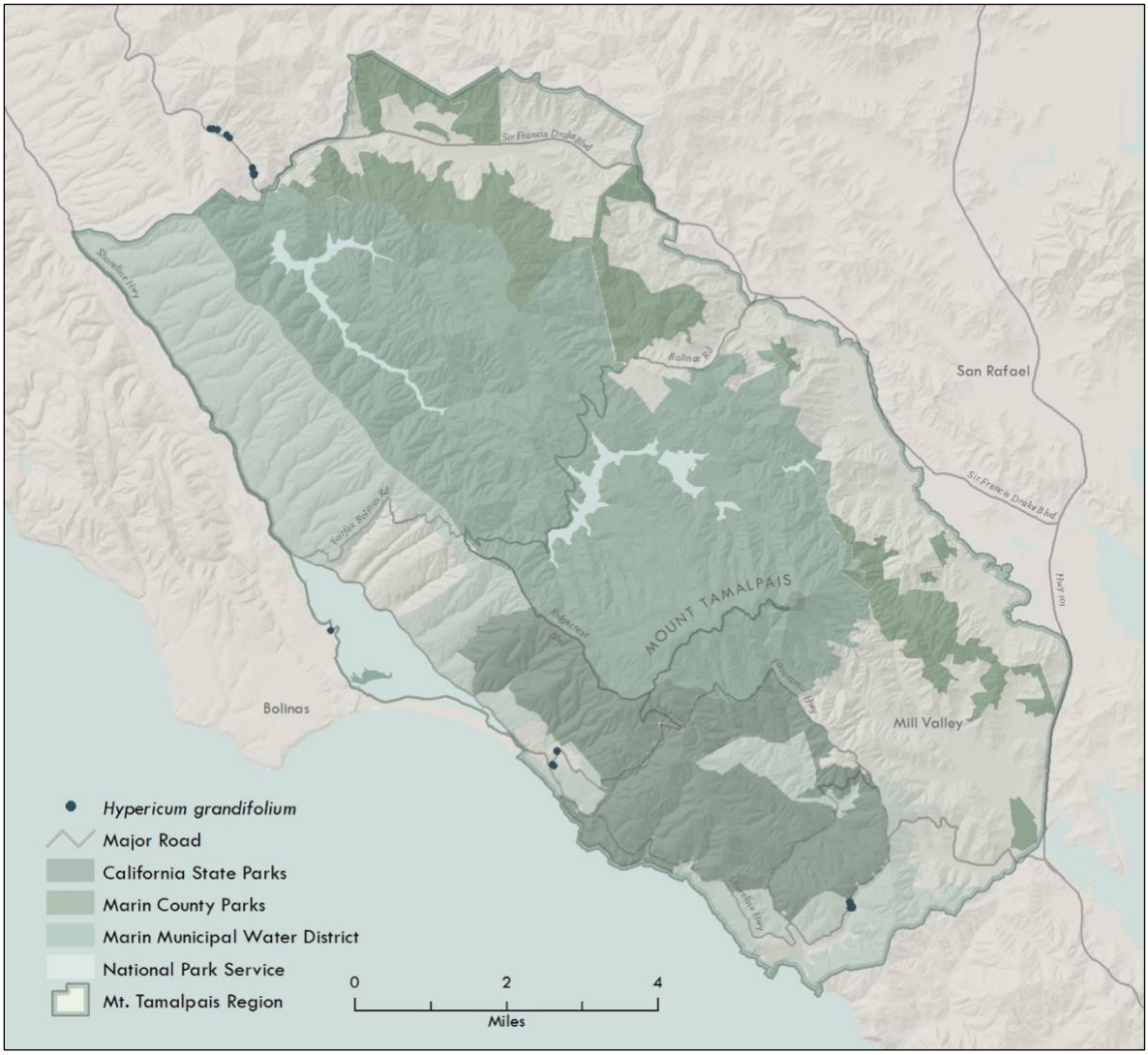
HYPERICUM GRANDIFOLIUM

Family: Hypericaceae
Cal-IPC Rating: Watch

Hypericum grandifolium (malfurada), a showy yellow-flowered shrub, frequents moist areas including creeks, wetlands, and foggy coastal scrub. This plant spreads by seeds and rhizomes. Manual removal is complicated by highly fractious root material that may resprout if not completely removed.

Marin County is the primary population center mapped in California to date, while limited records also exist in Calflora for San Mateo and Sonoma counties.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
9	0.92	0.07	96.6%

Malfurada's distribution concentrates along the coast on National Park Service land. Several patches also occur along Lagunitas Creek north of the Mt. Tamalpais region. Malfurada appears to have been planted on Audubon Canyon Ranch land in the past, where it has spread from a garden into an alder grove. This patch is under manual management.

Hypericum grandifolium does not appear in the Jepson eFlora (2020), perhaps due to lingering conflation with the similar species *Hypericum canariense*.

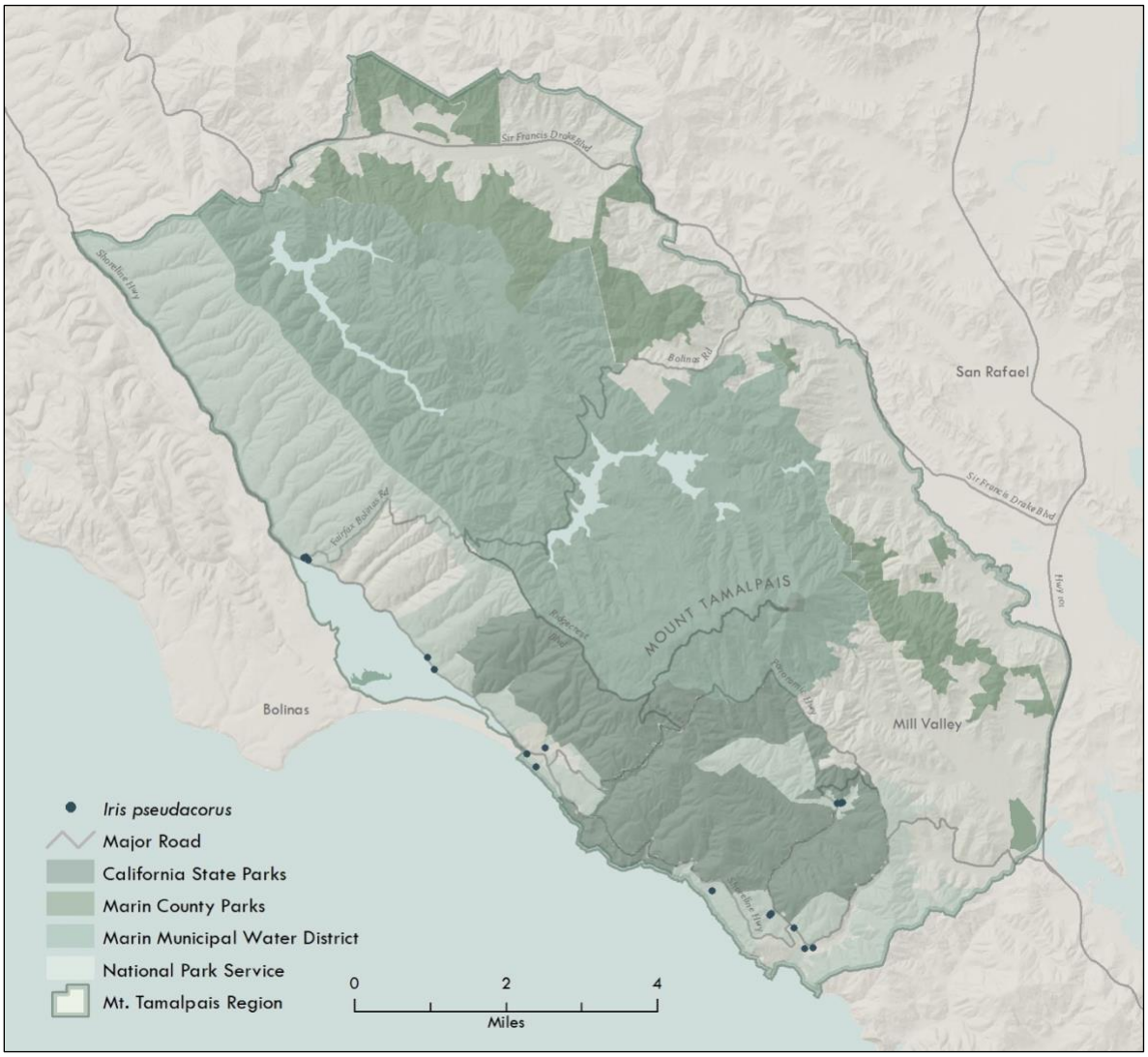
Jepson Flora Project (eds.) 2020. Jepson eFlora. University of California, Berkeley, CA. Available at https://ucjeps.berkeley.edu/eflora/ (accessed on 13 May 2020).

IRIS PSEUDACORUS

Family: Iridaceae
Cal-IPC Rating: Limited

Popular in garden ponds, *Iris pseudacorus* (yellow flag iris) makes a striking impression with tall green leaves and bright yellow flowers. This sizable perennial appears in and around water sources as it prefers to have its roots in moist soils, complicating treatment options. Dense rhizome biomass sunken into saturated mud proves a major challenge for removal efforts.

Regional Distribution



Occurrence details

Patches	Gross Acres	Net Acres	Percent Managed
17	0.61	0.09	0.1%

Yellow flag iris has been mapped primarily on NPS lands along the coast, as well as in one location in the southeast corner of Muir Woods National Monument. Less than 1% of mapped occurrences are under management. The species also occurs along Lagunitas Creek north of the Mt. Tamalpais region on NPS land. Additional populations occur on Point Reyes National Seashore lands and the Marin Headlands.

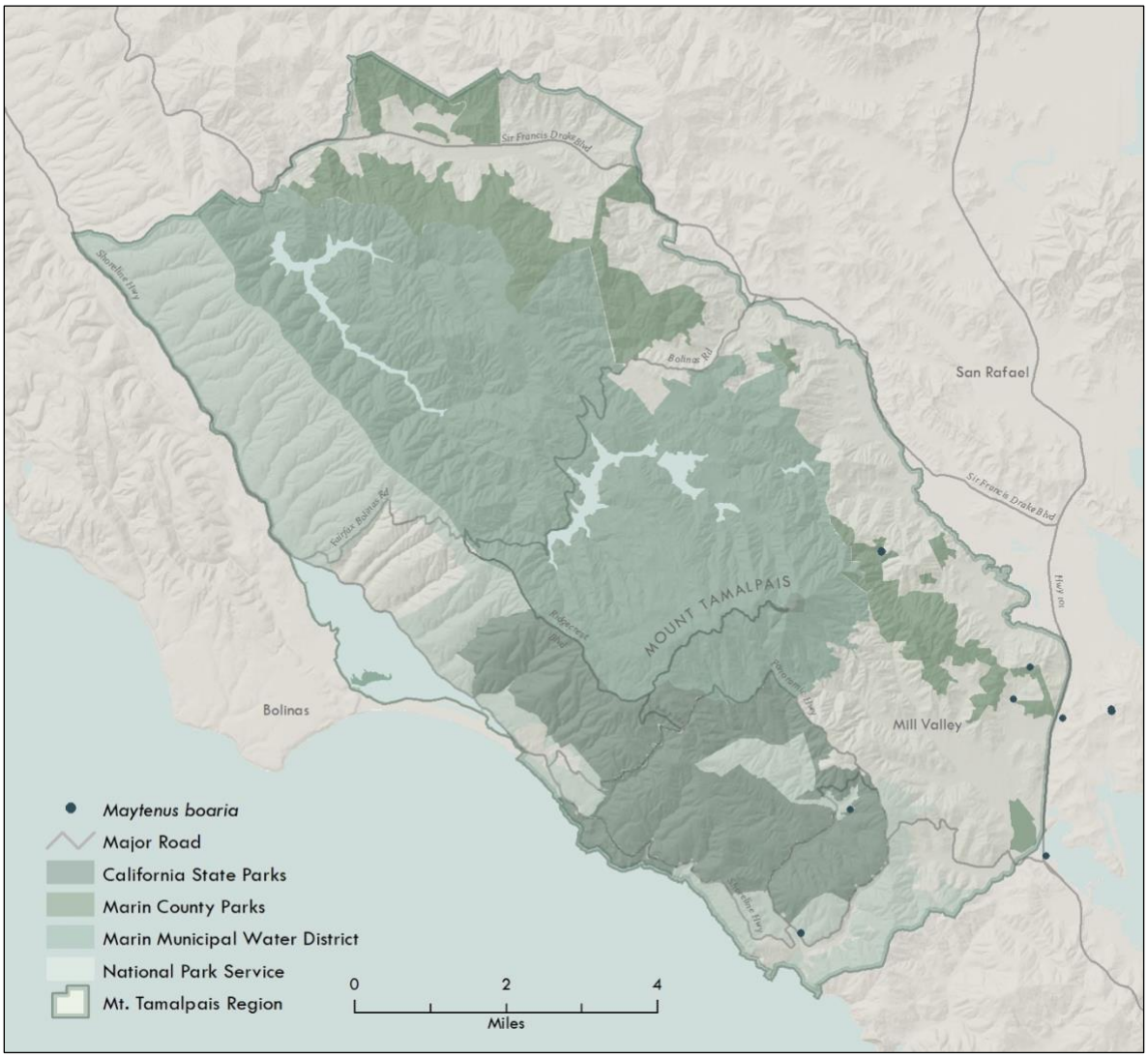
Priority One Table of Contents

MAYTENUS BOARIA

Family: Celastraceae
Cal-IPC Rating: Watch

With lovely raining branches and tiny green flowers, *Maytenus boaria* (mayten) occurs in Marin as an ornamental tree in landscaping. It has fallen out of favor as a street tree because its roots sucker prolifically, busting forth from sidewalk cracks with new shoots. This same characteristic makes it a management challenge in wildlands where the species favors moist soils but also makes its way into drier habitats when left unmanaged. It also spreads via seeds in California.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
5	5.57	0.79	0.3%

Mayten occurs in the south and eastern quadrants of the Mt. Tamalpais region, often near neighborhoods. A 5-acre patch on MCP land remains untreated.

Priority One Table of Contents

SESBANIA PUNICEA

Family: Fabaceae
Cal-IPC Rating: High

Sebania punicea (rattlebox) impacts riparian areas, where the shrub may grow in thick stands. Roadside ditches are another favored habitat. This pea family species fixes nitrogen and contains chemicals toxic to people and wildlife. Despite these characteristics, it is an ornamental favored for its showy red flowers.

Regional Distribution

Rattlebox is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
0	0	0	-

A report of a planted individual in a private garden near MMWD's Bill Williams Canyon has not yet been substantiated. The species has been mapped in Novato to the north—once at Rush Creek on MCP land and once in a residential area where it is presumed to be a garden plant.

Priority One Table of Contents

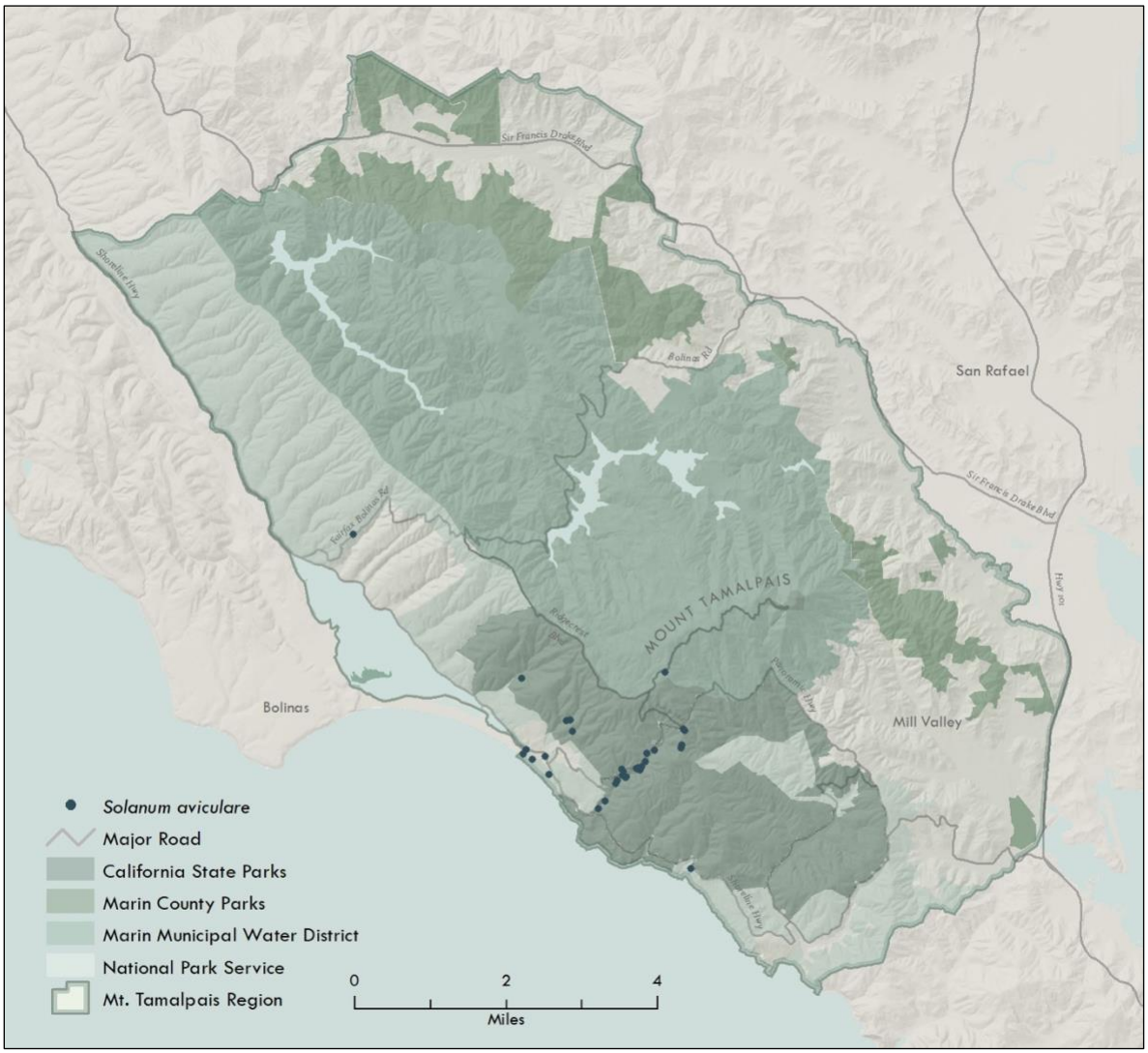
SOLANUM AVICULARE

Family: Solanaceae
Cal-IPC Rating: Watch

Solanum aviculare (New Zealand nightshade) occurs in riparian areas in the Mt. Tamalpais region. These leggy shrubs are difficult to spot in the deep shade and verdancy of creekside canyons like Steep Ravine's Webb Creek. Surveyors have successfully detected New Zealand nightshade by scanning suitable habitat through binoculars for the bright purple flowers, which have a wide bloom window. In areas where this species is suspected, out-and-back surveys are recommended to give surveyors the opportunity to see vegetation from multiple angles.

Ornamental plantings in Marin neighborhoods are the likely origin of this species locally. New Zealand nightshade propagates by seed, which is dispersed by wildlife.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
34	0.59	0.01	95.4%

In the Mt. Tamalpais region, New Zealand nightshade tends to occur near residential communities like Stinson Beach and Muir Beach, showing a preference for coastal locations. It also occurs outside the region on the Point Reyes peninsula.

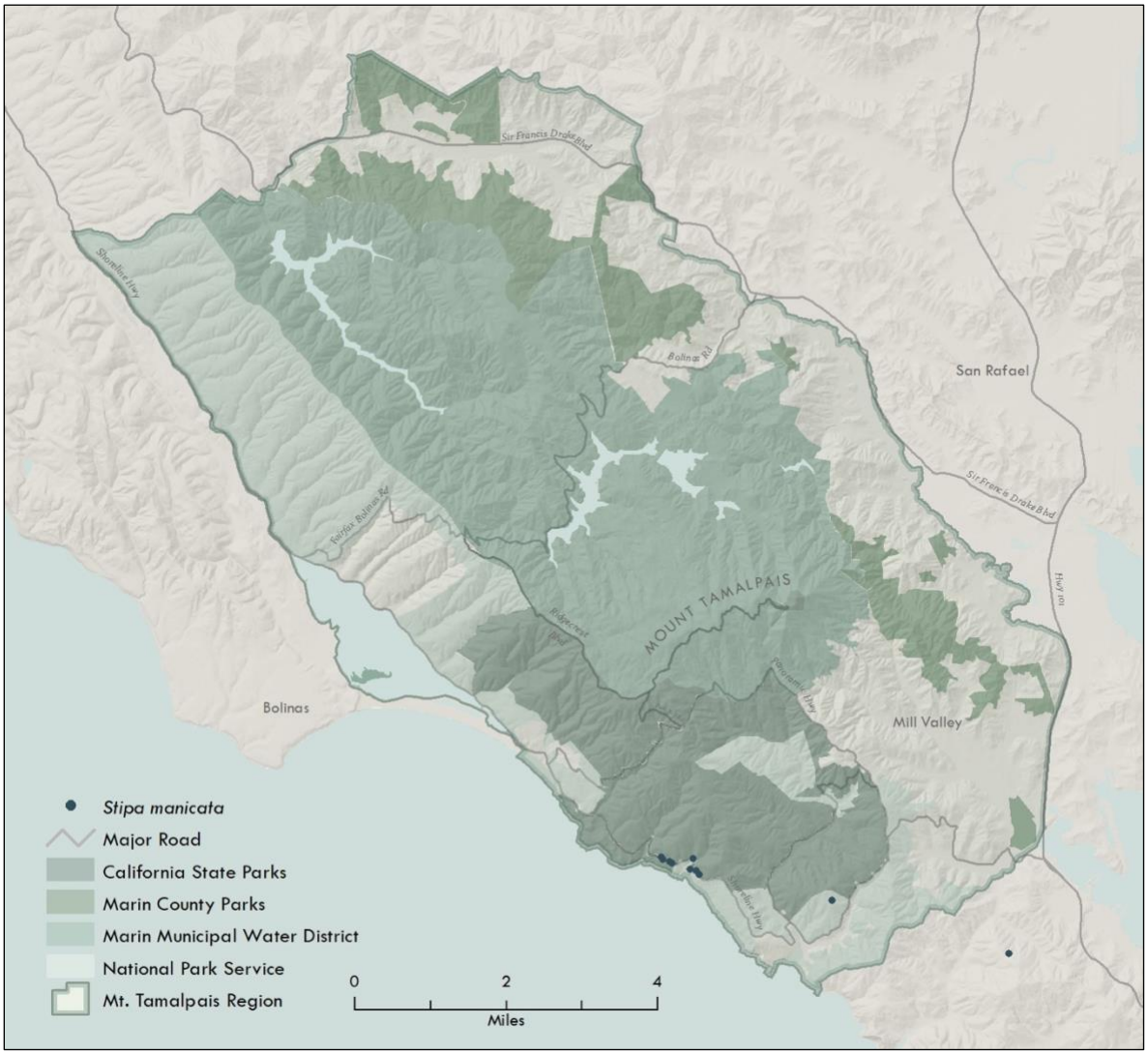
Priority One Table of Contents

STIPA MANICATA

Family: Poaceae
Cal-IPC Rating: Limited

Stipa manicata (Andean tussockgrass) looks very similar to its close relative *Stipa pulchra*, California's ubiquitous State Grass. Field identification of this perennial bunchgrass, which involves analyzing subtle details of the seeds, poses a challenge to comprehensive mapping. Most mapped occurrences are from areas where it was known to be accidentally planted—in one instance, Caltrans used Andean tussockgrass in a slope repair along Highway 1 thinking it was *Stipa pulchra*.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
8	5	0.01	0%

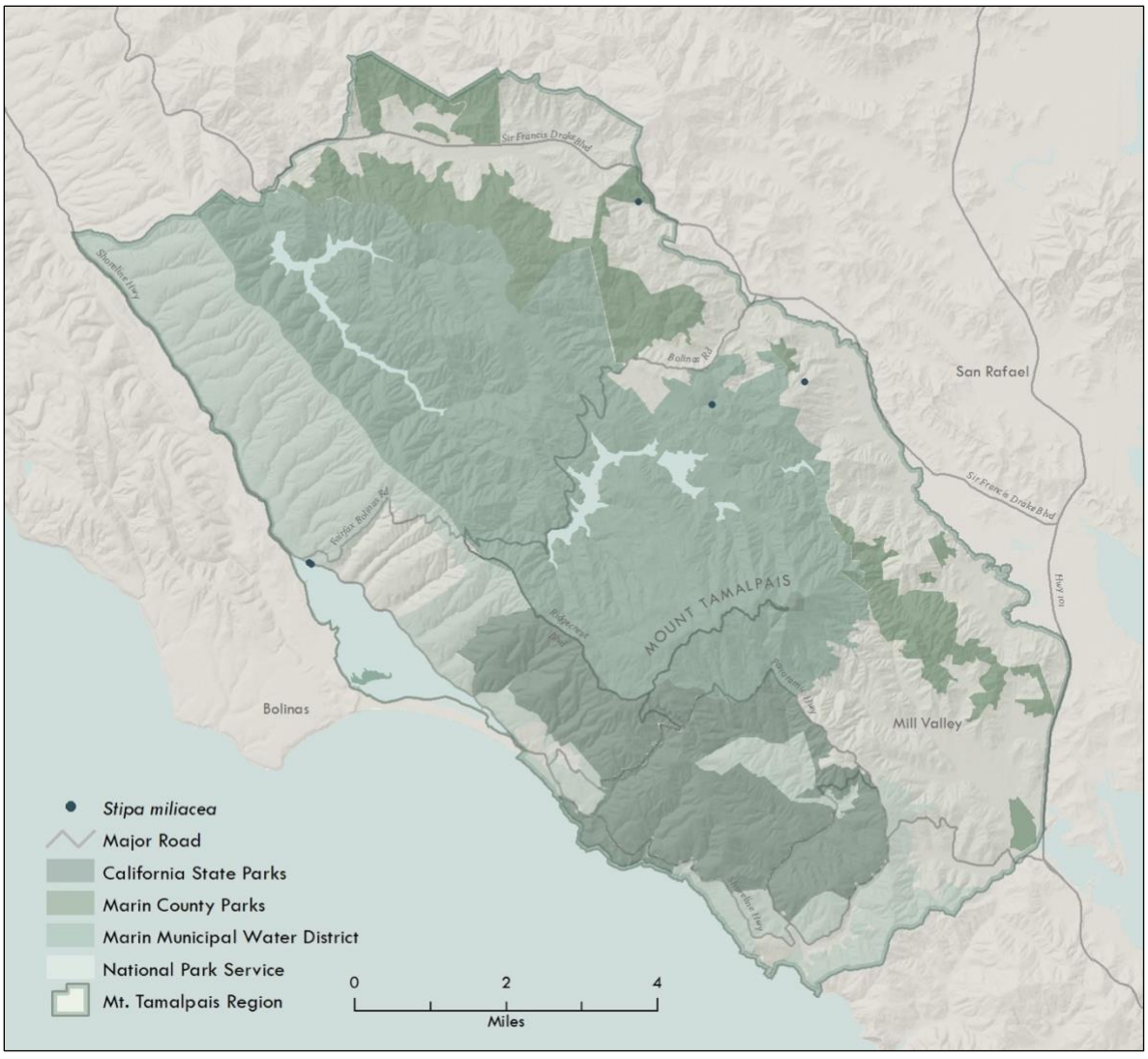
Andean tussockgrass occurs in the southwest quadrant of the Mt. Tamalpais region primarily along Highway 1 near the population planted by Caltrans. Treatment of that patch is complicated by the need for roadside erosion control on the steep slopes of the site. Trailing roadside patches are similarly in the Caltrans right of way with traffic hazards limiting options for treatment. A large occurrence also exists in the Marin Headlands near Fort Cronkhite, where it has become established following another accidental outplanting.

STIPA MILIACEA

Family: Poaceae
Cal-IPC Rating: Limited

Stipa miliacea (smilograss) lines several roadways in Marin, including stretches of Sir Francis Drake Boulevard in San Rafael and the San Geronimo Valley. Tiny seeds disperse on the wind and hitch rides around the county on vehicles, clothing, and wildlife. On Mt. Tamalpais this straggly perennial is often associated with construction sites, for example slide repair zones on Concrete Pipe Fire Road.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
12	0.06	< 0.01	54.2%

Smilograss occurs in the interior lands of MMWD as well as some coastal locations along Highway 1 south of Bolinas-Fairfax Road. Similar roadside patches occur along Sir Francis Drake Boulevard near MCP preserves. While the roadside patches are largely untreated, interior patches on MMWD land are under management.

Smilograss appears in the dataset as both *S. miliacea* and *S. miliacea* var. *miliacea*. In California, both of these names represent the same entity. The other described variety, *S. miliacea* var. *thomasii*, has never been recorded in the wild in North America.

Achnatherum miliaceum, Piptatherum miliaceum, and *Oryzopsis miliacea* are synonyms.

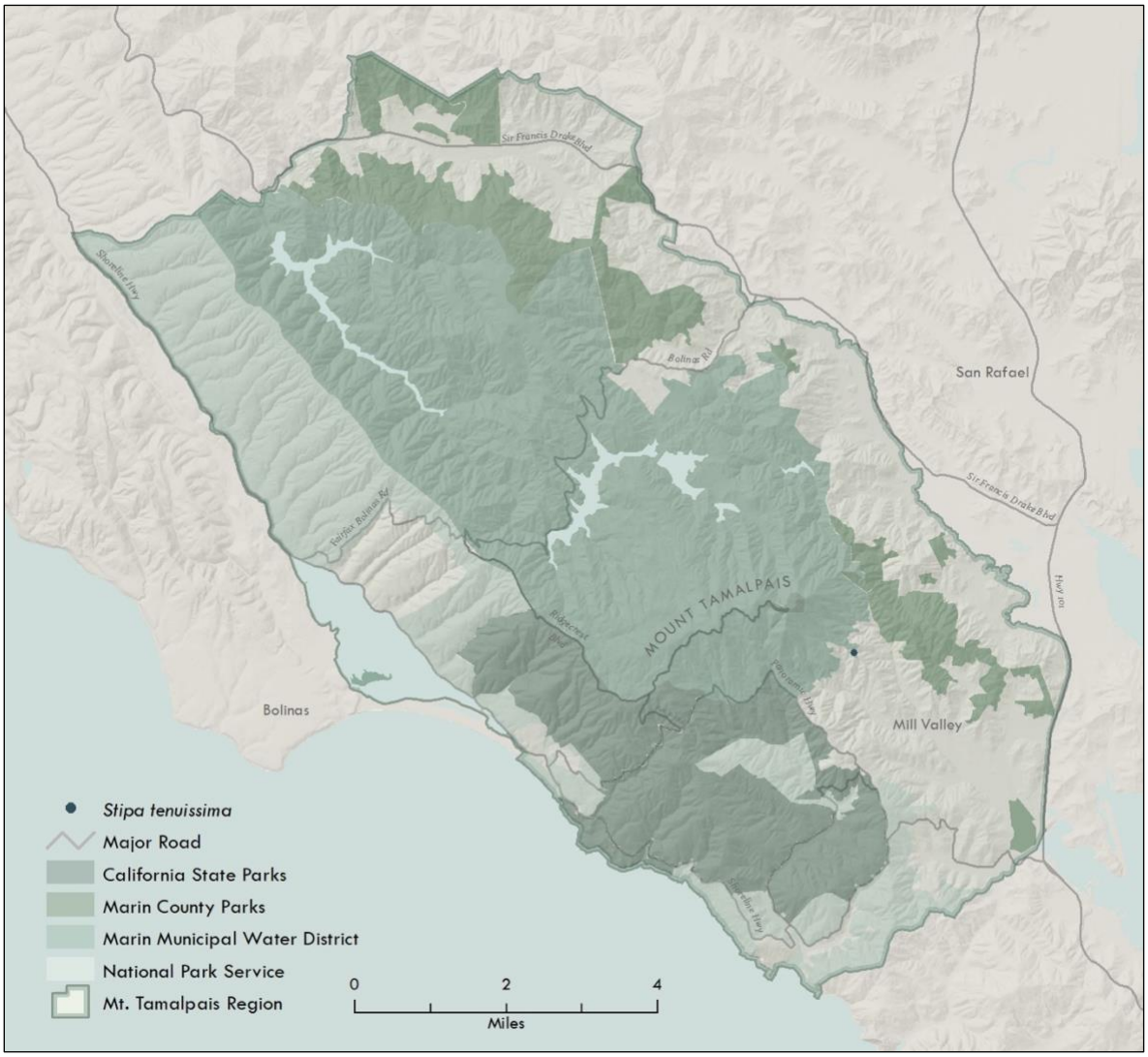
Priority One Table of Contents

STIPA TENUISSIMA

Family: Poaceae
Cal-IPC Rating: Watch

Dense yet delicate, *Stipa tenuissima* (Mexican feathergrass) has exploded in popularity as an ornamental throughout the Bay Area over the past ten years. Prized for its drought-tolerant nature and attractive tufts, extensive plantings were installed throughout the last decade. Tiny seeds with clinging awns ride wind currents, often germinating in sidewalk cracks adjacent to landscaping. Bird nests made entirely of Mexican feathergrass seeds and awns have been observed, indicating that wildlife move propagules as well.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
1	< 0.01	< 0.01	100%

To date, one lone Mexican feathergrass patch has been detected, on MMWD land near water tanks where it appears to have come in on service vehicles. That patch was removed and is now under surveillance. Roadside patches along Panoramic Highway and Highway 1 outside the Mt. Tamalpais region have also been documented. Several mapped patches occur on private lands. Vigilance along trails and disturbed areas near neighboring communities is recommended.

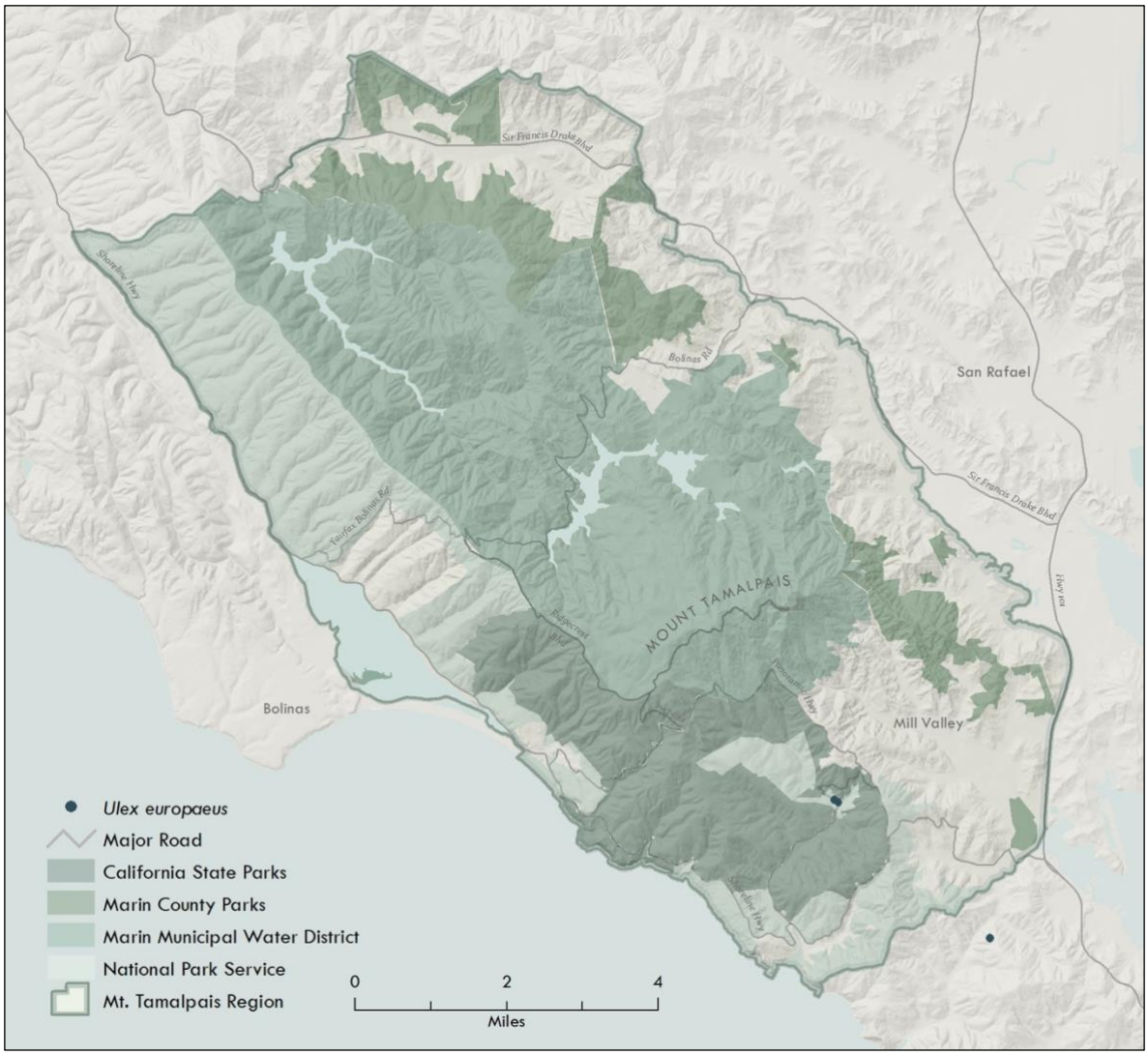
Nassella tenuissima is a synonym.

ULEX EUROPAEUS

Family: Fabaceae
Cal-IPC Rating: High

Among the invasive pea-family shrubs in the Bay Area, *Ulex europaeus* (gorse) stands out as a high priority for rapid response in part because of its growth habit. With stiff spines and a propensity for developing dense thickets, gorse presents significant treatment challenges once established. This species can impact visitor experiences when occurring near infrastructure or trails.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Net Acres	Percent Managed
2	0.15	0	100%

Two patches of gorse have been mapped in the Mt. Tamalpais region, both in the southeast corner of Muir Woods. These patches were treated many years ago and have not been found since, thus the population is believed to have been eradicated. Populations also occur outside the area along Tomales Bay, in Point Reyes National Seashore, and in the Marin Headlands. It is also mapped in the eastern area of the town of San Rafael.

List of Appendices

Appendix C. WHIPPET Analysis of Priority Two Species

INTRODUCTION

Vegetation managers across the Mt. Tamalpais region (Figure 1) manage dozens of invasive plant species each year under varying prioritization schemes. The One Tam collaborative has a ranking system for weeds in which agencies agree to treat all Priority One species (Appendix B) populations every year. On the other hand, an additional 39 species occur on the mountain in much wider, denser distributions, making it impossible to treat every patch every year with current and foreseeable funding resources.

THE **MT. TAMALPAIS REGION** DESCRIBES APPROXIMATELY 40,000 ACRES OF OPEN SPACE MANAGED BY THE PARTNERS OF THE ONE TAM COLLABORATIVE.

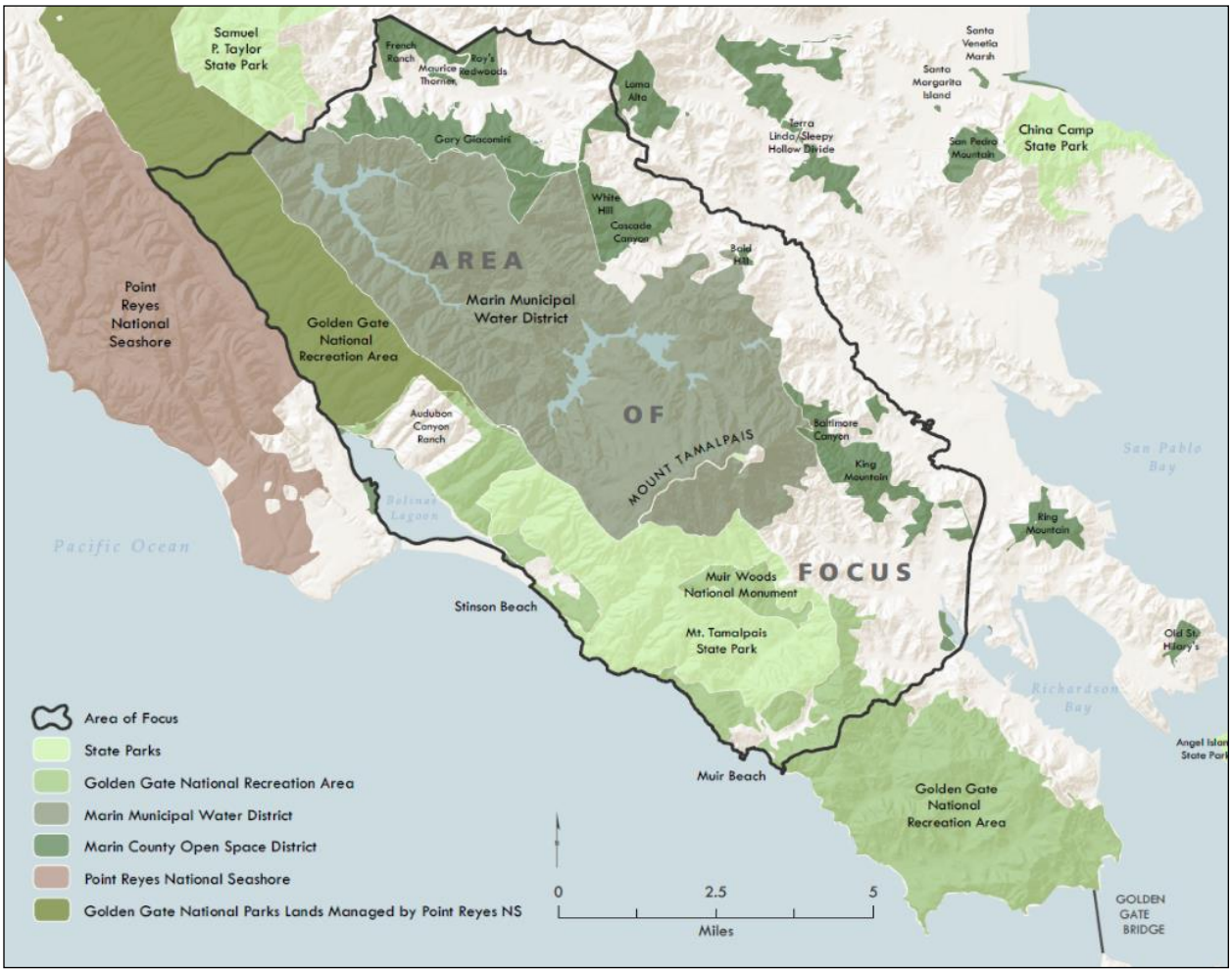


Figure 1. Four public agencies and a non-profit steward the lands of Mt. Tamalpais in Marin County, California. Together they form the One Tam collaborative. The Area of Focus in this map is also referred to as the Mt. Tamalpais region.

WHIPPET TOOL

The Weed Heuristics: Invasive Population Prioritization for Eradication Tool (WHIPPET) provides land managers with a systematic approach to selecting weed targets for eradication (Skurka Darin et al. 2011). The tool evaluates a suite of criteria related to species traits, geographic location, and cost. WHIPPET analyzes geospatial data with weed and vector locations in conjunction with tabular data about species traits and costs using various scoring criteria (Figure 2).

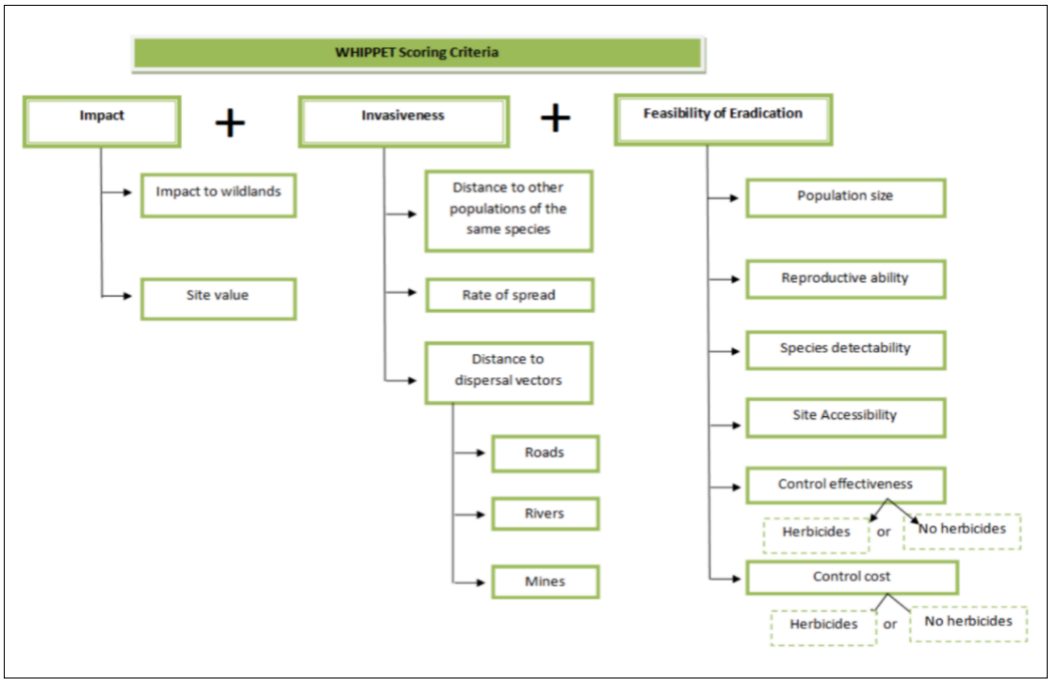


Figure 2. WHIPPET scoring criteria shown as a flow chart. (Skurka Darin 2011; Cal-IPC 2014)

Designed for use on California Department of Food and Agriculture's (CDFA) list of A-rated weeds (highest rating), WHIPPET offers a robust method of prioritizing infrequent weeds. Gina Darin worked with CDFA, the University of California, Davis, and the California Invasive Plant Council (Cal-IPC) to develop WHIPPET.

Five years into the One Tam partnership, most agency vegetation managers operate with an understanding of weed distributions on lands under their purview. Time constraints often preclude deeper analysis. With a survey of the road and trail network completed, One Tam took the opportunity to look at widespread weeds more holistically. WHIPPET offers a systematic framework for analyzing One Tam data.

In order to strategically assess invasive plant management strategies on the mountain, One Tam staff applied the WHIPPET tool to 32 widely distributed weed species across the Mount Tamalpais region. This analysis supports, but does not replace, vegetation management plans in place at any One Tam partner agencies. This supplemental approach to prioritization provides a regional perspective on weed distributions and management actions currently in progress.

Although WHIPPET provides some framing to a fundamental question—what species

should be managed and where?—it does not deliver a perfect list of weed patches to treat. The tool was originally designed for use on infrequently distributed species populations, and it seeks to rank the feasibility of eradication rather than mere control. One Tam used the tool for frequently distributed species where control is often the best-case outcome. While the tool design did not perfectly meet the needs of the One Tam prioritization, this heuristic approach delivered a useful framework for developing a regional strategy for widespread weed targets when paired with staff analysis.

METHODS

Weed species occurrence data used for the WHIPPET analysis came from the Calflora Database, where One Tam agencies host the majority of their invasive plant data. The parameters used to export a working dataset included the following:

- Species is on the One Tam Priority Two species list (Table 1)
- Species is evaluated in the Cal-IPC Inventory
- Observation date is from 2009 through 2019
- Occurrences are within the Mt. Tamalpais region plus a one-mile buffer
- Data is included in a project within agency Calflora groups
- Search filtered by 'most recent' to produce one record per history stack

Priority Two Species	
Acacia melanoxylon	*Genista monspessulana*
Ageratina adenophora	*Hedera canariensis*
Arctotheca prostrata	*Hedera helix*
*Calendula arvensis**	*Helichrysum petiolare*
Centaurea solstitialis	*Hypericum perforatum*
Cortaderia jubata	*Ilex aquifolium*
Cortaderia selloana	*Lathyrus latifolius**
Cotoneaster franchetii	*Leucanthemum vulgare*
Cotoneaster lacteus	*Ligustrum lucidum**
Cotoneaster pannosus	*Pennisetum clandestinum*
Crataegus monogyna	*Phalaris aquatica*
Cytisus scoparius	*Pittosporum crassifolium**
Delairea odorata	*Pyracantha angustifolia*
Digitalis purpurea	*Romulea rosea* var. *australis**
Dipsacus fullonum	*Rubus armeniacus*
Ehrharta erecta	*Rytidosperma caespitosum***
Eucalyptus globulus	*Rytidosperma penicillatum*
Euphorbia oblongata	*Spartium junceum*
Festuca arundinacea	*Tradescantia fluminensis**
Foeniculum vulgare	

Table 1. Priority Two species on the One Tam EDRR list.
*Species not covered by this prioritization because they do not appear in the Cal-IPC inventory.
**Species absent from the survey area and therefore not incorporated.

Several of the WHIPPET equation variables are drawn directly or indirectly from this dataset: population size, distance from nearest conspecific population, and difficulty of site access. Other variables are derived from assorted data sources (Table 2).

Data	Use	Source
Road and trail GIS layer	Applied to vector spread model	Agency data
Stream GIS layer	Applied to vector spread model	Agency data
Site value layer	Ranks importance of occurrence based on overall value of geographic area in which it occurs	Agency data
Species traits tabular data	Ranks species traits such as rate of spread and treatment cost	WHIPPET

Table 2. Data inputs for WHIPPET model.

Data downloaded from Calflora starts as a suite of three shapefiles for each species: points, lines, and polygons. The download contained over 15,000 records, each conceptually representing a mapped patch of weeds. Using ArcGIS, these patches were all converted to polygons and buffered by 30 meters, or roughly 100 feet. This distance was chosen as it had been successfully employed for the same purpose by the Bay Area Early Detection Network. The results were dissolved where overlap occurred to create a standardized representation of each plant's population distribution (Figure 3).

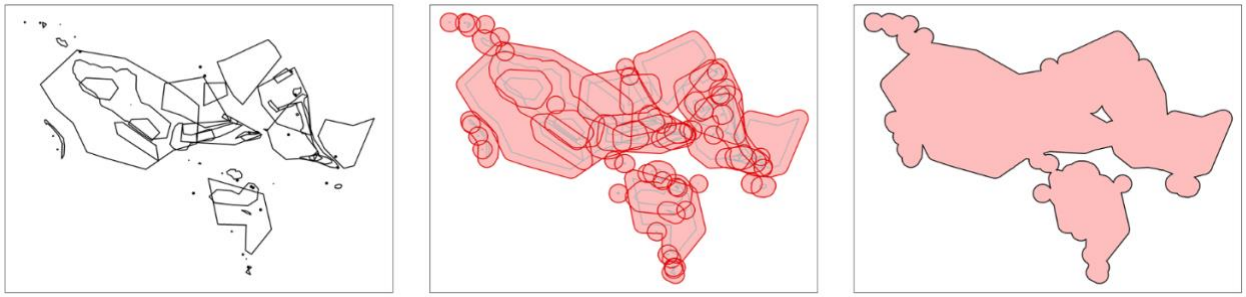
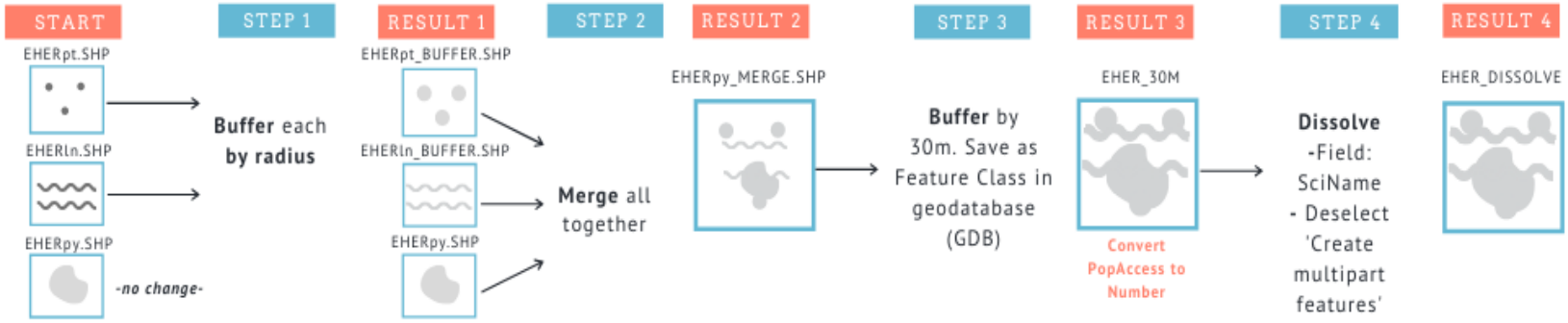
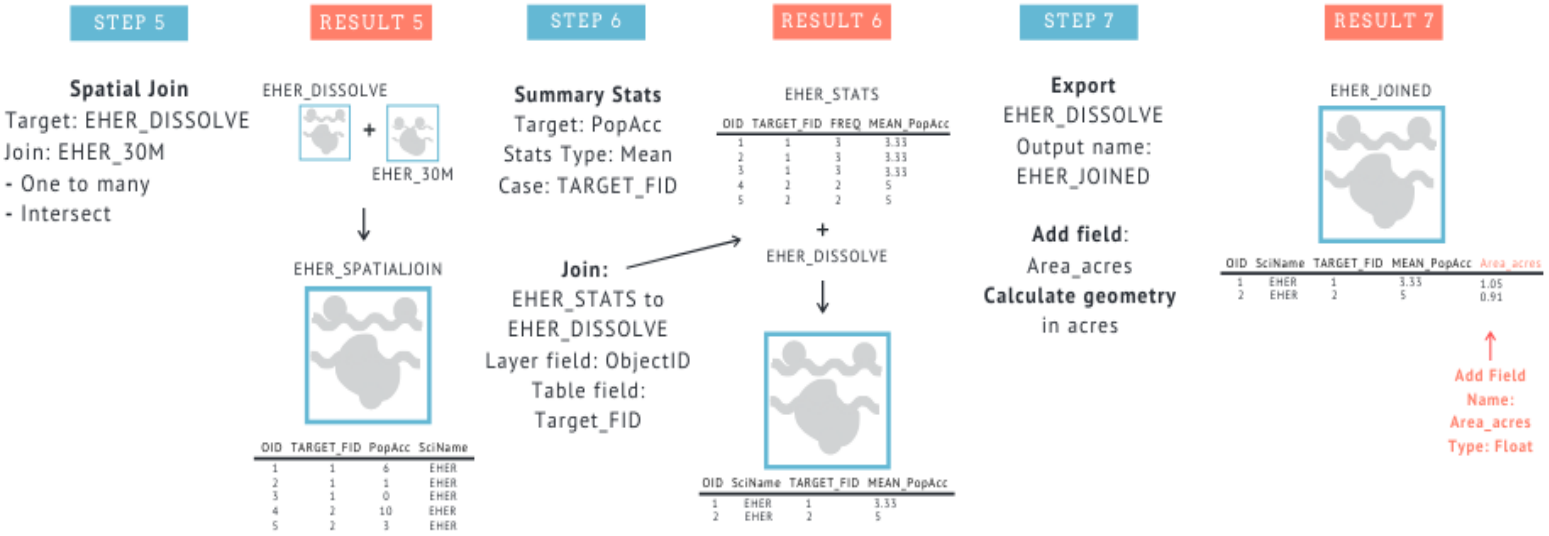


Figure 3. Converting occurrence data into populations. Panel 1 shows a localized cluster of 67 individually mapped records of *Ageratina adenophora* downloaded directly from Calflora. The overlapping, redundant nature of these features is incompatible with the concept of population prioritization. To solve this issue, the features were buffered by 30 meters (panel 2) and then dissolved into one single polygon representing a population of the weed (panel 3) that could be properly assessed.

This geospatial simplification brought the dataset down to under 6,000 records. These population polygons were used to calculate area, and the centroids of these polygons were used to calculate distances to nearest neighbor and to spread vectors. The tabular data was then run through the WHIPPET calculator in Microsoft Excel, resulting in a priority score for each population. An in-depth workflow for the steps leading up to the WHIPPET calculations is provided in Figure 4.

WHIPPET WORKFLOW





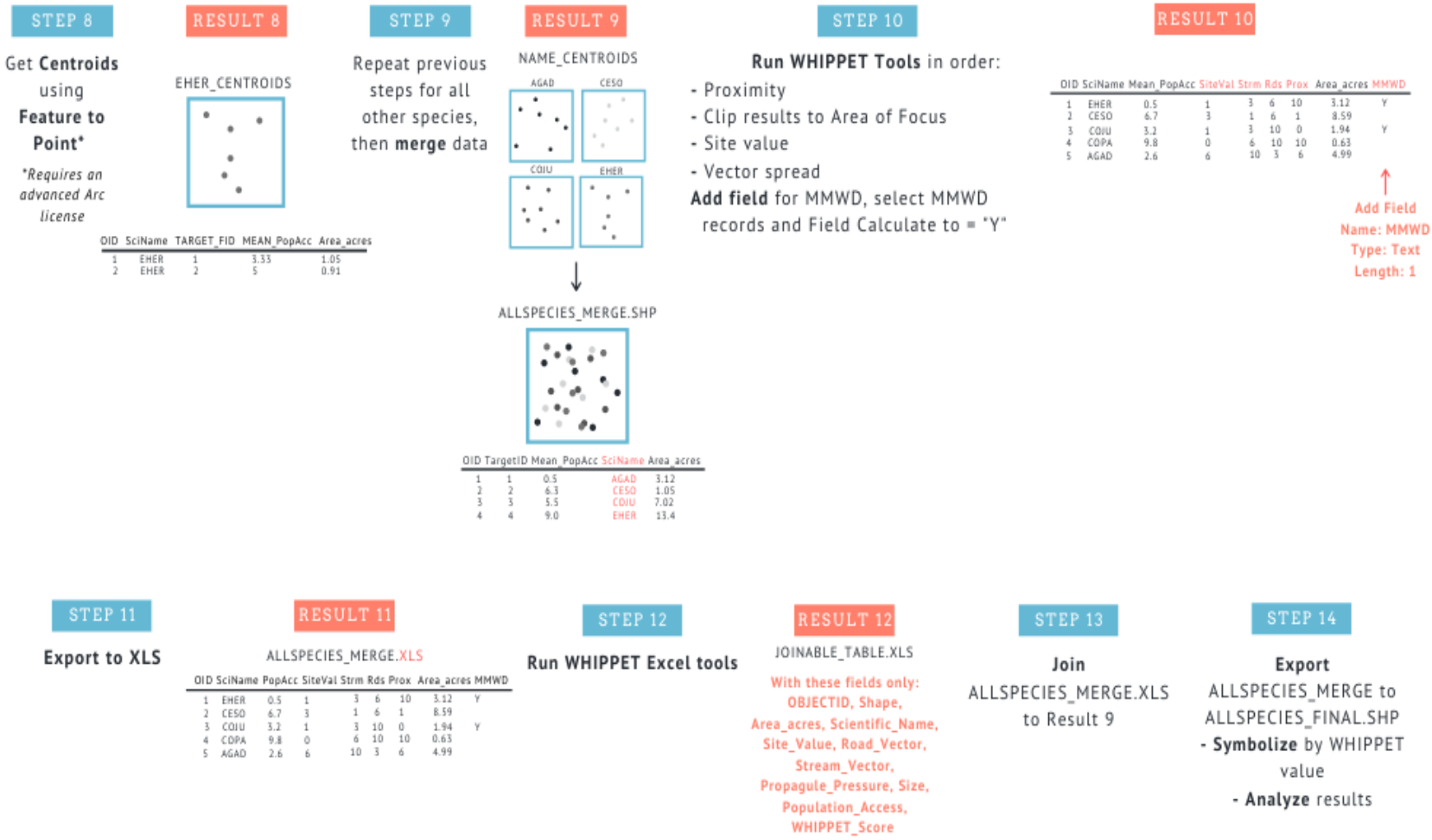


Figure 4. GIS workflow for dissolving discreetly mapped patches into polygons for use in the WHIPPET tool. This workflow allows the user to retain valuable attribute data stored in the Calflora system.

LIMITATIONS AND SOURCES OF ERROR

While WHIPPET incorporates a host of important criteria, it does not include every factor a land manager may consider important. Criteria excluded from the WHIPPET model include topography, population management status, and the presence of high-value resources, except as is captured by site values. Site values were developed by each agency, not as a collaborative. Furthermore, the tool does not account for the cost savings of initiating work within active restoration sites, or any other site-specific priorities.

- Calflora export
    - Some point and line records have blank gross area.
        - Resolution: Populate radius to equal one meter and recalculate area.
    - History stacking, a Calflora technique, is lacking across the dataset.
        - Resolution: Records that belong in a history stack are assimilated into a single population through the buffer + dissolve process.
    - A small subset of records represents absence data.
        - Resolution: Staff analysis of WHIPPET results should reveal any of these records, which can be eliminated from the prioritization.
- GIS Exercises/choices
    - Buffer distance of 30 meters chosen out of heuristic simplicity and in consultation with local ecologists.
    - Patches within a single population often have different site access values.
        - Resolution: Calculate the mean in these cases.
- WHIPPET
    - Preset calculators use inappropriate distances for The Mt. Tamalpais region.
        - Resolution: Alter code blocks to use smaller, more appropriate distances.
    - Tool uses centroid points to rank distance from conspecific neighbor and spread vectors. Population edges may in fact be far closer together than centroids.
    - Topography is not factored into the calculation.
    - Management status is not factored into the calculation.
- Data In
    - Site value scores are determined subjectively and vary dramatically across agencies in size and precision.
    - No single road and trail dataset for the area is both comprehensive and entirely accurate.

RESULTS

Theoretically, the WHIPPET equation can produce scores between 0 and 10. High scores connote high priority and high feasibility of patch eradication, while low scores connote

the opposite. In total, 5,373 total invasive species populations were assessed through the tool.

A population of *Foeniculum vulgare* claimed the highest score of the entire dataset at 8.28. A *Euphorbia oblongata* population took the lowest score at 2.97. Between those two bounds, the scores showed an approximately normal distribution (Figure 5).

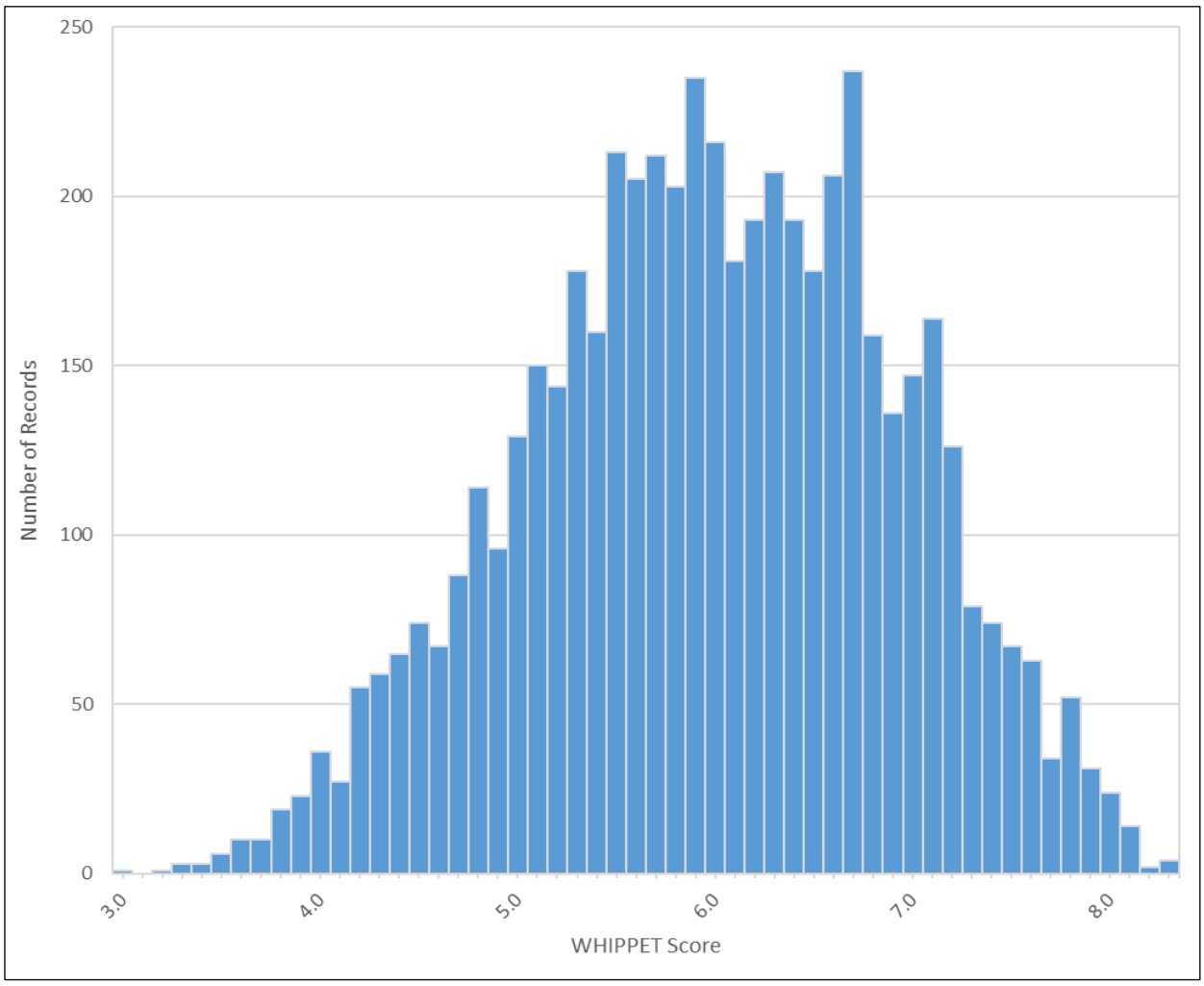


Figure 5. WHIPPET Score distribution histogram. n = 5,373

Several species clearly rose to the top of the rankings. *Cortaderia jubata*, for example, occupied 45 of the top 100 scores, *Hedera helix* and *Hedera canariensis* taken together accounted for 24, and *Rubus armeniacus* another 15. These four plus *Cortaderia selloana* made up the top 5 species in average score (Table 3). Notable among species at the bottom of average scoring is *Helichrysum petiolare*, the regional significance of which is perhaps understated by the tool.

Species	Min	Max	Mean
Cortaderia jubata	4.74	8.25	6.84
Cortaderia selloana	6.06	7.47	6.78
Hedera canariensis	5.17	7.97	6.63
Hedera helix	4.79	8.20	6.57
Rubus armeniacus	4.86	8.06	6.54
Genista monspessulana	4.27	7.80	6.45
Foeniculum vulgare	4.97	8.28	6.44
Delairea odorata	4.97	7.94	6.39
Ilex aquifolium	5.28	7.77	6.37
Arctotheca prostrata	5.17	7.24	6.29
Cytisus scoparius	4.22	8.05	6.23
Cotoneaster pannosus	4.53	7.67	6.04
Cotoneaster franchetii	4.34	7.41	6.03
Cotoneaster lacteus	5.17	7.48	6.02
Leucanthemum vulgare	4.77	6.94	5.86
Spartium junceum	4.74	7.46	5.86
Dipsacus fullonum	4.49	6.94	5.76
Ageratina adenophora	4.53	7.12	5.74
Pyracantha angustifolia	4.44	7.35	5.55
Hypericum perforatum	5.01	6.22	5.52
Eucalyptus globulus	3.72	7.18	5.51
Phalaris aquatica	3.86	7.04	5.45
Centaurea solstitialis	3.29	6.96	5.39
Pennisetum clandestinum	4.17	6.40	5.35
Ehrharta erecta	3.29	6.79	5.26
Crataegus monogyna	3.84	6.80	5.18
Acacia melanoxylon	3.55	6.66	4.97
Festuca arundinacea	3.32	6.32	4.88
Rytidosperma penicillatum	3.20	6.08	4.80
Digitalis purpurea	3.43	6.08	4.77
Helichrysum petiolare	3.34	6.07	4.66
Euphorbia oblongata	2.97	6.11	4.50

Table 3. WHIPPET statistics for all species evaluated in the assessment, sorted by mean score.

WHIPPET scores for populations on MMWD land are consistently lower than on any other agency's land, due to the WHIPPET evaluation of treatment effectiveness and cost when chemical methods are not an option. This has a damping effect on a given species' minimum and mean scores that must be considered when interpreting the analysis on a regional level.

RECOMMENDATIONS BY SPECIES

After running the WHIPPET tools, staff analyzed the results toward a deeper prioritization and synthesis. Because WHIPPET evaluates populations by species, this analysis takes a similar approach. Congeneric species, including those in *Cortaderia, Cotoneaster,* and *Hedera*, were assessed together in their respective groups. Due to similarities in invasiveness and treatment strategy, the three brooms are also grouped into a single profile despite hailing from different genera.

While One Tam has found a workable goal for managing Priority One early detection species widespread weeds require deeper consideration. These recommendations and

the map products offer a starting point for collaborative discussion of a regional strategy for widespread weed management. These products provide a regional-scale perspective on species distributions and treatment to date. Despite strong collaboration on weed management, most One Tam partner staff do not work across jurisdictions enough to carry an understanding of weed distributions beyond their agency borders. The EDRR survey of the road and trail network provided an opportunity to synthesize this information toward a regional strategy.

HOW TO USE THIS ANALYSIS

Each species account includes a repeating framework with the following components.

- Species description
- Regional distribution
- Map
- WHIPPET score
- Recommended treatment strategy
- Future management recommendations

To learn more about a species, follow the hyperlink to the Cal-IPC profile page. Each of those webpages contains a link to the *Weed Control in Natural Areas in the Western United States* (DiTomaso et al. 2013) for treatment options. This document covers those topics lightly in favor of focusing on a regional control strategy. Staff considered treatment options limitedly during the prioritization.

Some terminology in this report requires definition for clarity. Like applying a heuristic model to invasive plant data, the use of terms including *region, patch* and *population* comes with tradeoffs. For the purposes of this analysis, *region* refers to the One Tam area of focus. *Patch* refers to the data derived from dissolving overlapping records exported from Calflora. The term *population* refers to the buffered and dissolved data, as described in the Methods section. *Eradication* refers to the reduction of a population of invasive plants to zero plants for at least five years.

With this framework in place, staff analyzed species populations using the WHIPPET scores and management status. The team also used their knowledge of sites including topography and the presence of sensitive species or habitats. An understanding of staffing resources and agency priorities also informed the prioritization. Treatment limitations range from prohibitions on chemical treatments on MMWD land to access limitations on roadsides. These considerations also factored into the overall treatment strategies presented here.

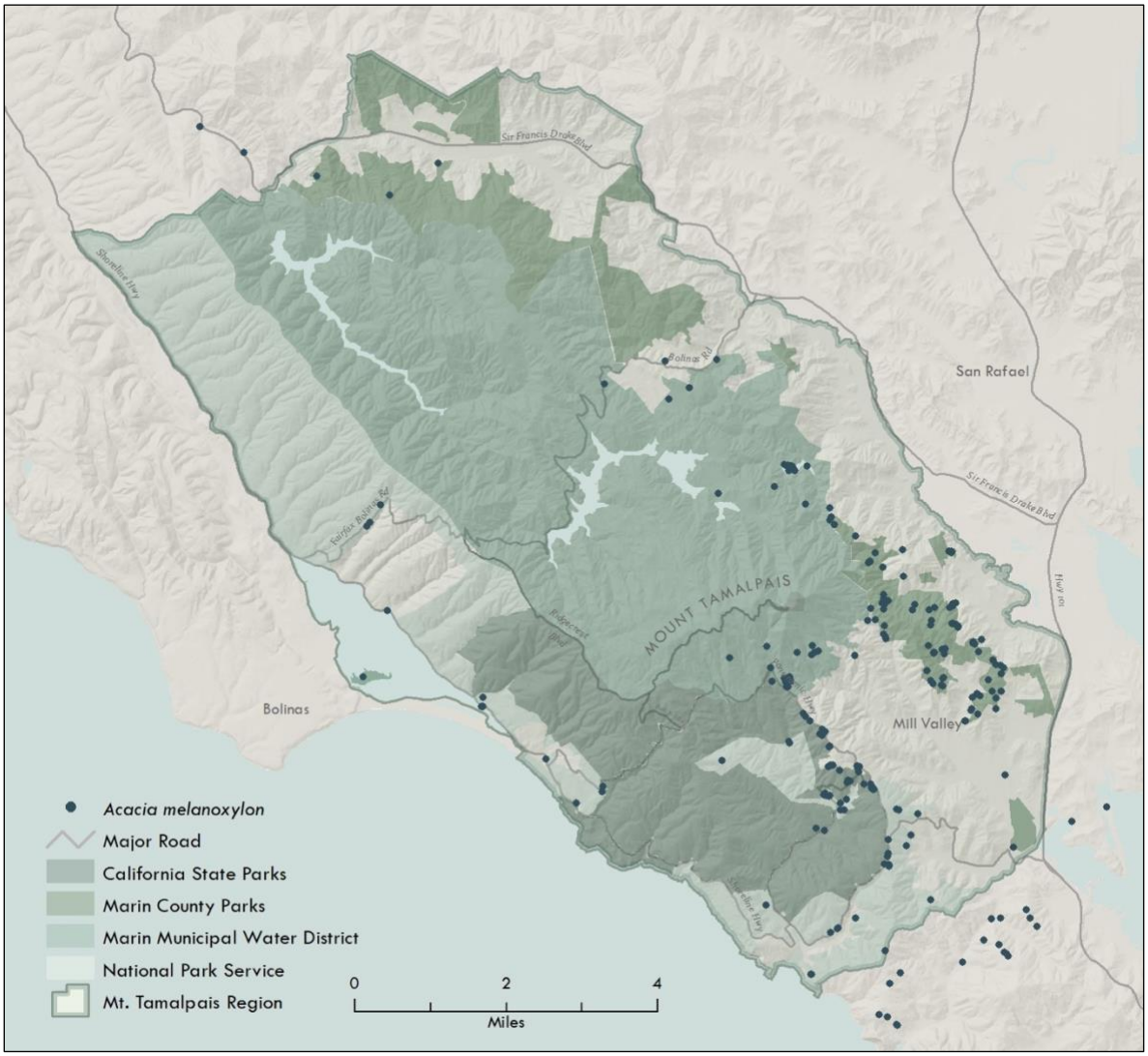
Maps are included to provide an overview of the regional distribution of each species or genus grouping when species are lumped. For those who want to zoom in to the patch level data, a map package will follow this report. One Tam staff will present the results and demonstrate how to navigate the geodatabase and map products. Similarly, all source data for this report are permanently available in the Calflora Database.

ACACIA MELANOXYLON

Family: Fabaceae
Cal-IPC Rating: Limited

A popular and swift growing tree, *Acacia melanoxylon* (blackwood acacia) is a common ornamental on private lands. Planted stands of blackwood acacia may encroach into wildlands. With heavy seeds and clonal growth, spread tends to occur incrementally from established plantings. This species can have long-lasting soil impacts through allelopathy and nitrogen fixation.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
165	129	28.24

This species occurs from Coyote Ridge in the south to Gary Giacomini Preserve in the north. It has populations as far west as Kent Island and as far east as King Mountain. Despite this distribution in all quadrants of the region on each agency's land, the species clusters south of the peaks and skews more inland than coastal.

Treatment history of this species includes work on all agency lands. State Parks has undertaken extensive treatment east of Muir Woods. NPS has treated areas near Diaz and Coyote Ridges as well as on lands near the Muir Beach and Stinson Beach communities. MMWD has treated patches south of the peaks, often in the course of fuel reduction work. MCP has treated patches at Gary Giacomini and Kings Mountain. This leaves extensive populations at the Blithedale Summit/Baltimore Canyon complex as well as on MMWD lands and near Homestead Valley on NPS land.

WHIPPET Scores

3.55 – 6.70

Concentrations of high scores occur north of Audubon Canyon ranch on NPS land (treated) as well as in the northwest corner of Muir Woods (untreated). Populations at the north end of Green Gulch (treated) and at the north end of Gary Giacomini (unknown treatment history) also rank highly. Other high scores include scattered areas in the Blithedale Summit area (untreated). Outliers on MMWD do not rank highly, likely because treatment costs for eradication are very high for this species without chemical treatment options.

Recommended Treatment Strategy

Treat in high-value areas.

Justification: The incremental spread of this species allows for a measured approach. Treatment options on MMWD land are highly limited. This approach aligns with current management status, which can protect valuable resources.

Future Management Recommendations

MCP

- Continue treatment in Gary Giacomini.

MMWD

- Treat as indicated by site-specific priorities.

NPS

- Continue treatment on Green Gulch and Bolinas-Fairfax Road populations.
- Initiate treatment on Muir Woods population.

State Parks

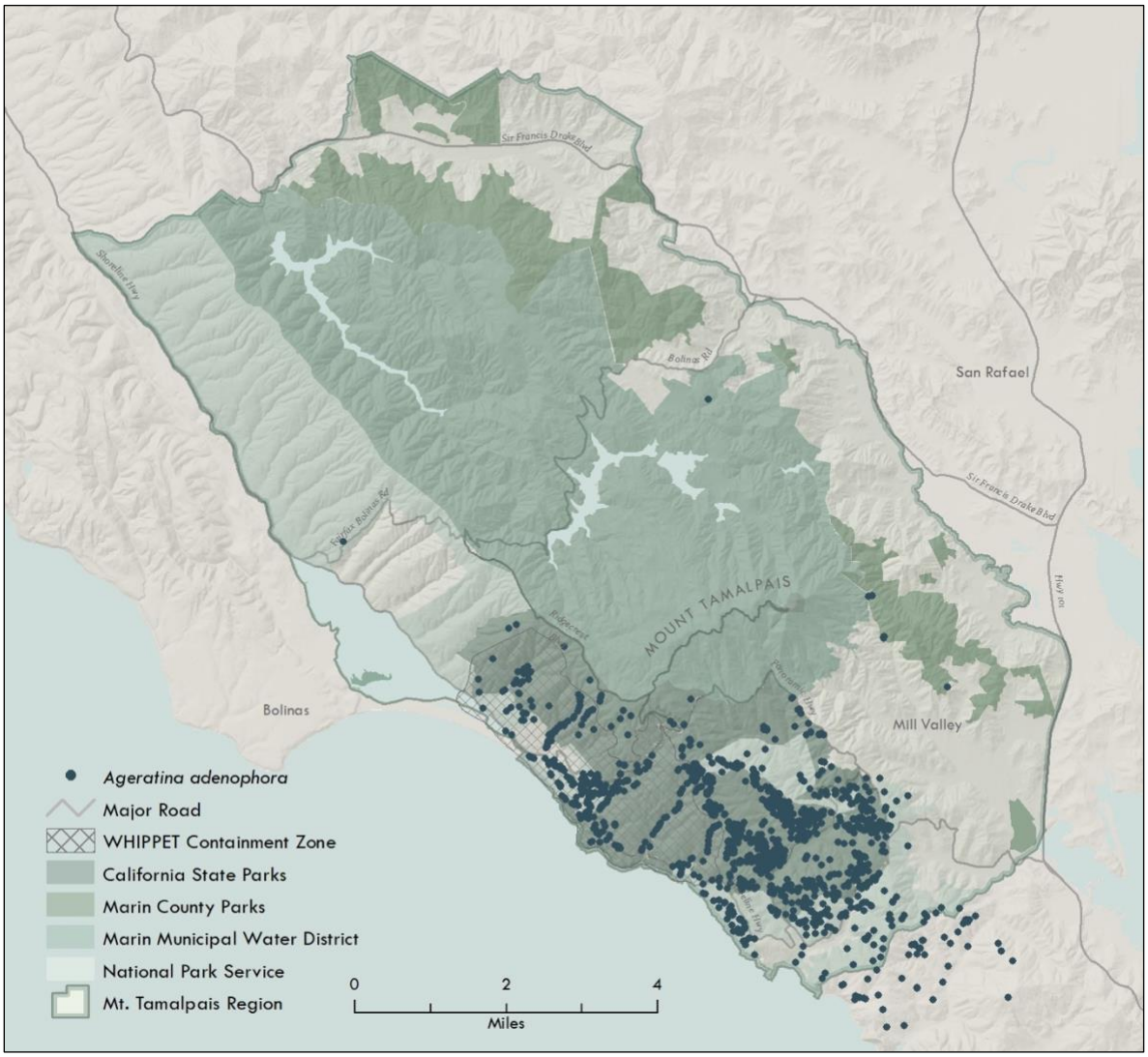
- Continue treatment east of Muir Woods.

AGERATINA ADENOPHORA

Family: Asteraceae
Cal-IPC Rating: Moderate

Ageratina adenophora (thoroughwort) is a perennial subshrub native to Mexico. Its introduction to California via the horticultural trade nearly 100 years ago has led to multiple escapes and establishments along the southern half of the state's coast. Marin County is the northernmost reported station for this species, lending a special import to the broader conservation implications of regional management. Thoroughwort is a moisture-loving plant, and as such it shows high fidelity to coastal fog zones and riparian systems. Apomictic reproduction and wind-dispersed seeds readily spread this species on Mt. Tamalpais' coast-facing slopes and in disturbed lowlands.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
1,174	479	184.37

Thoroughwort is largely confined to the southern end of the Mt. Tamalpais region, where foggy coastal scrub provides its favored habitat. Almost all populations lie in the Redwood Creek Watershed or the slopes below the Ridgecrest grasslands. Outliers beyond these confines are of highest management importance.

The northernmost occurrence in California was detected in 2008 on NPS land just north of the Mt. Tamalpais region—this patch was treated and has since been confirmed eradicated (zero plants found in 2018). MMWD's only known occurrence, a single plant in the Fairfax Hills area, was removed in 2016 and is under annual surveillance. The westernmost known population, another single plant along Bolinas-Fairfax Road on NPS land, was detected and removed in 2018. Four MCP populations have been mapped in the Blithedale/Baltimore Canyon region and are largely under management.

Significant infestations have been mapped in several Bolinas Ridge gulches, but not every gulch has been surveyed. It's possible that this species is more widespread than currently mapped on Bolinas Ridge.

WHIPPET Scores

4.53 – 7.12

Thoroughwort scores fall in the lower, middle, and upper tiers of all rankings. Clusters of high scores are mainly found in and around Muir Woods. The 10 highest scores are all under management already by agency or One Tam staff.

Recommended Treatment Strategy

Continue treatment and annual monitoring of northern outliers. Initiate treatment of populations in Ridgecrest grasslands. Institute containment downslope of these grasslands from the forest boundary all the way to the coast. Continue Redwood Creek management according to collaborative goals, with an emphasis on keeping the species out of Muir Woods.

Justification: Outliers beyond the major infestation are good targets for eradication. The proposed containment zone circumscribes dozens of large unmanaged populations, along with some areas of focused management—reintroduction potential is inescapable at the current level of treatment effort.

Future Management Recommendations

MCP

- Verify status of Blithedale Summit/Baltimore Canyon complex populations. If extant plants are found, initiate or continue treatment.

MMWD

- Continue annual surveillance of lone population on Concrete Pipe Road until eradication status is achieved.

NPS

- Continue annual surveillance of Bolinas-Fairfax Road population until eradication status is achieved.
- Defer action north and east of Stinson Beach.
- Treat populations within containment zone according to agency directives.
- Continue follow-up in Muir Woods.
- Survey Bolinas Ridge drainages to determine true extent.

State Parks

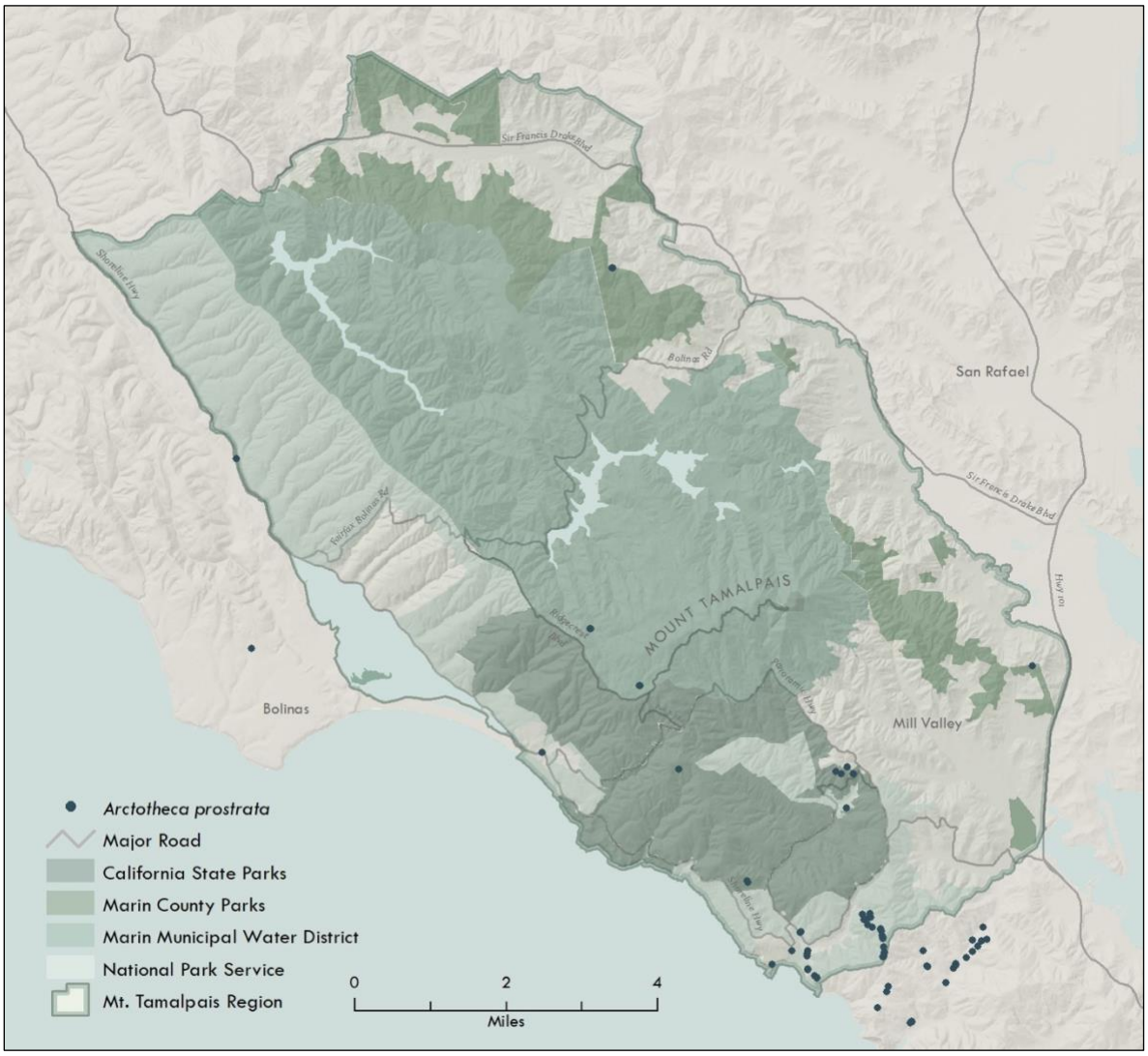
- Initiate treatment on all unmanaged populations in and around Ridgecrest grasslands.
- Continue follow-up and monitoring on all previous managed populations in and around Ridgecrest grasslands.
- Establish containment line approximately at grassland-forest interface below Ridgecrest.

ARCTOTHECA PROSTRATA

Perennial herb
Cal-IPC Rating: Moderate

Arctotheca prostrata (prostrate capeweed) is a creeping herb native to South Africa. This species is widely used in landscaping as a low-maintenance groundcover due to its rosette-forming habit with fast-spreading stolons. Escapes occur exclusively via fragmentation and vegetative spread—prostrate capeweed flowers are infertile. As such, most detections occur near buildings and residential areas where it had been planted, and along heavily trafficked trails.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
45	27	0.97

This species is widespread in the Marin Headlands, and its northward thrust extends into the Mt. Tamalpais region most densely around Coyote Ridge and Muir Beach. Other blips appear around the mountain's periphery, but very few occurrences are known from undisturbed interior habitat.

WHIPPET Scores

5.17 – 7.24

Several uppermost scores, including the highest overall mark, belong to populations either on private property. The highest-scoring population in a wildland setting is in a weedy spring along Dipsea Trail above Lone Tree Creek.

Recommended Treatment Strategy

Treat in high-value areas only.

Justification: Prostrate capeweed has significant impacts to wildlands but has trouble reaching them in the first place. Low-quality habitats such as heavily compacted trailsides, historic homesteads, and neighborhood lawns host the bulk of this plant's distribution in the region.

Future Management Recommendations

MCP

- None

MMWD

- Continue follow-up treatment on Rock Spring population.

NPS

- Continue early detection in the Muir Beach area to prevent encroachment into California red-legged frog habitat.

State Parks

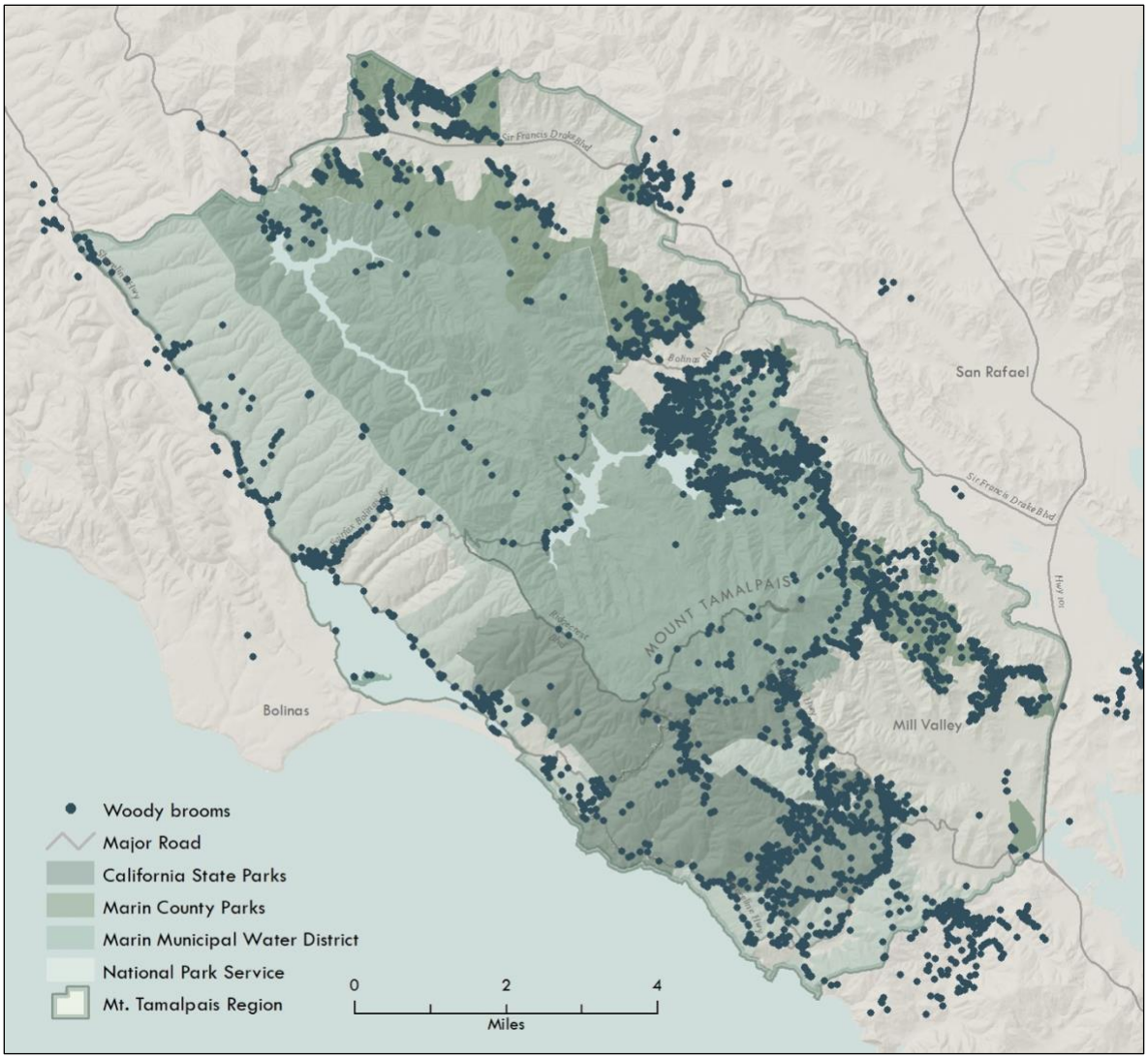
- Assess feasibility of management at Dipsea Trail population—several other high-scoring weed patches occur at that locality that may merit treatment, including *Foeniculum vulgare, Hedera spp.,* and *Cotoneaster pannosus*. Consider entire suite together.

BROOMS

Family: Fabaceae
Cal-IPC Rating: High

Four broom species occur in the Mt. Tamalpais region. The EDRR collaborative classifies one of them, *Cytisus striatus* (Portuguese broom), as a Priority One species. Priority Two broom species include *Cytisus scoparius* (Scotch broom), *Genista monspessulana* (French broom), and *Spartium junceum* (Spanish broom). For the purposes of the WHIPPET prioritization, these three species are lumped for analysis. The brooms readily invade grassland, woodland, disturbed areas, and coastal scrub, creating dense infestations and deep, long-lived seedbanks. Like many species in *Fabaceae*, these shrubs fix atmospheric nitrogen, enriching soil to the disadvantage of many native species (Haubensak et al. 2004). These legacy effects persist after broom removal.

Regional Distribution



Occurrence Details

	Patches	Populations	Gross Acres
Cytisus scoparius	475	200	191.26
Genista monspessulana	1,262	477	3,710.16
Spartium junceum	63	37	51.72

Well-known in Marin, French broom has an oppressive reach in the Mt. Tamalpais region. While the eastern and southern portions of the region have the most extensive populations, this species occurs throughout the area, often in large, contiguous populations. Scotch and Spanish brooms cover far fewer acres, concentrating inland, often mixing with French broom.

These species are well-mapped by surveyors and treatment staff. Special efforts to map broom include a five-year cycle at MMWD to map all broom on the watershed.

Treatment of broom species is highly prioritized by agency staff. Rigorous plans exist for MMWD and MCP lands. Many of the broom populations on NPS land are under routine management, as evidenced by the data from Calflora. All agencies have some areas under management and some in a deferred action or containment status, often along inaccessible roadsides.

WHIPPET Scores

Cytisus scoparius 4.23 – 8.05

Genista monspessulana 4.27 – 7.80

Spartium junceum 4.74 - 7.46

Somewhat surprisingly, all three brooms have populations in the high and middle tiers. High scores do not cluster tightly as they only occur on populations under 5 square meters and out of range of other broom populations. All scores over 7.5 are under management, unless they are on Panoramic Highway or Highway 1 roadsides. This indicates that land managers have rigorously prioritized their broom management. One area that emerges as having interrupted management and a higher priority is the band from approximately Bootjack to Pantoll Campground, mostly above Panoramic Highway and up toward the hairpin on Pan Toll Road.

Recommended Treatment Strategy

Proceed with existing agency prioritization plans. Consider undertaking deeper analysis of populations along property boundaries, including the area along Panoramic Highway from Bootjack to Pantoll.

Future Treatment Recommendations

All Agencies

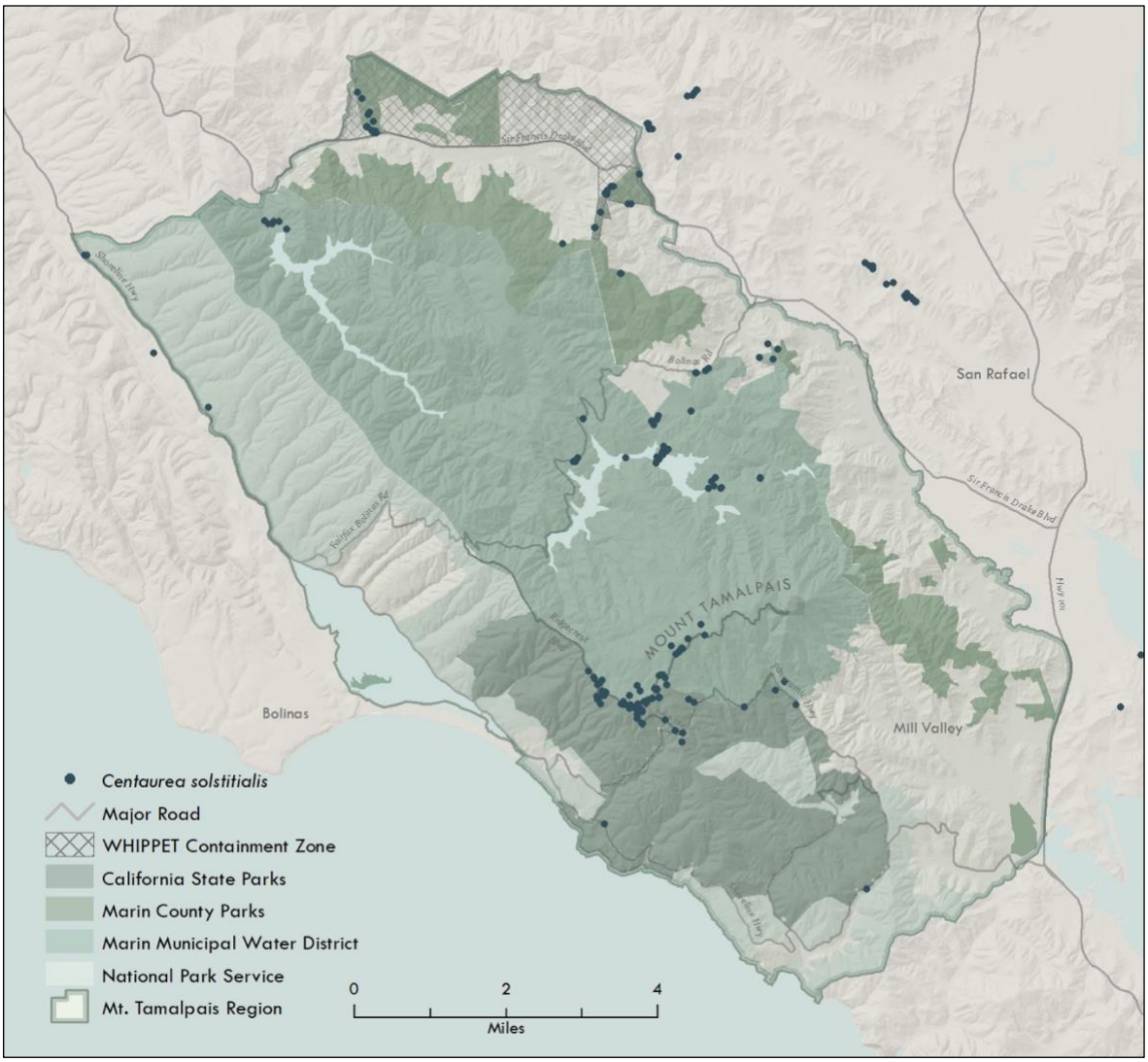
- Continue treatments on EDRR surveys

CENTAUREA SOLSTITIALIS

Family: Asteraceae
Cal-IPC Rating: High

Centaurea solstitialis (yellow starthistle), a spiny annual forb from the Mediterranean, is considered one of the costliest invasive plants in California. It spreads readily in grasslands, disturbed areas, and along roads and trails through scrub and woodland habitats. This propensity for spreading along roadways challenges rapid response efforts as populations on winding roads are difficult to manage safely.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
145	59	190

Yellow starthistle ranges through all quadrants of the region with a strong concentration near the top of the mountain at West Peak and the sweeping grasslands of West Ridgecrest Boulevard. Smaller populations are found in grasslands and roadsides on the south side of the mountain as well as the Alpine and Bon Tempe lakes areas of MMWD. Further populations are found on White Hill, Peters Dam, and on French Ranch Preserve.

Most populations of yellow starthistle are under management with some exceptions on Marin County Parks land near Sir Francis Drake Boulevard. Considerable unmanaged populations occur on private land as well.

WHIPPET Scores

3.29 – 6.96

Yellow starthistle scores fall into the middle and lower tiers.

Recommended Treatment Strategy

Contain yellow starthistle north of Sir Francis Drake as far east as Woodacre. There, use the large open grassland of White Hill as a line, managing all populations to the south.

Justification: This approach largely aligns with current management practice. The containment zone leaves several small patches along White Hill Fire Road unmanaged. These patches are adjacent to larger, uncontrolled patches on private land which are likely to remain unmanaged. Without coordination with those private properties, drawing the line at Sir Francis Drake would likely prove aspirational.

Future Management Recommendations

MCP

- Continue management of new patches in White Hill Preserve.
- Initiate treatment on Bald Hill Preserve to tie in with MMWD efforts to the west.

MMWD

- Continue follow-up treatments on all patches.

NPS

- Continue follow-up treatments on all outlier patches.

State Parks

- Initiate treatment on roadside population on lower Pantoll Road.
- Continue follow-up treatments on all other populations.

Critical Collaboration Zones

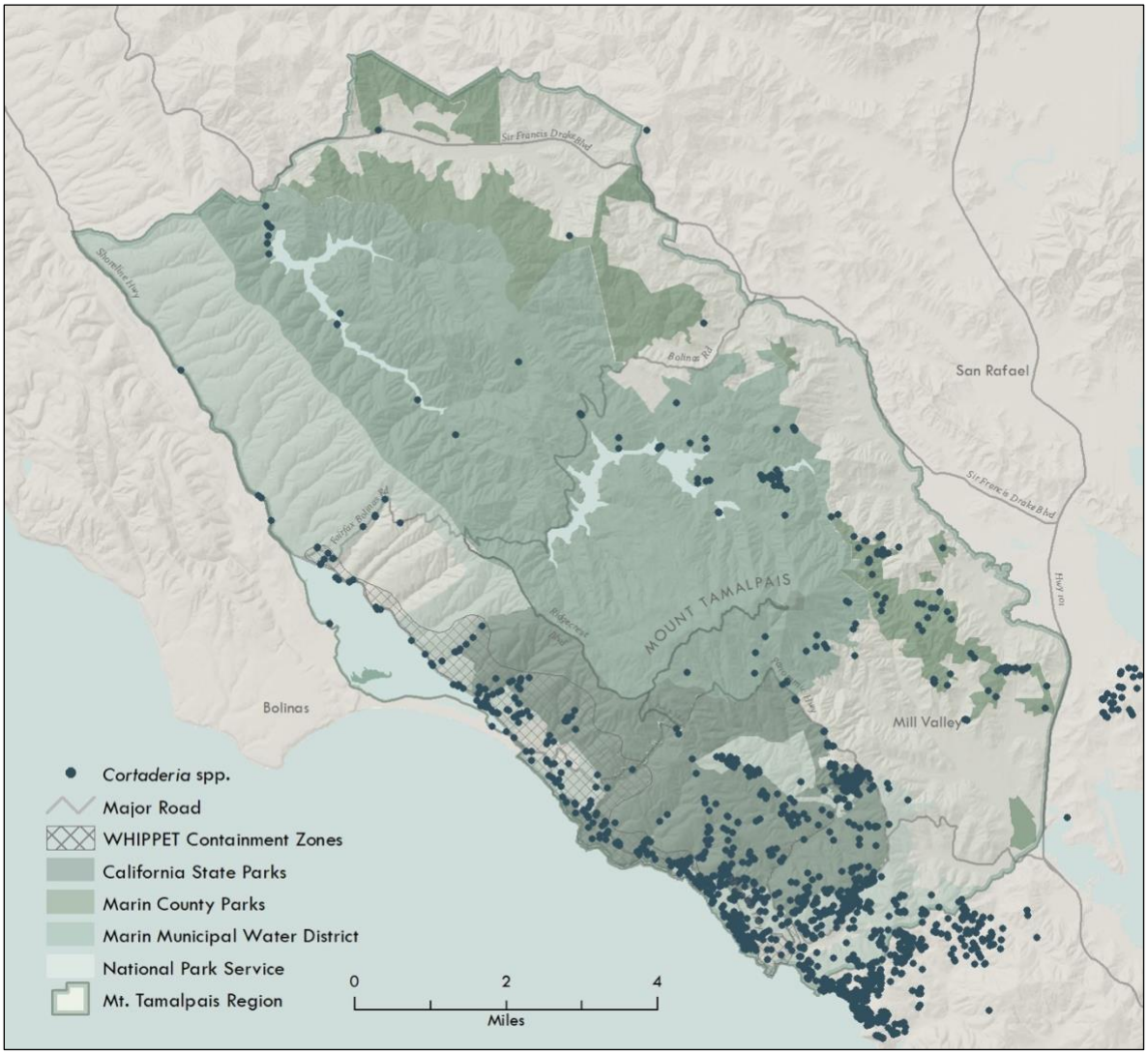
- Continue One Tam coordination of treatments of West Ridgecrest Boulevard to ensure all populations on all agency lands are treated annually.
- Consider collaborative approach to Bald Hill initial treatment.

CORTADERIA SPP.

Family: Poaceae
Cal-IPC Rating: High

Cortaderia jubata (jubata grass) and *Cortaderia selloana* (pampas grass) are large perennial bunchgrasses from South America. Despite significant differences in morphology and reproductive biology, the two taxa are similar-looking, frequently confused, and managed in the same way—therefore they are treated together in one profile herein.

Regional Distribution



Occurrence Details

	Patches	Populations	Gross Acres
Cortaderia jubata	988	445	128.04
Cortaderia selloana	18	15	0.65

These plants flourish along the coastline and move inland wherever conditions are mild and moist. Mt. Tamalpais is no exception—jubata grass is a fixture of coastal bluffs and grasslands in the southwest quadrant of the region, but also ventures toward the interior to sporadically inhabit lakeshores, drainages, springs, and foggy exposures. These plants readily escape from horticultural installations and are seen densely represented within the wildland-urban interface east of the mountain's peak and around coastal hamlets like Stinson Beach. High potential for reintroduction from private lands and other untreated populations should be considered in all management planning for jubata and pampas grass.

WHIPPET Scores

Cortaderia jubata 4.74 – 8.25

Cortaderia selloana 6.06 – 7.47

Jubata and pampas grass populations make up a huge proportion of the overall top scores irrespective of species. These high scores cluster in geographic areas that have been assigned high site values—Muir Woods, Lone Tree/Cold Stream, and Dias Ridge especially. High-scoring populations in Baltimore Canyon and Blithedale Summit require management status verification.

Recommended Treatment Strategy

Continue follow-up treatments where populations are at maintenance level. Initiate new treatment only in highest-value habitats. Where possible, prioritize tops of watersheds over bottoms.

Justification: Many populations of jubata and pampas grass, unfortunately, exist in a variety of untreatable conditions. Some have found purchase on near-vertical coastal cliffs, and others are peppered throughout the landscaping of private residences. These plants will likely always exist as source material for reintroduction, and as such, the best-case outcome for adjacent patches is at the level of maintenance rather than eradication.

Jubata and pampas grass have a long history of devoted management in the region and many populations are already at maintenance level. The Redwood Creek Watershed and areas south of it have been extensively managed and we recommend that these efforts continue. For sporadic interior patches, rapid response is recommended, especially in instances where sensitive habitat or rare plant impacts are present such as serpentine chaparral and grasslands.

Future Management Recommendations

MCP

- Verify management status of high-scoring populations in the Blithedale Summit/Baltimore Canyon complex before moving forward with prioritization.
- Follow up on managed population in high-value habitat at French Ranch.
- Defer action in Alto Bowl and Camino Alto.
- Continue to treat new or small patches during EDRR surveys.

MMWD

- Continue follow-up on maintenance-level populations at Filter Plant and Peters Dam.
- Continue follow-up on populations in high-value habitats at Azalea Hill, Old Stage Fire Road, and Kent Lake shoreline.
- Initiate treatment on Matt Davis Trail population – contractors likely necessary.
- Follow up on managed one-off populations such as those around Hoo-Koo-E-Koo and Double Bowknot opportunistically during adjacent fieldwork or during EDRR surveys.
- Continue to treat new or small patches during EDRR surveys.

NPS

- Follow up on managed population in high-value habitat toward upper end of Bolinas-Fairfax Rd.
- Continue maintenance-level management in Redwood Creek Watershed.
- Verify management status of populations near Stinson Beach before attempting prioritization. In the meantime, institute containment around coastal corridor from Bolinas Lagoon to Slide Ranch.

State Parks

- Initiate treatment at two small populations in high-value serpentine habitat just west of Pantoll Campground.
- Continue maintenance-level management in Redwood Creek Watershed.
- Institute containment to keep plants out of Ridgecrest grassland complex.
- Assess feasibility of treating populations in high-value habitats in Lone Tree Creek and Cold Stream Creek.
- Continue to treat new or small patches during EDRR surveys.

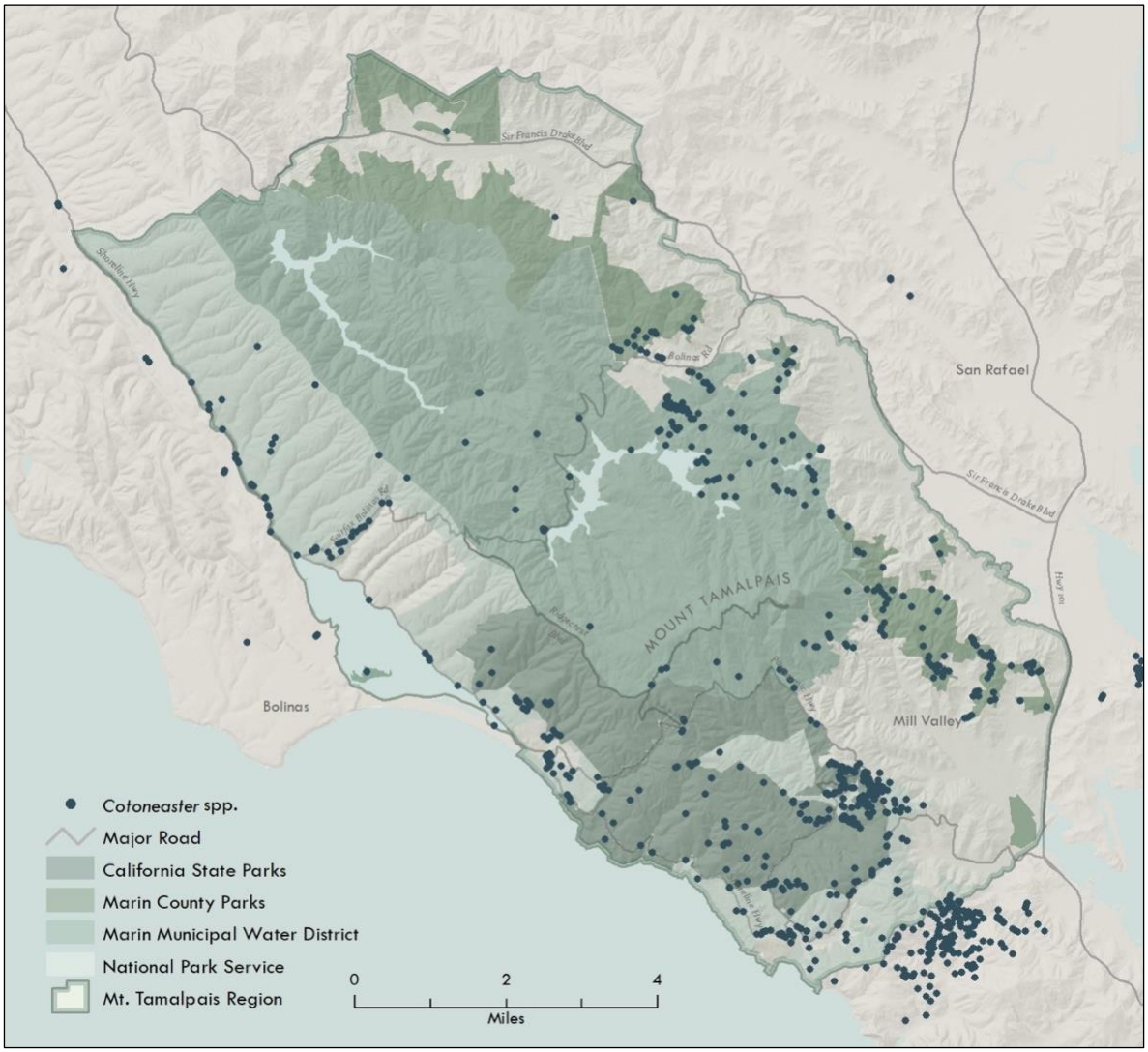
COTONEASTER SPP.

Family: Rosaceae
Cal-IPC Rating: Moderate

Three species of *Cotoneaster* are mapped during EDRR surveys: *C. pannosus* (silverleaf cotoneaster), *C. franchetii* (orange cotoneaster), and *C. lacteus* (milkflower cotoneaster). While their distributions vary, these shrubs follow an identical pathway to wildland invasion: source populations abound in landscaping, birds disperse the fruits, and new infestations take hold in woodlands, shrublands, and grasslands. As such, this group of closely related plants are treated in one profile here.

Other similar EDRR species include *Pyracantha angustifolia*, *Crataegus monogyna*, and the unrelated *Ilex aquifolium*. Management strategy is the same for all of these plants, and they should be considered together with cotoneasters when planning treatment.

Regional Distribution



Occurrence Details

	Patches	Populations	Gross Acres
Cotoneaster franchetii	120	74	49.32
Cotoneaster lacteus	50	46	0.12
Cotoneaster pannosus	524	307	11.85

Cotoneasters are represented throughout all quadrants of the Mt. Tamalpais region. Major concentrations exist along the eastern periphery where propagules flow in from nearby residential zones; such is also the case near Muir Beach and Stinson Beach. Outliers can be found anywhere frugivorous birds venture, although there is a significantly lower density of mapped occurrences in the northern half of the region. It is presumed that these species are under-mapped, since most mapping efforts only follow roads and trails—birds do not.

The treatment history shows that cotoneaster has not been highly prioritized. Only about a third of the records in the dataset across the three species are listed as "managed."

WHIPPET Scores

Cotoneaster franchetii 4.34 – 7.41

Cotoneaster lacteus 5.17 – 7.48

Cotoneaster pannosus 4.53 – 7.67

Scores fall across the lower, middle, and upper tiers of overall rankings. Clusters of high scores can be seen the coastal shrublands and grasslands of Mount Tamalpais State Park, the woodlands of Blithedale Summit and Baltimore Canyon, and the high-value sections of Bolinas Ridge's west-facing flank.

Recommended Treatment Strategy

Treat in high-value areas, particularly coastal scrub and coastal grasslands.

Justification: Cotoneaster's significant impacts occur in coastal habitats, where plants can form impenetrable, wind-hardened thickets that are inhospitable to the wildlife and native plants that need intact, open land to thrive. Outlier seedlings should be pulled as found. The endless propagule pressure from neighborhoods makes management along the margins of public lands unlikely to succeed.

Future Management Recommendations

MCP

- Defer action.

MMWD

- Continue annual follow-up in Lagunitas Meadows to protect *Calochortus uniflorus*, *Perideridia gairdneri* ssp. *gairdneri*, *Castilleja ambigua* ssp. *ambigua*, and other rare wet meadow species.
- Manage incipient patches and outliers as detected.

NPS

- Defer action.

State Parks

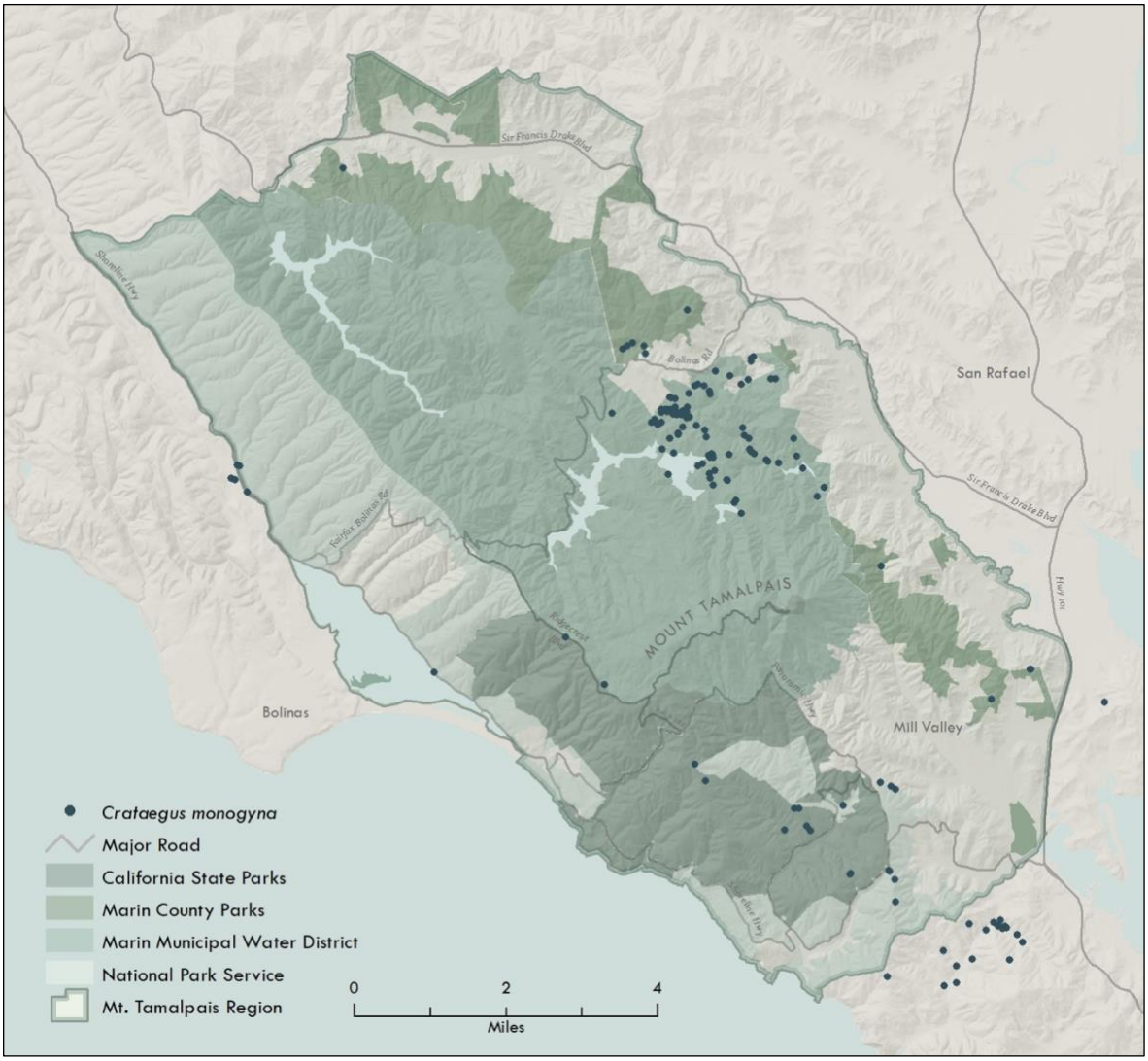
- Defer action along Panoramic corridor east of Muir Woods.
- Initiate treatment in Lone Tree and Cold Stream grasslands alongside broom and *Helichrysum petiolare* sweeps.

CRATAEGUS MONOGYNA

Family: Rosaceae
Cal-IPC Rating: Limited

Crataegus monogyna (English hawthorn) is a shrub or tree native to Eurasia and established throughout the Bay Area via the horticultural trade. Its red berries are browsed and dispersed by birds, who sometimes prefer it to the native *Crataegus douglasii*.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
126	85	19.71

English hawthorn is mainly concentrated in the Sky Oaks region of the MMWD watershed. It is sporadic elsewhere in the Mt. Tamalpais region and nearly absent in the northwest half.

WHIPPET Scores

3.84 – 6.80

English hawthorn scores place it in the lower to middle tiers of the overall score distribution. Treatment history varies widely.

Recommended Treatment Strategy

Treat only in high-value areas, particularly wet meadows. Treatment is recommended outside this context where similarly behaving species are slated for management—English hawthorn, *Pyracantha angustifolia*, *Cotoneaster* spp., and *Ilex aquifolium* should all be considered together. Treat new and small populations when encountered.

Future Management Recommendations

MCP

- Defer action

MMWD

- Continue annual follow-up in Lagunitas Meadows to protect *Calochortus uniflorus*, *Perideridia gairdneri* ssp. *gairdneri*, *Castilleja ambigua* ssp. *ambigua*, and other rare wet meadow species.

NPS

- Defer action

State Parks

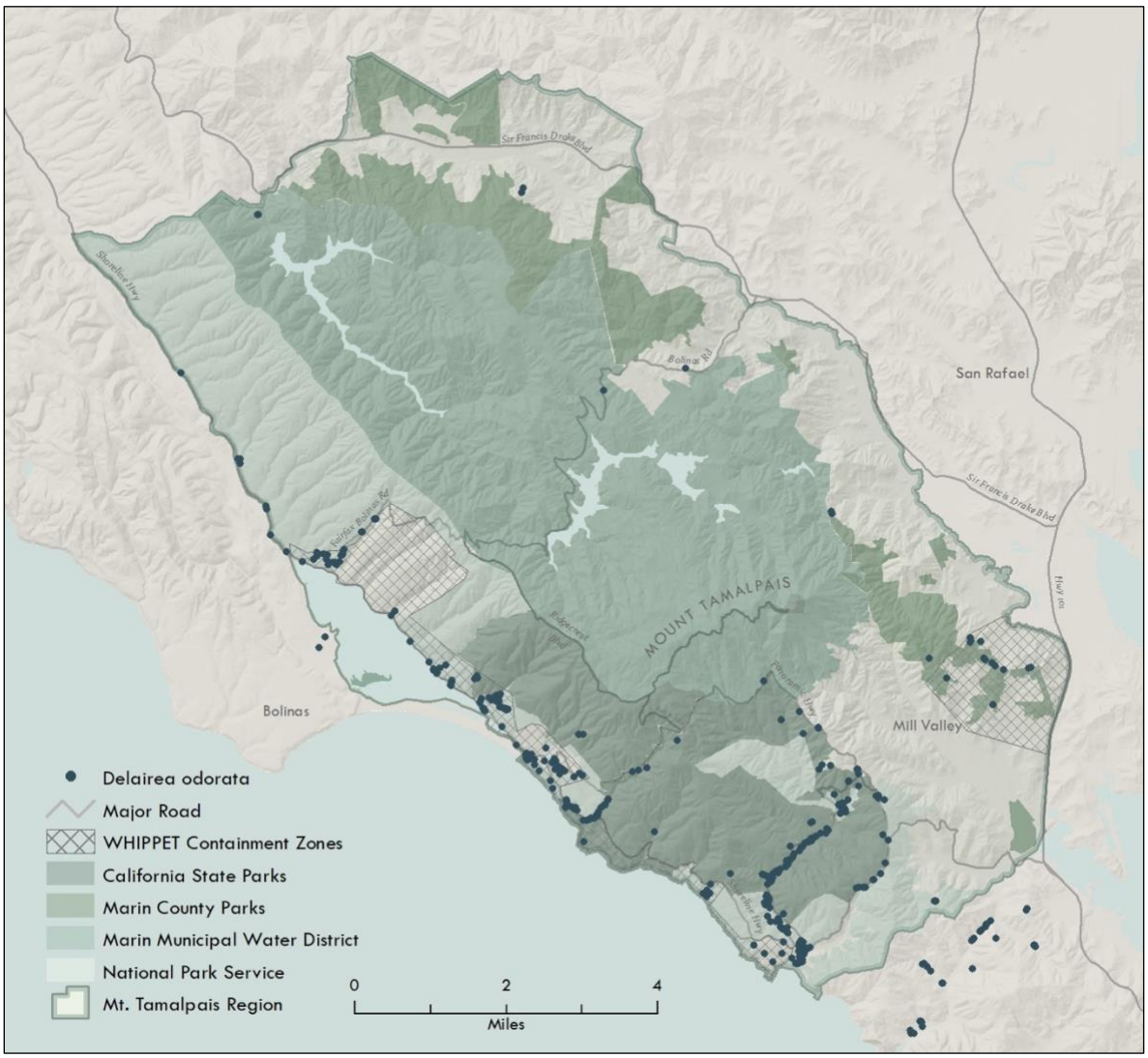
- Defer action

DELAIREA ODORATA

Family: Asteraceae
Cal-IPC Rating: High

A fragile yet aggressive climbing forb, *Delairea odorata* (Cape ivy), spreads readily by vegetative fragments. In California, very few plants produce viable seed (DiTomaso et al. 2013). A vigorous competitor in riparian and coastal habitats, this species also establishes in drier interior lands, though more slowly. Beyond smothering native vegetation, Cape ivy contains toxic alkaloids capable of leaching if leaves steep in standing water. Vulnerable habitats include seeps and creeks that may support California red-legged frogs. Recent field trials with a gall fly suggest a successful biocontrol may be available in the years to come.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
344	123	55.55

Managed and unmanaged populations of Cape ivy abound along the foggy coast and lower Redwood Creek. Webb Creek in Steep Ravine canyon also has several populations with varying management histories. Disparate patches persevere inland, largely in forests at the wildland urban interface or lining moist drainages.

Several patches trace the lower end of drainages off the west side of Bolinas Ridge. Nearby Audubon Canyon Ranch (ACR) has many uncontrolled patches of Cape ivy between NPS-managed areas. While ACR has undertaken initial containment lines on some patches, that organization's manual-only treatment strategy for Cape ivy indicates the species will persist on its inholding for the foreseeable future.

NPS staff have, at times, managed the Bolinas-Fairfax Road cluster, which falls west of the ridgetop. They also manage several patches in the Stinson Beach area. Redwood Creek staff manage high-priority populations in Muir Woods, though one large Camino del Canyon patch appears unmanaged in the Calflora data. That team also manages several populations along Redwood Creek, though much of that larger population remains untreated. Treatment history on Slide Ranch and Muir Beach areas require verification.

State Parks deploys contractors to manage some lower Webb Creek patches. This area may benefit from off-trail mapping and monitoring of treatment efficacy to ensure all patches in the population are under management. MMWD staff manage the Peters Dam area while a population near the Meadow Club remains untreated. MCP staff manage one population at Blithedale Summit (Elinor Fire Road) while nearby Baltimore Canyon populations remain unmanaged.

Cape ivy exists on private property north of Gary Giacomini near Carson Road and Conifer Way and along Pine Mountain Tunnel Road. The distribution of Cape ivy on private land is likely much higher than mapping indicates.

WHIPPET Scores

4.97 – 7.94

Cape ivy scores place it in the middle and highest tiers of the overall ranking. Clusters of high scores are found along Bolinas-Fairfax Road, the top of Webb Creek, lower Lone Tree Creek, Slide Ranch, Muir Beach community, lower Muir Woods, Fern Creek trail, and an unnamed creek north of Cronin Gulch east of Hwy 1.

Two outlier patches on MMWD land (Bolinas-Fairfax Road near the Meadow Club and Peters Dam) are not highly ranked, likely because of treatment costs on that agency's land.

Regional Treatment Strategy

Implement progressive containment from upper elevations toward the coast to the west and Mill Valley to the east. Treat outlier MMWD patches. Monitor patches mapped off agency property for spread onto managed lands.

Justification: Cape ivy exists in all quadrants of the Mt. Tamalpais region with significant concentrations in the coastal zone. This approach largely aligns with current management practices.

Future Management Recommendations

MCP

- Establish and annually maintain a containment line around population at Crown Road.
- Continue annual treatment of Elinor Fire Road population.

MMWD

- Establish and annually maintain a containment line around population near Bolinas-Fairfax Road near the Meadow Club.
- Continue annual treatment of Peters Dam population.

NPS

- Continue treatment along upper Bolinas-Fairfax Road, in Muir Woods and Green Gulch.
- Establish and annually maintain a containment line above patches north of Cronin Gulch.
- Assess treatment approach to Stinson Beach and lower Bolinas-Fairfax Road populations.

State Parks

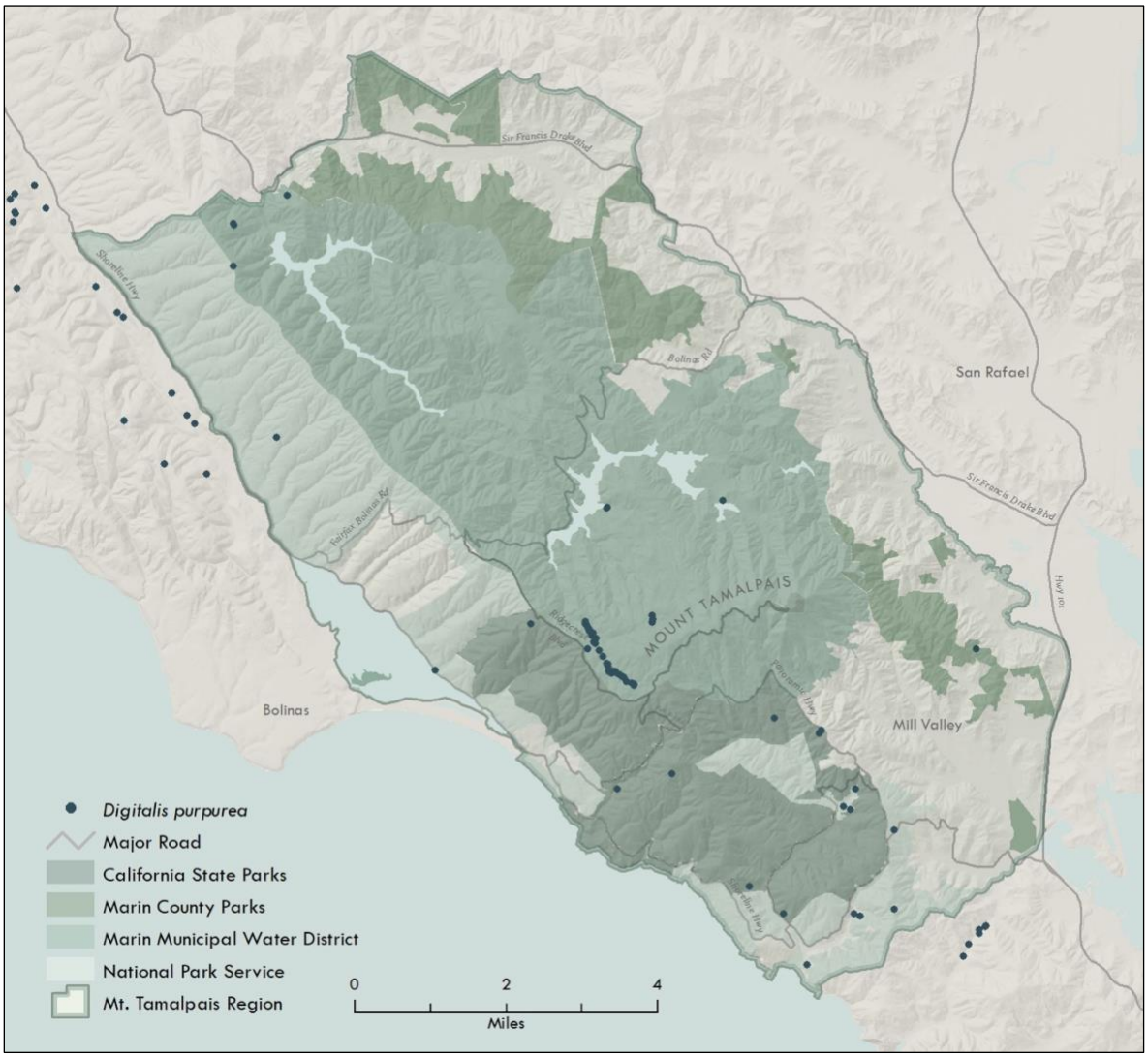
- Initiate treatment at upper Fern Creek Trail.
- Continue annual treatment of Lone Tree population.
    - Resurvey drainage in 2020 or 2021 to confirm that no spread has occurred upstream.
- Assess treatment approach to Webb Creek population, including upstream outliers along creek and Panoramic Highway.

DIGITALIS PURPUREA

Family: Plantaginaceae
Cal-IPC Rating: Limited

Digitalis purpurea (foxglove) is a showy, columnar plant, popular in gardens. It's chiefly a horticultural escape specializing in moist habitats such as riparian corridors and drainages. Its thousands of tiny seeds readily spread via watercourses and on muddy boots.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
344	123	55.55

Foxglove has only one prominent infestation within the region—Cataract Creek between Rock Spring and Laurel Dell. Small one-offs are scattered around the well-trafficked and peripheral portions of the Mt. Tamalpais region.

Detection of this plant is exceedingly easy during its peak bloom time in early summer but can be quite difficult otherwise. Springtime surveys may overlook the subtle rosettes and it is likely that the species is under-mapped as a result.

WHIPPET Scores

3.43 – 6.08

These scores fall in the middle and lower tiers of the overall ranking. The highest scores are found in areas with high site value, including McCurdy Trail, Dipsea Trail, and Cataract Creek.

The Cataract population undergoes annual treatment by MMWD staff and contractors. The incipient occurrence at Dipsea Trail was also removed. The McCurdy population is the only high score that has no recorded management history.

Recommended Treatment Strategy

Continue treatment in high-value habitat. Manage early detections opportunistically.

Justification: Most populations of this plant are of minimal gross area, meaning they are early detections – managing these opportunistically during surveys and other fieldwork requires minimal effort. Larger infestations in high-quality habitat can be slated for treatment during summertime, a somewhat less busy part of the year for many land managers compared to spring.

Future Management Recommendations

MCP

- Treat new or small patches opportunistically.

MMWD

- Continue annual follow-up treatment at Cataract Creek population.
- Continue annual follow-up treatment at Kent Trail population.
- Treat new or small patches opportunistically.

NPS

- Treat new or small patches opportunistically.

State Parks

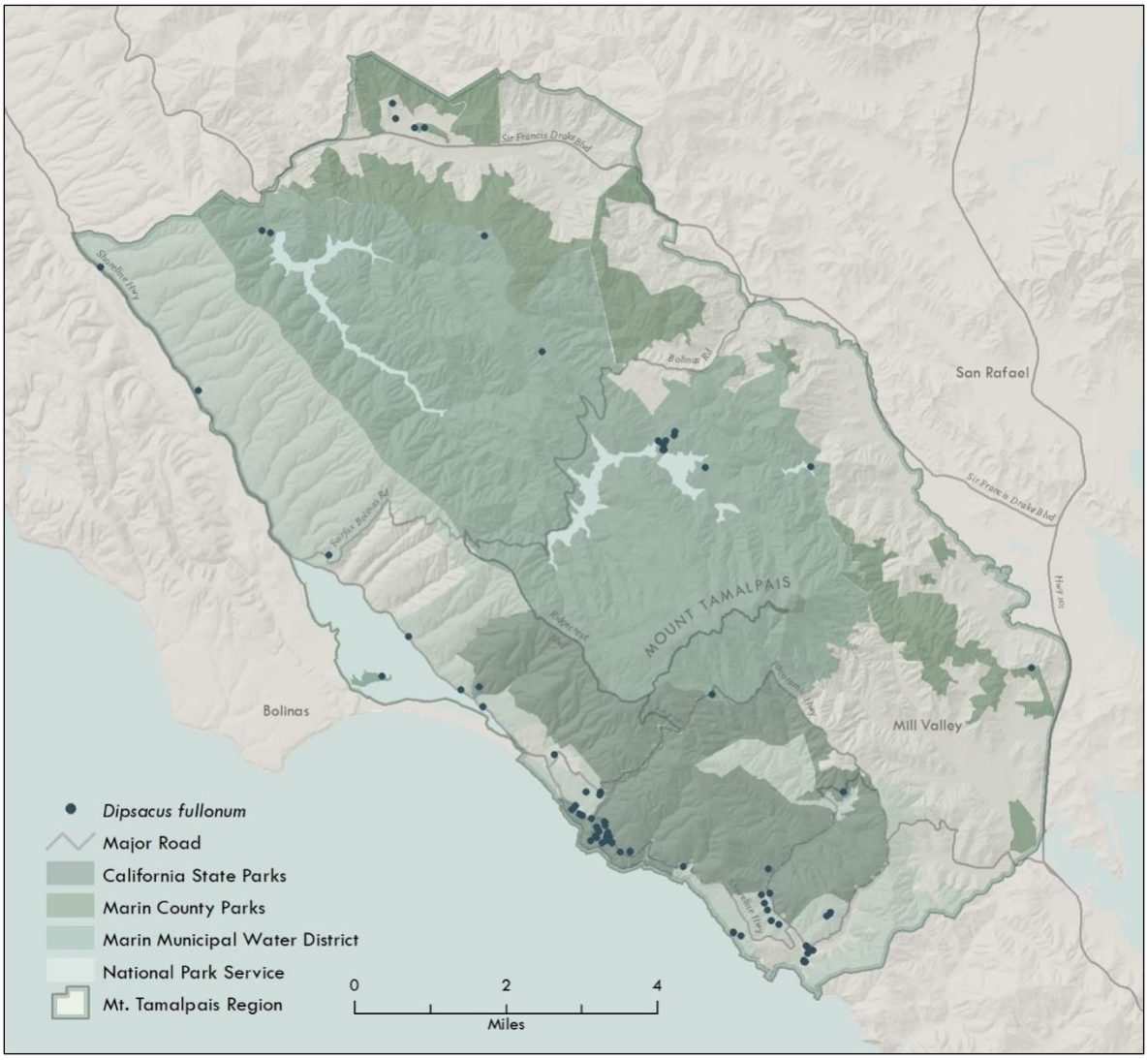
- Treat new or small patches opportunistically.

DIPSACUS FULLONUM

Family: Dipsacaceae
Cal-IPC Rating: Moderate

Dipsacus fullonum (wild teasel) spreads successfully along roadsides, particularly in drainages. It also invades wetland areas, which are the primary resource focus in the following recommendations. Wild teasel often co-occurs with other wetland-loving weeds including *Phalaris aquatica* and *Festuca arundinacea*.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
83	60	26.54

Wild teasel is found sporadically throughout the Mt Tam region, with heavy concentrations along the coast and southern edges of the region. This species is likely under-mapped as it rarely makes it into vegetation management plans.

WHIPPET Scores

4.49 – 6.94

Wild teasel scores fall in the middle tier of the rankings.

Recommended Treatment Strategy

Treat in high-value areas, particularly wet meadows.

Justification: This species has a wide distribution throughout the region. It occurs on all agency lands, inland and coastal. Drawing a containment line is not straightforward given the distribution. Roadside areas are unlikely to be treated or maintained, thus providing significant opportunity for re-introduction.

Future Management Recommendations

MCP

- Continue annual treatment on Kent Island – This locality has the highest WHIPPET score (6.94) of any teasel population.

MMWD

- Initiate treatment at Alex Foreman parking lot to prevent spread to Lagunitas Meadows.
- Initiate treatment at Pine Mountain Fire Road to protect *Toxicoscordion fontanum* population.
    - Treat *Phalaris aquatica* at same location.
- Follow up on Bathtub Gap treatment as part of ongoing *Phalaris aquatica* management.

NPS

- Treat as indicated by site-specific priorities.

State Parks

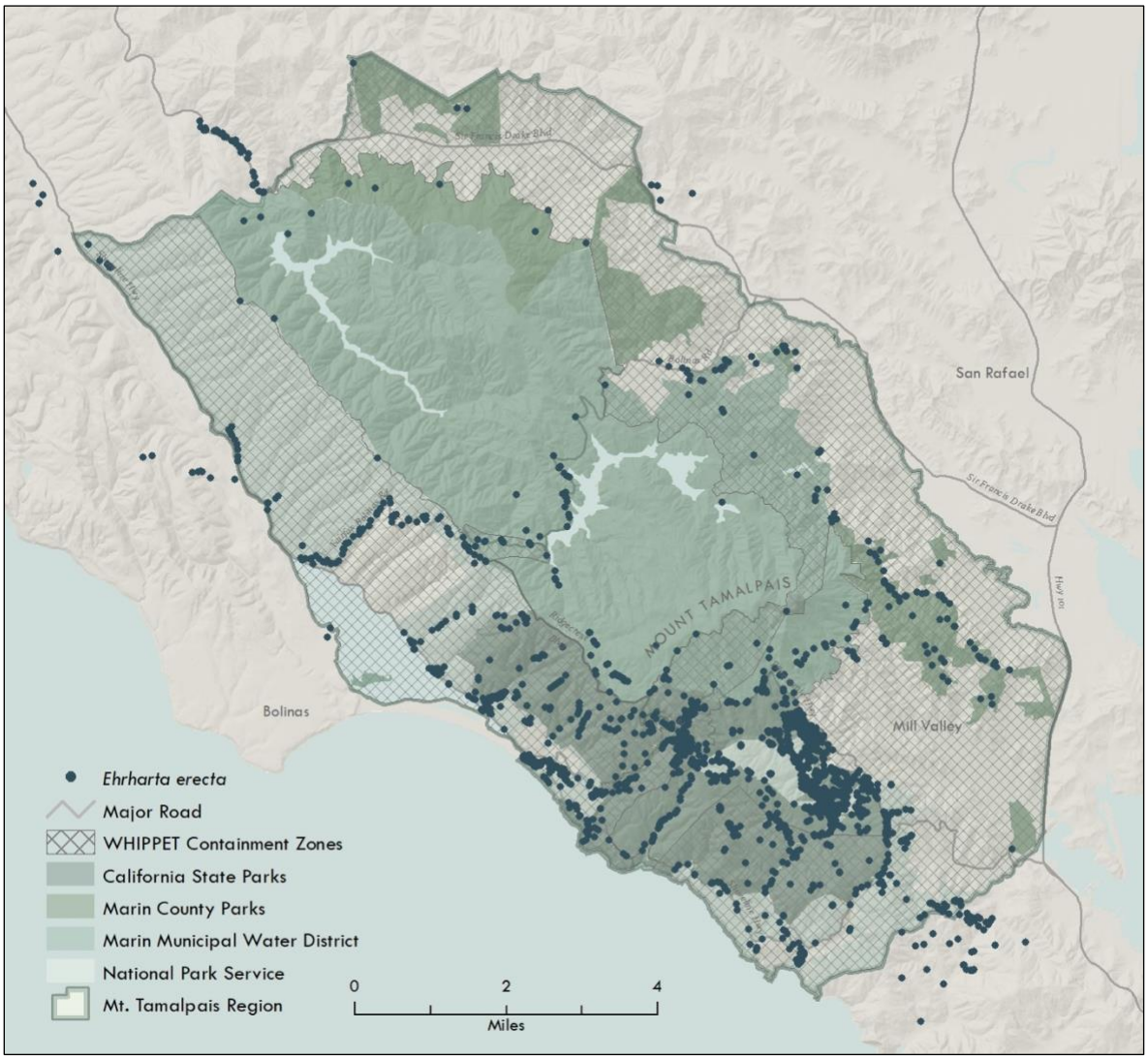
- Treat as indicated by site-specific priorities.

EHRHARTA ERECTA

Family: Poaceae
Cal-IPC Rating: Moderate

Ehrharta erecta (panic veldtgrass) populations have exploded in the Bay Area in the past 30 years. First grown as a subject of genetic research by academic institutions in Berkeley and Davis, this perennial grass grows vigorously in riparian areas and most other habitats with even small amounts of summer fog drip. Panic veldtgrass has the uncommon ability to spread in old growth redwood forests, including in Muir Woods. Despite the dark understory conditions, panic veldtgrass spreads easily. Tiny, highly mobile seeds catch a ride on wind, water, wildlife, hikers, and vehicles. Protracted urban populations of panic veldtgrass indicate a future of continual introductions from visitors and workers.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
1,402	462	510.81

Although this species shows strong preference for infrastructure areas, riparian systems, and forests in the southwest quadrant of the region, populations exist throughout the region on public and private lands. With smaller populations on ridgetops, including East Peak, panic veldtgrass is poised to move into the interior lands of MMWD, which to date remain the least impacted. Extensive populations along winding, steep roadways (Bolinas-Fairfax Road, Highway 1, and Panoramic Highway) further complicate holistic treatment of panic veldtgrass.

While many populations appear as managed in the dataset, the dates of populations along several drainages and Bolinas-Fairfax road vary in terms of recency. Additionally, this species is likely under-mapped both in cross country contexts, particularly in drainages, and on private lands. Substantial, uncontrolled populations are known to exist on Audubon Canyon Ranch lands, for example. Urban areas adjacent to MCP and MMWD lands also have abundant populations. Areas include Deer Park and Marin Stables, entrances to Blithedale Summit and Baltimore Canyon, as well as the private property above Sky Oaks Road.

WHIPPET Scores

3.30 – 6.80

Panic veldtgrass scores place it in the middle and lower tiers of the overall ranking. High scores are distributed largely on State Parks and NPS sites around Muir Woods and Pantoll Campground out Coastal Fire Road and down into the Lone Tree basin. These high scores do not fully align with existing management goals.

Large, contiguous swaths of panic veldtgrass in Muir Woods rank in the lowest tier because of their total gross area, however, these populations are under routine maintenance after years of treatment. One small population on MMWD ranks at the high end of the scale for this species, but all other MMWD infestations rank in the low tier, likely because of treatment costs on those lands. Some patches on eastern MCP lands rank high for this species, but because these areas abut private urban lands, unmapped populations likely border these occurrences.

Several attributes of this species – its impact to old growth redwood understory habitat, broad ecological tolerance, high seed mobility, and urban abundance - challenge the WHIPPET model.

Recommended Treatment Strategy

The complicated nature of this species requires a combined approach of treatment in high-value areas, particularly old growth redwood stands, and containment. High-value areas include Muir Woods National Monument and surrounding State Parks lands, as well as the Lone Tree basin.

Site-specific restoration plans should inform the extent and duration of panic veldt grass treatment. For example, agencies may manage panic veldtgrass while restoration

plantings become established, but walk away when those plants become established, particularly if plantings are of trees or larger stature shrubs.

Containment of panic veldtgrass at the ridgetops should be attempted to preserve the lesser affected lands of MMWD and Gary Giacomini Preserve. Management of ridgetop populations on East Ridgecrest Boulevard, West Ridgecrest Boulevard, and Bolinas Ridge Road can enact an upper watershed containment line. It is possible that the line on West Ridgecrest Boulevard may be best placed at Cataract Creek. Cross-country surveys of this area are needed.

Eastern containment should emphasize areas north of Bolinas-Fairfax Road, which itself has many unmanaged populations. Trails leading north from this road remain largely unaffected. Northern containment at the boundary of Gary Giacomini can be attempted. If this proves unsustainable, moving the line in to San Geronimo Ridge Fire Road may be more realistic. This containment strategy should be reviewed annually.

Justification: Panic veldtgrass compromises valuable redwood habitat in Muir Woods National Monument. Well-vetted control strategies in the Redwood Creek watershed can successfully protect understory characteristics, though widespread populations may require frequent maintenance. Roadside areas are unlikely to be treated or maintained, thus providing significant opportunity for re-introduction.

The interior lands of MMWD and MCP's Gary Giacomini Preserve have less panic veldtgrass than surrounding areas. Vigilance and rapid response may keep the species in check on these lands. Treatment limitations on MMWD land may hinder successful control of this prolific seeding species.

Future Management Recommendations

MCP

- Continue maintenance treatments in Gary Giacomini Preserve.

MMWD

- Continue maintenance treatments on West Ridgecrest Boulevard, Laurel Dell Fire Road, and Cataract Trail.
- Continue maintenance treatments on East Ridgecrest Boulevard, including at Mountain Theater and Rock Spring parking areas.
- Continue maintenance treatments in Peters Dam area.
- Continue maintenance treatments on Bolinas Ridge Road.
- Continue maintenance treatments on Kent Pump Road.
- Continue maintenance treatments at Sky Oaks Road and Concrete Pipe Fire Road.
- Continue maintenance at Canyon Trail and Moore Trail.
- Annually survey Kent Pump Road and Old Sled Road for new populations. Treat any new populations.

NPS

- Continue maintenance treatments in Muir Woods.

- Continue to treat in other high-value areas as restoration goals require.

State Parks

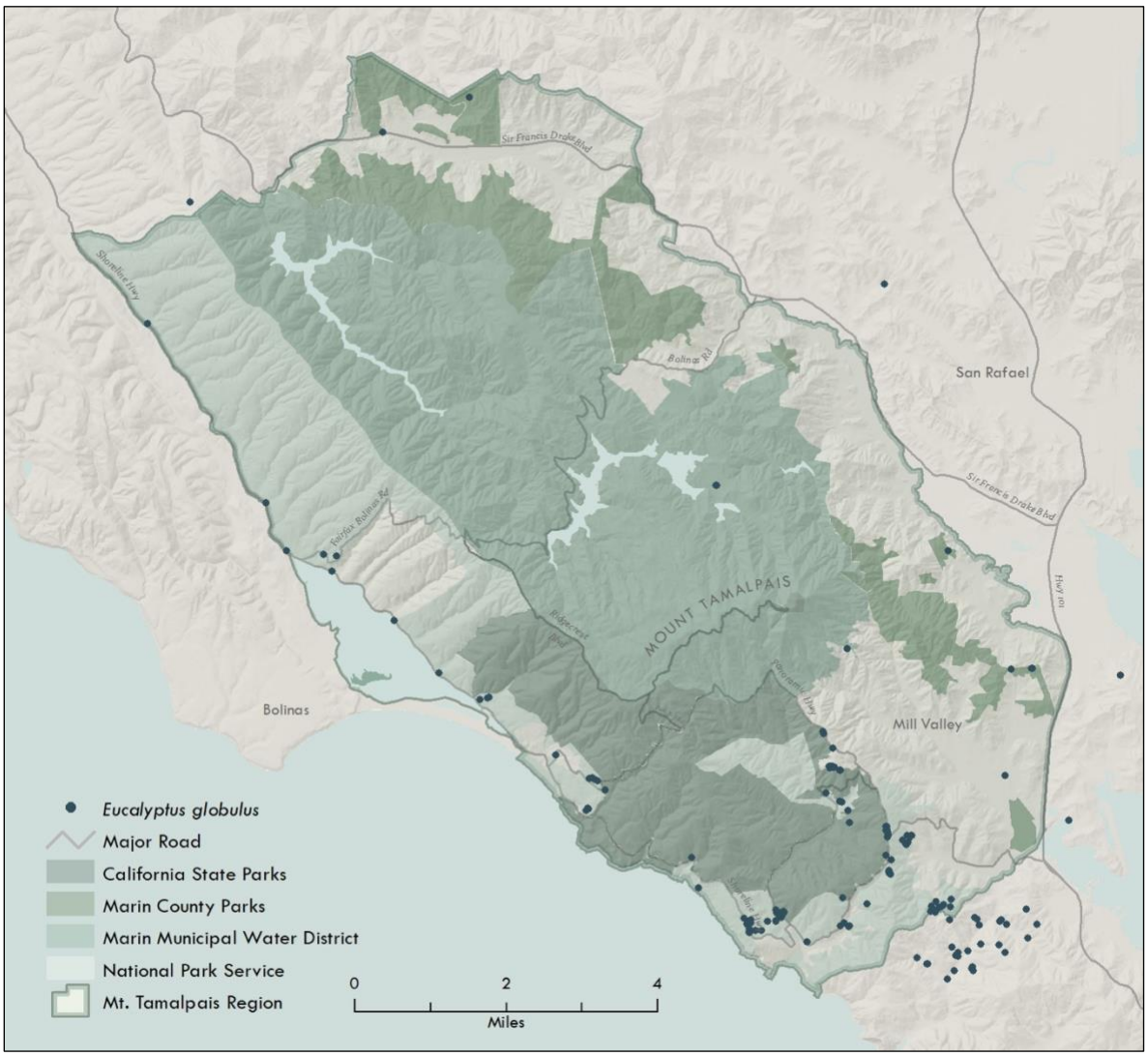
- Continue maintenance treatments surrounding Muir Woods, including the Pantoll area.
- Continue annual treatment of East Peak population.
- Continue to treat in other high-value areas as restoration goals require.
- Evaluate feasibility of extending control into Lone Tree basin.

EUCALYPTUS GLOBULUS

Family: Myrtaceae
Cal-IPC Rating: Limited

Eucalyptus globulus (blue gum eucalyptus) represents one of the most contentious species on the list in terms of public opinion. Nostalgic odes to the tree's stateliness often clash with management concerns around flammability and invasiveness. This robust species, planted extensively in groves for windbreaks and timber in the last 100-plus years, persists near homesteads and along roadsides, and spreads in a limited fashion. Blue gum eucalyptus readily over-shades grassland and scrubland habitats. It reproduces most successfully near riparian areas, where it can draw significantly on water resources with a deep root system.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
96	48	111.96

Most of the blue gum eucalyptus present on Mt. Tam occurs south of the peaks on NPS and private property, though all agencies have at least one population. Highway 1 and Muir Woods Road have the most substantial populations, with outliers on MCP preserves in the east and north. MMWD has one population near the sludge pond east of Bon Tempe reservoir.

Treatment tends to focus on saplings. Leaving mature trees in place requires staff to control saplings indefinitely. Dispersal distance for this species is limited, thus large trees are an easy beacon for locating areas to manage saplings. Seedlings rarely appear more than 200 meters from a mature tree.

WHIPPET Scores

3.72 – 7.18

These scores fall in the middle and lower tiers of the overall ranking. Clusters of high scores occur near Miwok Trail and along roads in the southeast part of the region.

WHIPPET scores for this species have little bearing on treatment likelihood. Public interest in these trees, as well as cultural designations for some agencies make treatment of mature stands highly unlikely.

Recommended Treatment Strategy

Treat all saplings growing outside of mature stands at least every five years.

Justification: Public interest and cost of removal complicate the treatment of mature stands. Treating saplings from the edges of stands will mitigate impacts by limiting spread.

Future Treatment Recommendations

All Agencies

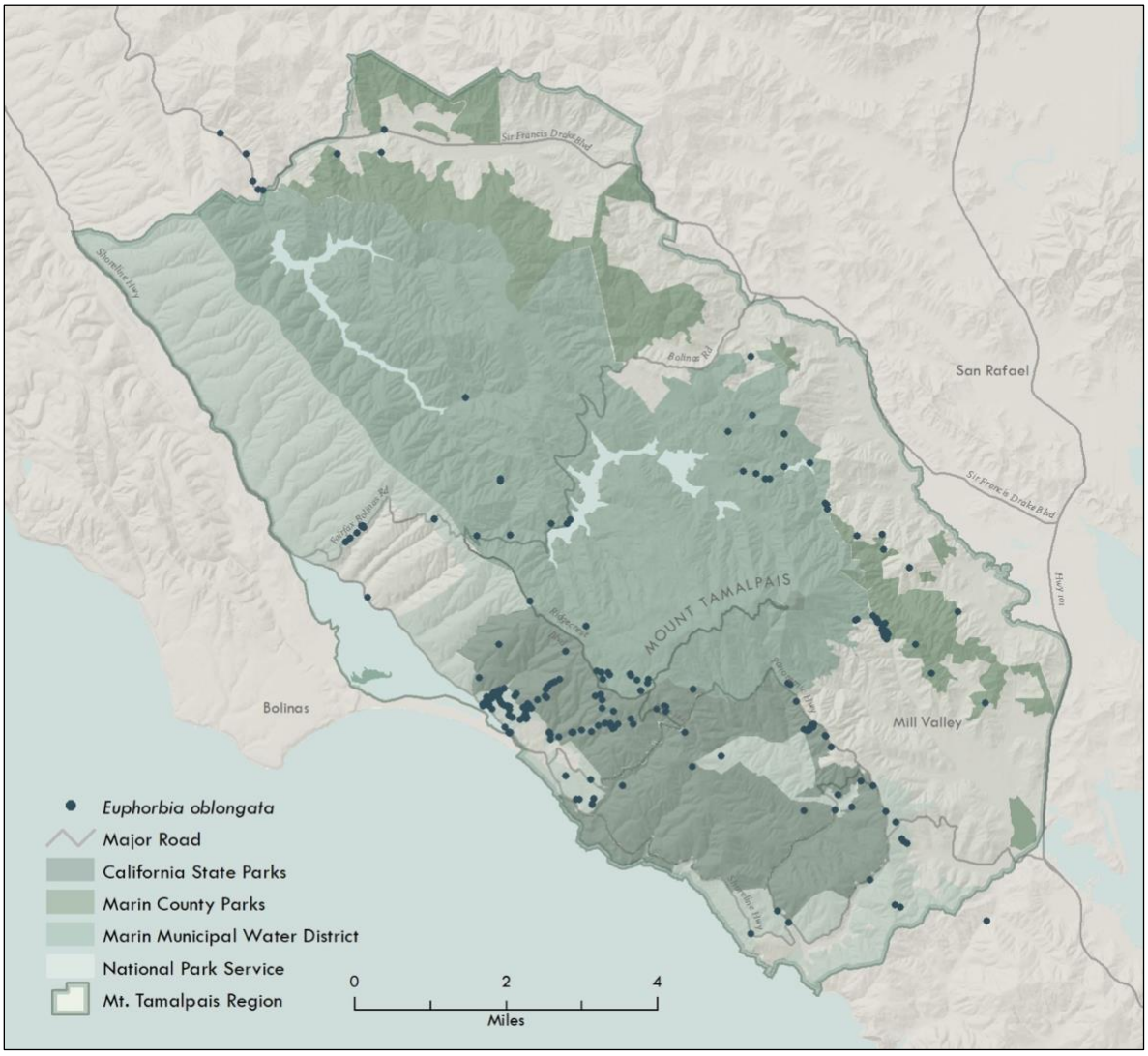
- Treat all saplings growing outside of mature stands at least every five years.

EUPHORBIA OBLONGATA

Family: Euphorbiaceae
Cal-IPC Rating: Limited

Euphorbia oblongata (oblong spurge) is a perennial herb native to Eurasia. This species has moderate fidelity to disturbance corridors but thrives in moist natural areas as well—on Mt. Tamalpais it shows up primarily in riparian woodland, wet meadows, and foggy coastal slopes. Its preference for moist soil can make small patches easy to tackle by hand, but workers must be careful to avoid skin or eye contact with the plant's toxic white sap.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
196	117	31.71

Populations exist in all quadrants of the region but are most prevalent in the south and east. The most significant concentration is centered north of Stinson Beach on NPS land, stretching up into the State Park. Scattered patches radiate upslope to the ridgeline and over into the wet meadow complex at Rock Spring.

WHIPPET Scores

2.97 – 6.11

WHIPPET Scores place it in the lower and middle tiers of all scores. The innate characteristics of this species keep it from ranking very high, especially on MMWD land where treatment cost is higher and effectiveness is lower.

Recommended Treatment Strategy

Treat in high-value areas. Continue existing treatment efforts according to agency priorities. Defer action southwest of Ridgecrest Boulevard.

Justification: Oblong spurge rarely invades high-quality habitat but makes an exception to the rule in the wet meadows north and west of the Rock Spring parking lot. These meadows host rare wetland obligates such as *Astragalus breweri* and *Hosackia gracilis,* as well as several locally rare taxa. Some patches are directly adjacent and pose an explicit threat. Less mesic grasslands appear less hospitable to oblong spurge, which makes the coast-facing bulk of the Ridgecrest grasslands suitable as a natural containment line. The infestation epicenter at Stinson Beach has a long and intentional management history, yet there is a large unmanaged bloc uphill around the water tank road that threatens to perpetually support reinvasion.

Future Management Recommendations

MCP

- Initiate treatment on French Ranch population. It is the highest scoring species occurrence and it is located reasonably close to high-value grasslands.
- Verify management status of H-Line/Old Railroad Grade populations—no 2019 data available.

MMWD

- Continue follow-up on Rock Spring and Cataract Creek populations.
- Continue follow-up on Kent Pump Road population.
- Treat new or small patches opportunistically.

NPS

- Treat according to site-specific priorities.

State Parks

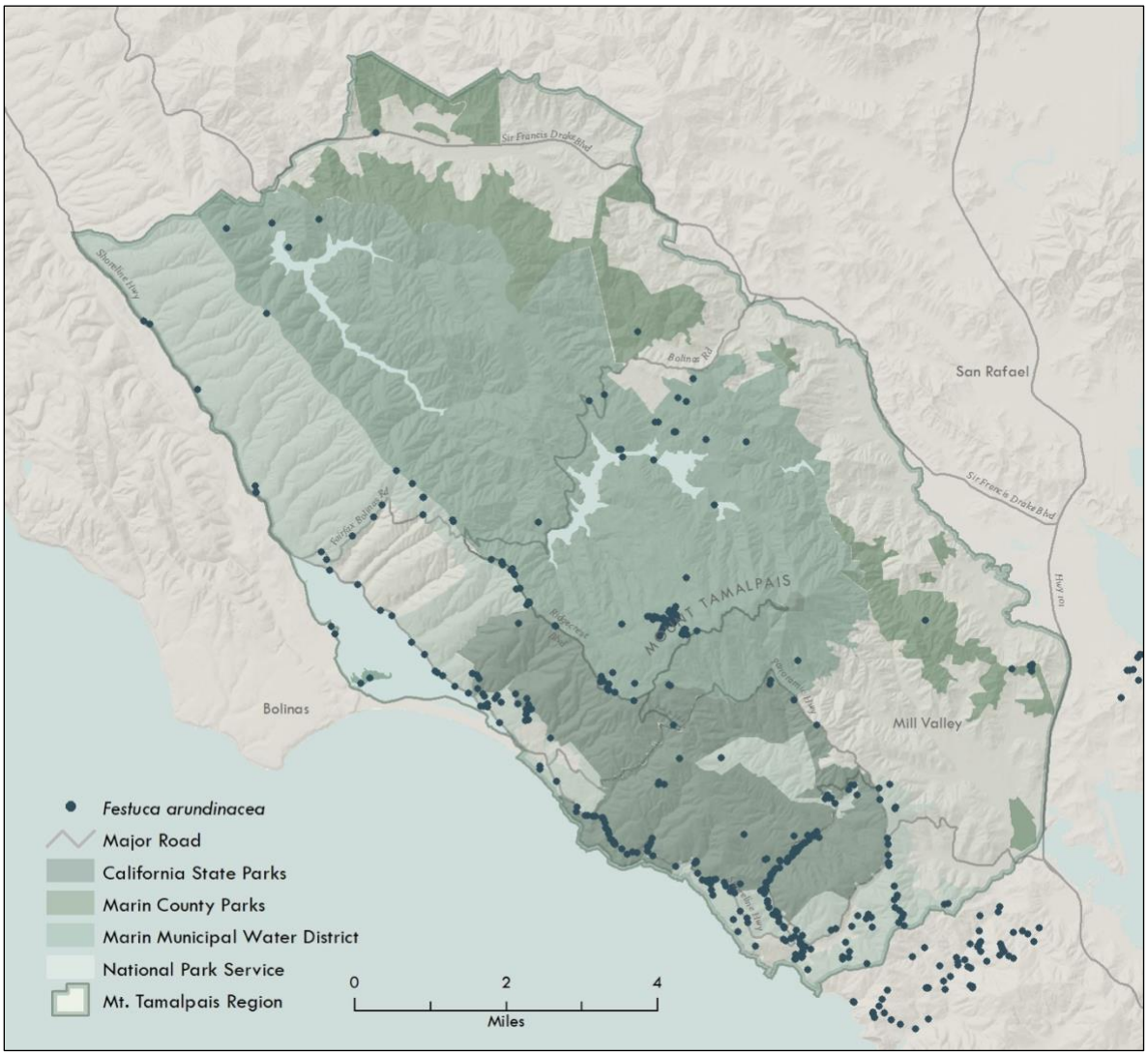
- Continue follow-up treatments in Ridgecrest grasslands to establish containment.

FESTUCA ARUNDINACEA

Family: Poaceae
Cal-IPC Rating: Moderate

Festuca arundinacea (tall fescue), a sometimes-rhizomatous perennial grass, has a wide distribution on Mount Tamalpais. It traces roadsides, including Highway 1 and Muir Woods Road, in addition to invading grassland, wet meadow, and some coastal scrub communities. Favored for its winter luster in turf and agriculture, this species has a long history of intentional introduction throughout much of California and the United States.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
399	211	45.04

While tall fescue has some populations in the northern part of the region near Peters Dam, most of the distribution occurs south of the MMWD reservoirs. The largest population occupies Potrero Meadow and surrounding environments north of West Peak where it impacts important wet meadow habitat. In addition to the previously mentioned roadside populations, tall fescue also has impacts to grasslands along West Ridgecrest Boulevard.

This species is likely well mapped on public lands but may be under-mapped on unsurveyed roadsides in the county, as well as on private land or recreation areas. Treatment history has emphasized small patches in areas including West Ridgecrest Boulevard, Coyote Ridge, and north of Stinson Beach community.

WHIPPET Scores

3.32 – 6.32

All scores for this species fall in the middle and lower tiers. High scores for this species appear in areas largely inappropriate for management focus. Those areas include a northwest, forested section of Muir Woods, two areas along Highway 1, and one area adjacent to Sir Francis Drake Boulevard. All high-ranking patches remain untreated at this time. Some other highly ranked middle-tier populations include grasslands at Rock Spring and near Pantoll station.

Recommended Treatment Strategy

Treat in high-value areas, particularly wet meadows, seeps or springs, and grasslands. Treat in conjunction with *Phalaris aquatica* when feasible.

Justification: This species has a strong distribution in the county. Roadside areas are unlikely to be treated or maintained, thus providing significant opportunity for re-introduction. Populations with rhizomes present significant treatment challenges, both in terms of workers' ability to comprehensively identify the species as well as the efficacy of manual and chemical methods.

Future Management Recommendations

MCP

- Continue treatments of new and small populations found on EDRR surveys.

MMWD

- Continue and expand annual treatment of West Ridgecrest Boulevard populations. Work between road and Cataract trail toward eradication.
- Continue to evaluate feasibility of removing Potrero Meadow population with associated trail realignments.

NPS

- Continue treatment along Miwok Trail on Coyote Ridge. Pair with treatment of *Phalaris aquatica*.
- Initiate treatment of populations on West Ridgecrest Boulevard to match effort of MMWD.
- Evaluate success of Muir Beach treatments to determine whether to continue.

State Parks

- Initiate treatment of populations on West Ridgecrest Boulevard to match effort of MMWD and align with existing *Phalaris aquatica* treatments.

Critical Collaboration Zones

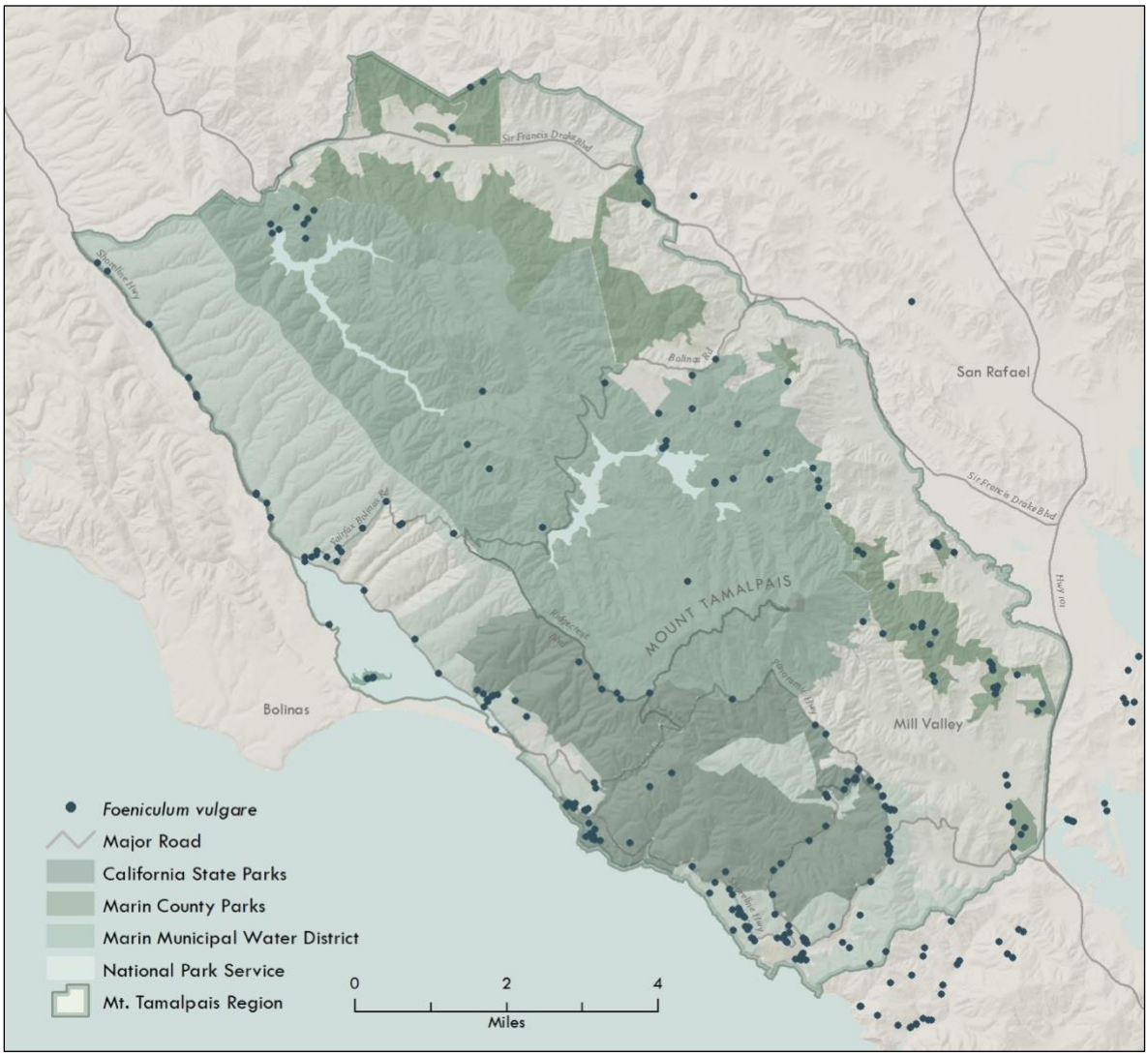
- West Ridgecrest Boulevard populations offer an opportunity for collaboration to reach successful eradication. This area sees much collaboration led by One Tam staff in Restoration, Conservation Management, and Youth Engagement around *Centaurea solstitialis* and *Phalaris aquatica*. Tall fescue is a challenge for most volunteers but may prove suitable for returning volunteers. Conservation Management staff could lead well-trained contractors on *F. arundinacea* control projects.

FOENICULUM VULGARE

Family: Apiaceae
Cal-IPC Rating: Moderate

Foeniculum vulgare (fennel) is a perennial herb or subshrub with impacts to grasslands and coastal scrub communities in the region. While it shows some preference for coastal habitats in Marin, extensive populations also arise inland, including throughout large sections of Highway 101. Large populations in grasslands may alter the structural complexity of those systems, while in scrubland it often occurs at lower densities. Fennel establishes easily in disturbed areas, particularly roadsides. Entrenched populations require chemical treatment or labor-intensive, high-disturbance manual removal of sizable taproots.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
217	161	94.01

Fennel appears extensively in the southwestern quadrant of the region, particularly along the Highway 1 corridor. The Blithedale Summit/Baltimore Canyon complex on the southeastern side of the mountain also has substantial populations. Scattered populations persist throughout suitable habitat on the mountain, including areas of West Ridgecrest Boulevard, Bolinas Ridge, one forested area of Gary Giacomini, and the interior of the MMWD watershed in low levels. This species is likely under-mapped in the county. Significant populations exist on private lands and rights of way.

Treatment history varies among agencies. One Tam and MCP surveyors routinely remove small plants found on EDRR surveys. Priority grassland and scrubland habitats of NPS, including near Homestead Valley and the Muir Beach community have had treatments. Similarly, areas of Bothin Marsh, Kent Island, and the Blithedale Summit/Baltimore Canyon complex have had treatments. Some areas on State Parks and MMWD have had treatments. All agencies have extensive unmanaged fennel acreage.

WHIPPET Scores

4.97 – 8.28

High scores for fennel appear around Rock Spring on MMWD land and in the Blithedale Summit/Baltimore Canyon complex as well as Bothin Marsh. Additional high scores appear along lower Coastal Fire Road on State Parks land and down into NPS land, as well as some areas of Muir Woods Road. Many outliers on MMWD land do not rank highly, likely as a result of treatment costs on those lands.

Recommended Treatment Strategy

Treat in high-value areas, particularly in grasslands. Treatment limitations on MMWD land indicate a need to treat early and thoroughly.

Justification: While fennel is widespread throughout Marin and has a high fidelity to disturbance, the species can have significant impacts on grasslands and coast scrub habitats. Roadside areas are unlikely to be treated or maintained, thus providing significant opportunity for re-introduction. This approach aligns with current management status, which sufficiently protects vulnerable grassland and coastal scrub resources.

Future Treatment Recommendations

MCP

- Continue annual treatment of populations at Kent Island, Bothin Marsh, and the Blithedale Summit/Baltimore Canyon complex.
- Continue treatments of new and small populations found on EDRR surveys.
- Rapidly respond to new detections in priority grasslands, particularly Gary Giacomini.

MMWD

- Continue treatments of new and small populations found on EDRR surveys.
- Rapidly respond to new detections in priority grasslands.

NPS

- Continue annual treatment on populations in Homestead Valley and Owl Trail.
- Continue annual treatment of population south of Muir Beach, which is currently under management.

State Parks

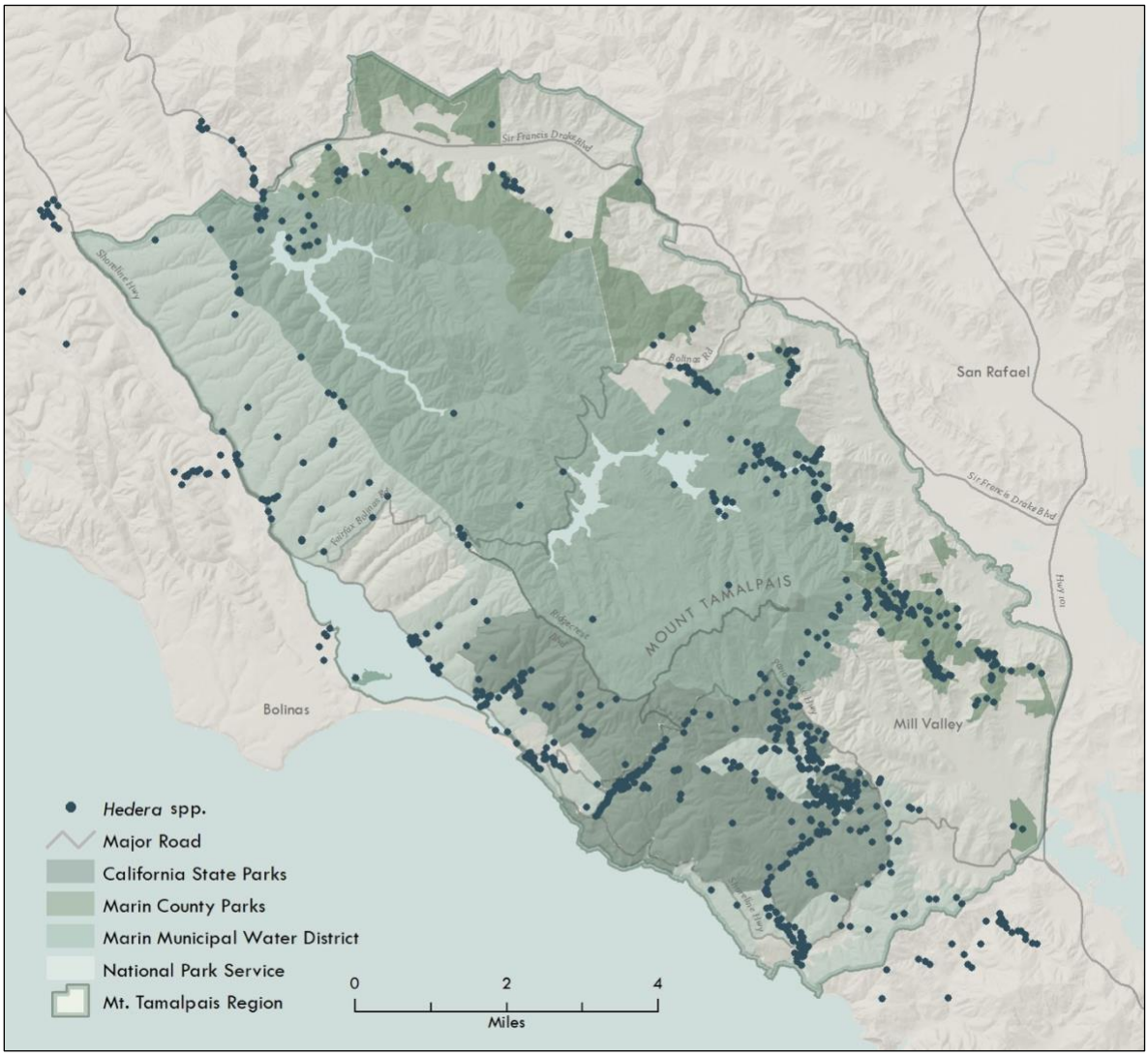
- Continue treatments of new and small populations found on EDRR surveys.

HEDERA SPP.

Family: Araliaceae
Cal-IPC Rating: Limited

Hedera canariensis (Algerian ivy) and *Hedera helix* (English ivy), well-known ornamental vines, occur throughout the Mount Tamalpais region in forests and woodlands. Riparian systems often suffer the most from these species. These species will form dense, strangling mats that climb trees and hang down like curtains. Dense understory mats smother all vegetation, greatly reducing biodiversity as well as altering ecosystem structure. These ivies only fruit when allowed to grow vertically. A waxy cuticle complicates chemical treatment, amplifying the need promptly address small patches. These species do not strictly follow roads and trails, thus the corridor approach to early detection surveys may not fully capture their full extent.

Regional Distribution



Occurrence Details

	Patches	Populations	Gross Acres
Hedera canariensis	219	157	6.95
Hedera helix	643	422	31.27

Algerian and English ivies have small populations throughout the Mt. Tamalpais region. Distributed from neighborhood plantings into wildlands by frugivorous birds, these species have higher densities and larger populations adjacent to communities. Riparian surveys down Bolinas Ridge picked up repeated off trail occurrences. Similar surveys of the eastern side of the ridge may document some currently unmapped populations. Staff have observed significant populations in human communities around the region, which also remain unmapped.

Treatment history of these species appears to vary along size parameters: Surveyors often pluck seedlings as they encounter them while larger populations linger unmanaged in many areas. Notable treatment areas include Muir Woods where most populations appear under management with a few exceptions. NPS work in the Stinson Beach area has emphasized these species at times.

WHIPPET Scores

Hedera canariensis 5.17 – 7.97

Hedera helix 4.79 – 8.20

Algerian ivy and English ivy have scores in the high and middle tiers among all species. These species have more high scores than most other species, barring *Cortaderia jubata.* Much of this can be attributed to small population sizes in high-value areas like Muir Woods and Steep Ravine. Many of the patches elevated by the WHIPPET model are at the minimum mapping unit of 1 square meter The WHIPPET model looks at these two species separately, thus a patch of Algerian ivy next to a patch of English ivy may rank higher than it should when aggregating to genus level. Species are lumped in this analysis because impact and treatment are the same across the two species.

Populations on MMWD land consistently rank lower because of treatment costs on those lands. Notable exceptions include outliers on Kent Pump Road, Shadyside Trail, Matt Davis Trail, and Hoo-Koo-E-Koo near Baltimore Canyon. Other areas with high scores include small patches in drainages of Bolinas Ridge, State Parks in the Alice Eastwood area, and much of the Blithedale Summit/Baltimore Canyon complex. The latter area deserves deeper consideration as untreated populations in neighboring communities may prevent eradication.

Recommended Treatment Strategy

Progressive containment to margins of publicly owned open space: Treat all interior patches and consider Bolinas Ridge Fire Road a containment line.

Justification: Algerian and English ivy have low population sizes in the interior lands of the One Tam collaborative. Management strategies on larger patches appear to work. Management of larger infestations, such as the areas in and around the north and east of Muir Woods, aligns with current agency approaches. Pushing back toward source populations at community boundaries is the most feasible approach. Without routine management of MMWD lands, future control becomes infeasible given the limited toolkit.

Future Management Recommendations

MCP

- Continue removal of small patches detected on EDRR surveys.

MMWD

- Initiate treatment on Lake Lagunitas populations.
- Initiate treatment on north Kent Lake populations.
- Initiate treatment on Concrete Pipe Road.
- Initiate treatment on Fish Grade.
- Continue treatment of all trailside patches detected on EDRR surveys.

NPS

- Continue and expand management in Muir Woods.
- Continue management in Muir Beach, Coyote Ridge, Stinson Beach areas.
- Initiate management of small patches on EDRR surveys, if feasible.

State Parks

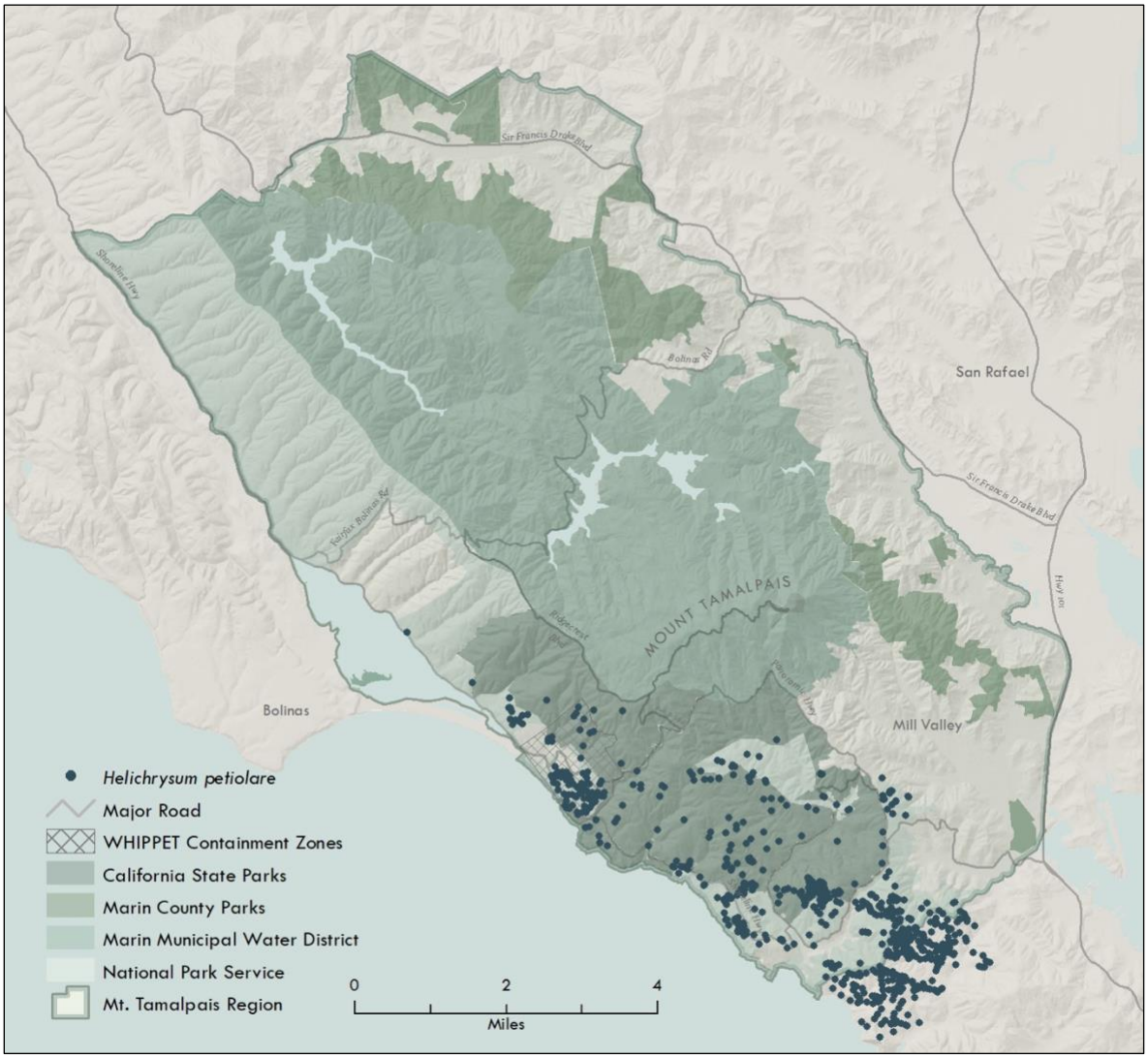
- Continue and expand management in the Redwood Creek Watershed.
- Initiate management in upper Steep Ravine canyon.
- Continue removal of small patches detected on EDRR surveys.

HELICHRYSUM PETIOLARE

Family: Asteraceae
Cal-IPC Rating: Limited

Helichrysum petiolare (licorice plant), a soft, climbing ornamental, has an unprecedented and disturbing distribution on Mount Tamalpais. The populations in Marin County represent the largest mapped infestations in California. This shrub grows readily in coastal scrub where it can create dense mats of smothering vegetation. It also invades forest understory habitat where it rises into trees. The wind dispersed seeds of licorice plant do not appear to require disturbance to germinate and establish. The nature of the habitats it invades makes detection in off-trail areas a challenge.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
399	198	360.86

Licorice plant is largely concentrated on coastal slopes. This species has not crossed the ridgeline to the interior lands of MMWD or MCP. Considerable populations also occur south of the Mt. Tamalpais region in the Marin Headlands. Golden Gate National Recreation Area staff treat these populations.

Licorice plant is the focus of concerted treatment effort on both NPS and CDPR lands. Extensive populations on steep, inaccessible slopes and private land above Stinson Beach remain untreated, casting seeds into the wind for wide-ranging dispersal each year. Treatments have gained and lost ground over many years of treatment.

WHIPPET Scores

3.34 – 6.07

Raw scores place licorice plant in the low and middle tiers of the rankings.

Recommended Treatment Strategy

Establish a progressive containment line around the two large Stinson patches as the northern and eastern boundaries. Use the forested areas as the boundary to the northeast. Remove any populations that jump the line toward ridgetops.

Justification: Extensive populations of largely contiguous licorice plant remains untreated or partially treated. The difficult terrain and lack of long-term funding has forced managers to take a measured approach to this species to date.

Future Management Recommendations

MCP

- Continue to monitor for and address new patches.

MMWD

- Continue EDRR efforts to monitor for and address new patches.

NPS

- Verify that all known patches are under management.
- Continue treatment of southern patches, particularly in Muir Woods and surrounding forests.
- Continue to monitor for and address new patches outside of containment zone.

State Parks

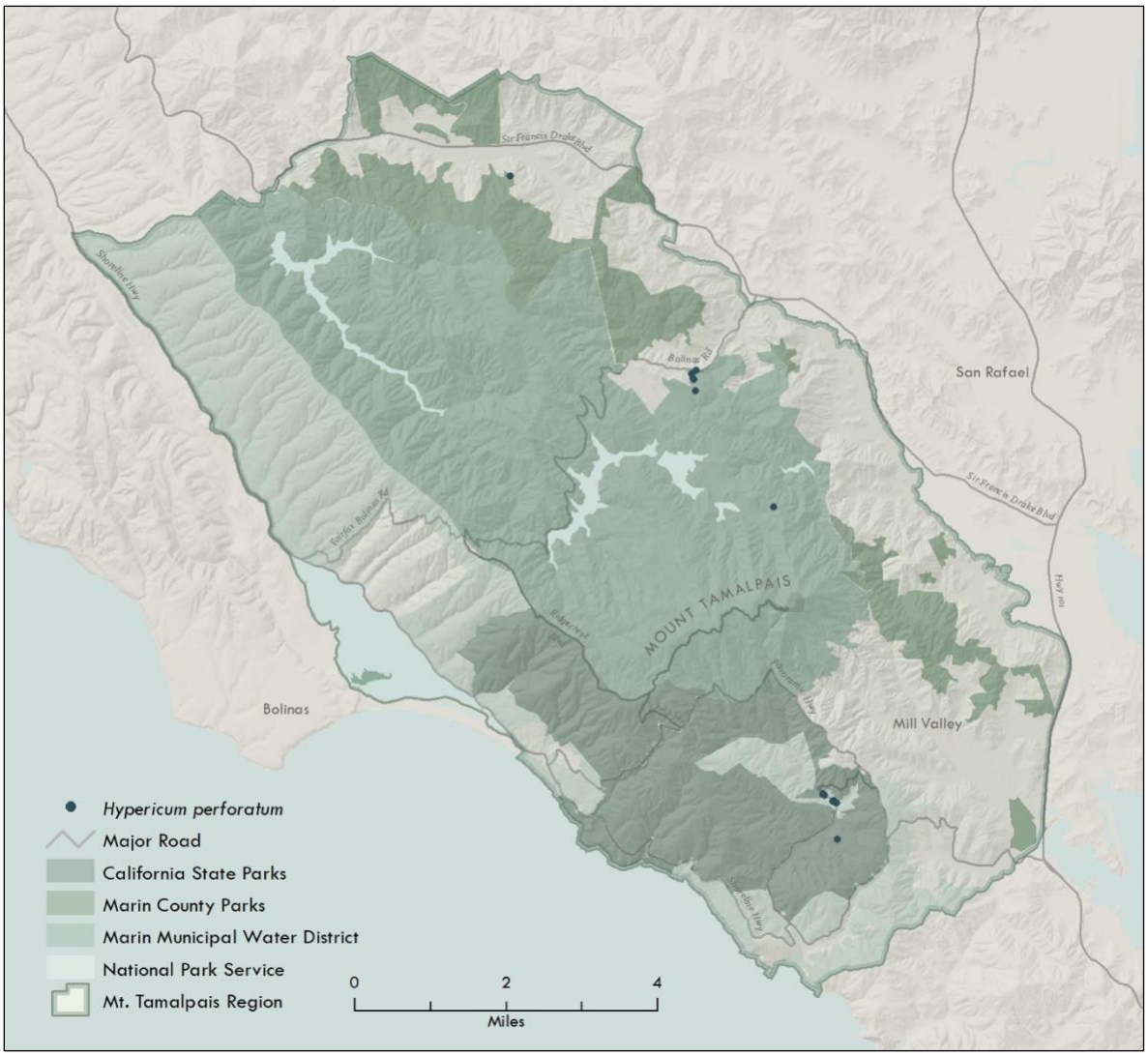
- Verify that all patches designated as managed are in annual treatment plans.
- Assess the feasibility of long-term management of the largest patch east of Stinson Beach.
- Continue contractor effort on outliers.
- Continue to monitor for and address new patches outside of proposed containment zone.

HYPERICUM PERFORATUM

Family: Hypericaceae
Cal-IPC Rating: Limited

Hypericum perforatum (Klamathweed), a perennial herb popular for its medicinal qualities, has spread throughout much of California. Klamathweed appears in disturbance zones including roadsides, and in grasslands, forests, and woodlands. Because of its toxicity to some livestock, agricultural departments have targeted it for control. Biocontrol agents, including the Klamathweed beetle (*Chrysolina hyperici, C. quadrigemina*) and St. Johnswort root borer (*Agrilus hyperici*) have proven highly successful in lower elevation habitats (DiTomaso *et al.* 2013).

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
16	9	0.87

Klamathweed ranges from the Redwood Creek Watershed in the south to Gary Giacomini Preserve in the north. Unlike many species monitored by the One Tam collaborative, this species prefers drier inland habitats. Surveyors have documented 17 populations. The largest cluster appears near the Sky Oaks area of MMWD, with Redwood Creek populations following close behind in size. While the MCP population in Gary Giacomini and the largest patch on MMWD have no treatment history, agencies have performed at least one treatment on all other populations.

WHIPPET Scores

5.01 – 6.22

These scores fall throughout the tiers of WHIPPET scores. The highest-ranking scores are in Gary Giacomini and State Parks land between Muir Woods Road and Dias Ridge Fire Road. These are small, outlier populations, while the additional populations in Muir Woods and MMWD lands have more patches covering larger areas.

Recommended Treatment Strategy

Treat in high-value areas, including new restoration plantings. Defer action in all other areas until population reaches level for biocontrol re-introduction.

Justification: Klamathweed has limited impacts on wildlands. Impacted agency lands do not host livestock. Biocontrol treatment for this species has proven efficacy but requires population sizes sufficient to host the insects.

Future Management Recommendations

MCP

- Defer action until populations reach size adequate to support biocontrol hosts.

MMWD

- Defer action until populations reach size adequate to support biocontrol hosts.

NPS

- Continue annual treatments in Muir Woods.

State Parks

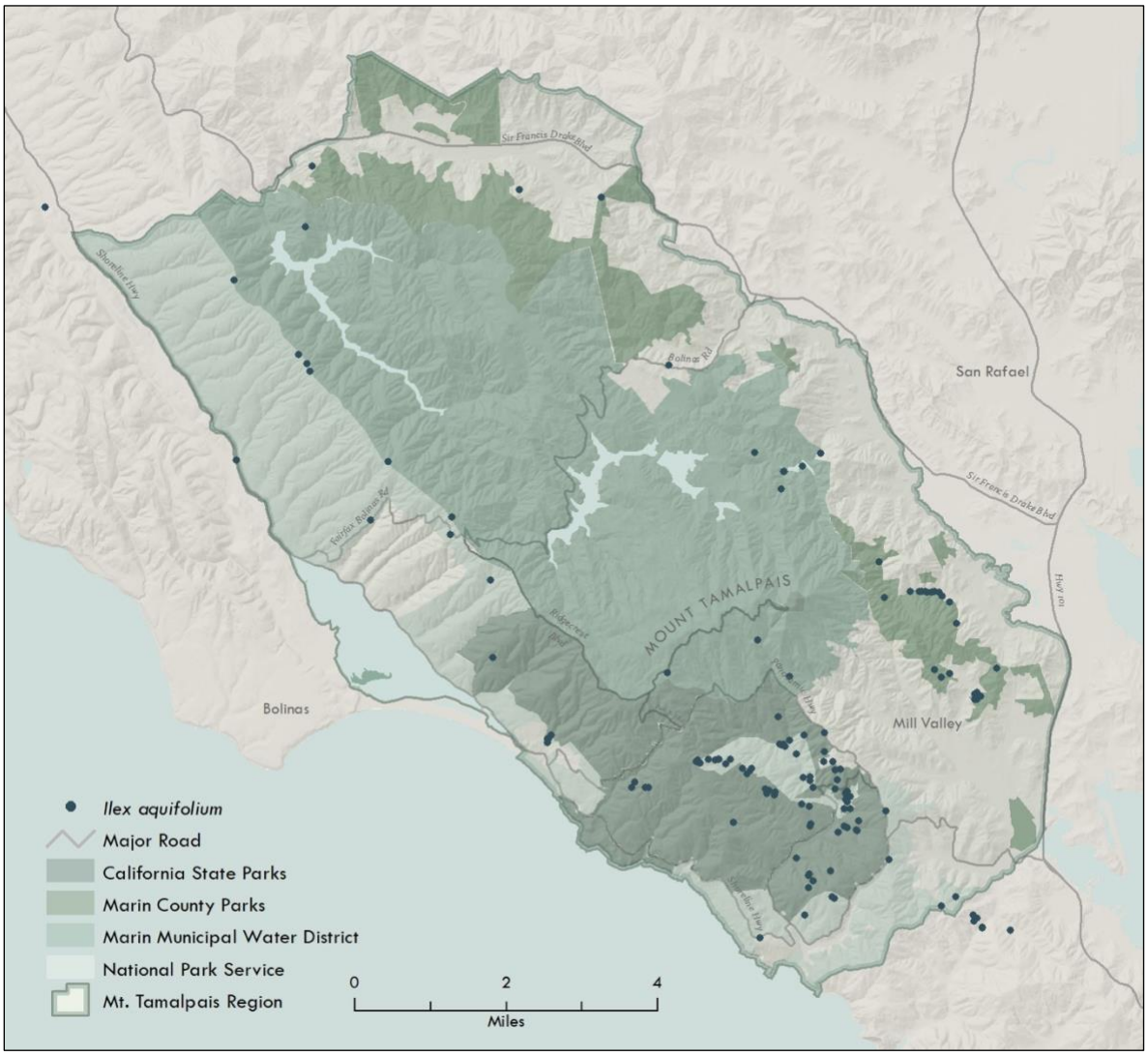
- Continue annual treatment on Dias Ridge.

ILEX AQUIFOLIUM

Family: Aquifoliaceae
Cal-IPC Rating: Limited

Ilex aquifolium (English holly) is a Mediterranean perennial shrub that can reach small tree sizes. It is popular as a landscaping plant due to its dramatic foliage and clusters of red berries, which are dispersed into wildlands by birds and other animals. This species prefers moist, mild forests and woodlands, where it can thrive even in heavy shade.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
135	102	2.13

Like most bird-dispersed species in this report, English holly is densest in areas close to residential housing and old homesteads. The most prominent concentration in the region is in the Redwood Creek watershed, but English hawthorn can be found in forests throughout all quadrants. It is prudent to consider other bird-dispersed invasive shrubs when planning English hawthorn management. Populations often overlap with taxa that occupy a similar niche, such as Cotoneaster spp.

WHIPPET Scores

5.28 – 7.77

English holly's scores sit in the middle and upper tiers of all rankings. A cluster of high scores is situated at the eastern corner of Muir Woods along the Deer Park corridor.

Recommended Treatment Strategy

Initiate treatment in high-value forests – namely Muir Woods. Manage outliers when encountered during EDRR surveys.

Future Management Recommendations

MCP

- Treat new and small populations during EDRR surveys.

MMWD

- Treat new and small populations or resprouting individuals during EDRR surveys.

NPS

- Initiate treatment of populations in Muir Woods National Monument footprint.
- Treat new and small populations as detected, with an emphasis on Bolinas Ridge.

State Parks

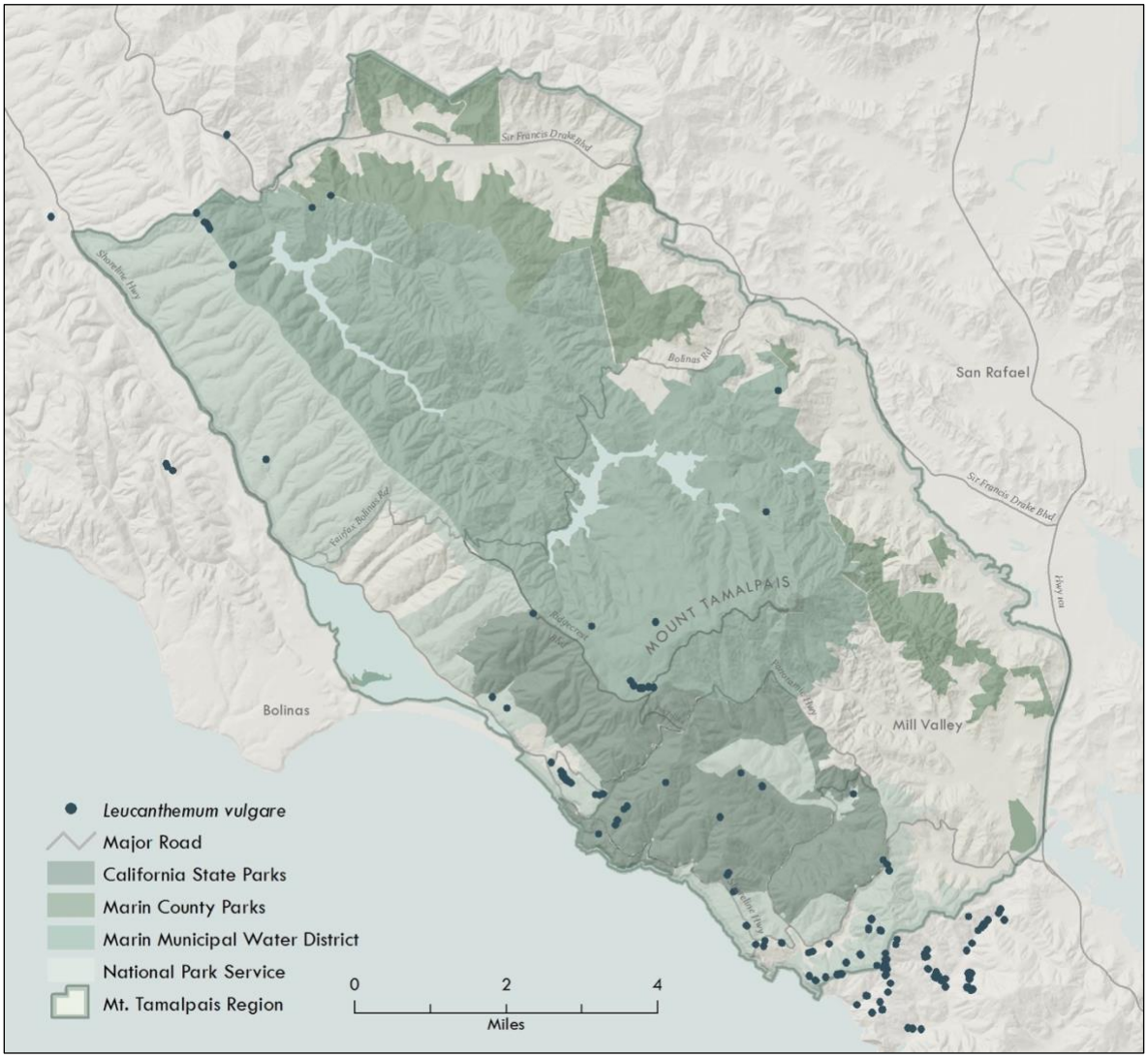
- Treat only around Muir Woods.

LEUCANTHEMUM VULGARE

Family: Asteraceae
Cal-IPC Rating: Moderate

Leucanthemum vulgare (oxeye daisy) is a Eurasian perennial herb that spreads both via seed and by fragmentation of fragile rhizomes. It follows disturbance along trails and ditches but demonstrates the ability to move into coastal shrublands and grasslands with fog influence, as well as wet meadows.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
75	50	9.07

Oxeye daisy is extremely prevalent in the southern Marin Headlands, and pokes into the Mt. Tamalpais region mostly along the southwest edge at Coyote Ridge and Coastal View. The northern half of the area much sparser, with one cluster on the formerly grazed northern end of Bolinas Ridge. There's a significant concentration along the seepy watercourse in Rock Spring Meadow.

WHIPPET Scores

4.77 – 6.94

Oxeye daisy scores place it in the middle of the pack among all species. High-scoring populations can be found at the top of Lone Tree Fire Road, in the town of Muir Beach on private property, and at Rock Spring Meadow. An occurrence at McCurdy Trail has the highest ranking but the annotations report no plants were found at last check. Most high-scoring populations are under management.

Recommended Treatment Strategy

Treat in high-value habitat, particularly wet meadows. Defer action otherwise.

Justification: The prolific seed production, impressive seed viability, and easily fragmenting root system of this species make successful eradication unlikely. The habitats it invades can host rare plants, especially in the unique wet meadow complexes on the lee side of Ridgecrest. Care should be taken to time treatment to minimize soil disturbance wherever hand-pulling is required.

Future Management Recommendations

MCP

- No mapped occurrences.

MMWD

- Continue annual follow-up treatment at Rock Spring Meadow.
- Continue annual follow-up treatment at Laurel Dell Road by Potrero Meadow.

NPS

- Defer action.

State Parks

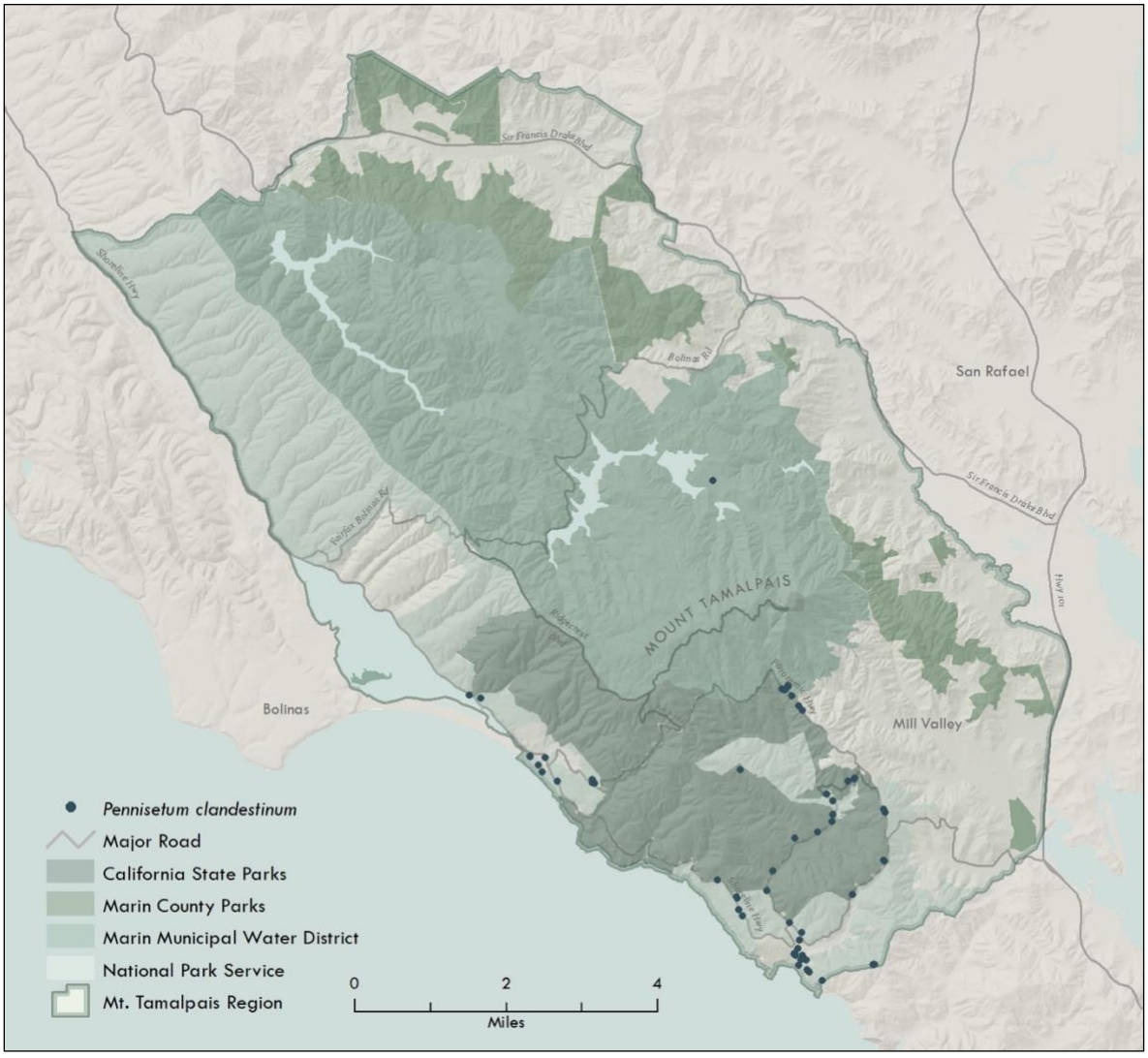
- Defer action.

PENNISETUM CLANDESTINUM

Family: Poaceae
Cal-IPC Rating: Limited

Pennisetum clandestinum (kikuyugrass), a mat-forming perennial grass, often occurs in urban and disturbed areas. It frequently spreads vegetatively in a fairly localized fashion, though fertile plants also occur in California. Mechanical vegetation management practices, including roadside mowing, often spread viable rhizomes and stolons. Habitat preferences on Mt. Tam include seeps, roadsides, and debris piles.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
62	45	1.36

Kikuyugrass populations cluster along Highway 1 near Stinson Beach, Panoramic Highway near Throckmorton, and along Muir Woods Road. Additional populations occur at Muir Beach and on Coyote Ridge.

Treatment history varies with most land managers leaving roadside patches alone but initiating treatment when populations spread into desirable habitat. For example, the NPS Habitat Restoration Team treats kikuyugrass on Panoramic Highway where it has invaded herbaceous wetland habitat. The team manages other species in that location, including *Ageratina adenophora*. These site-specific weed management approaches likely drive the decision to treat this species. Kikuyugrass's frequent affiliation with disturbance means that it regularly co-occurs with other weeds in this prioritization.

WHIPPET Scores

4.17 – 6.40

Kikuyugrass falls into the middle and lower scores among all species. Areas with high scores for eradication appear along Muir Woods Road, Highway 1, and Panoramic Highway. These scores likely reflect the high site values of their respective regions.

Recommended Treatment Strategy

Treat in high-value areas, particularly wetland habitat.

Justification: The roadside nature and limited spread of this species should influence its ranking for treatment more than the possibility to eradicate particular populations.

Future Management Recommendations

All Agencies

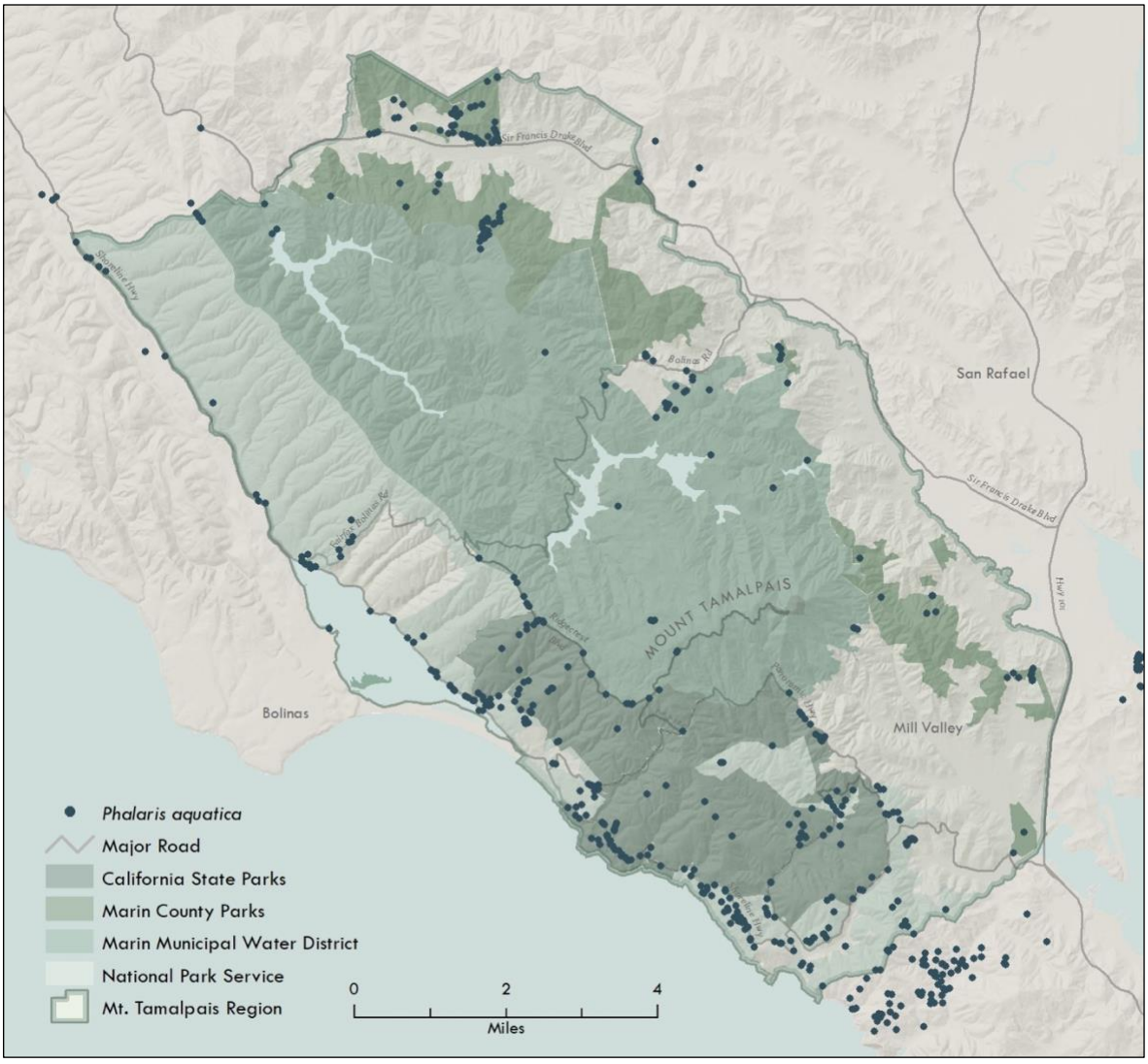
- Treat as indicated by site-specific priorities.

PHALARIS AQUATICA

Family: Poaceae
Cal-IPC Rating: Moderate

Phalaris aquatica (Hardinggrass), a robust perennial with lanky culms and a hardy crown, often appears in disturbed areas including roadsides and pastures. It can have significant impacts to grassland species composition in wildlands. Surveyors may occasionally confuse this species with the native *Phalaris californica* in wet areas.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
450	259	101.63

Hardinggrass occurs sporadically on the margins of the region as well as densely on the western and southern sides. It has spotty distribution across the interior MMWD lands with notable outliers near Potrero Meadow, Kent Trail, and Pine Mountain Fire Road south of the intersection with San Geronimo Ridge Road. Like *Festuca arundinacea* and several herbaceous weeds, this species traces major roadsides including Muir Woods Road, Highway 1, and West Ridgecrest Boulevard.

Hardinggrass species is likely well-mapped on public lands, but under-mapped on rights of way and private lands, particularly pastures. Treatment history for this species includes extensive work on Owl Trail, Coyote Ridge, Homestead Valley, and near the bottom of Panoramic Highway. Work on West Ridgecrest Boulevard by One Tam Restoration has emphasized State Parks land while MMWD has performed some limited control on the north side of that road. MMWD has also committed significant effort to the management of the northern population at Bathtub Gap, while MCP has largely abandoned the effort to control the population on their property. One Tam EDRR staff remove individual plants encountered in grassland habitat on surveys.

WHIPPET Scores

3.86 – 7.04

The highest scoring population appears along Bootjack trail on State Parks land above Muir Woods; Redwood Creek staff managed this 1 square meter population in 2016. Additional high scores appear at the top of Lone Tree Fire Road on State Parks land as well as Pantoll Road at Panoramic Highway. Many other high scores appear along trails or roads in forests where they represent outliers in high site value zones. These high scores do not align well with current management efforts for this species, which typically aim to protect rich grasslands. Large populations like those above Bathtub Gap get low rankings because of their size and site value.

Recommended Treatment Strategy

Treat in high-value areas, particularly grasslands.

Justification: Hardinggrass has prolific populations throughout the region. The wide distribution and fidelity to roadside habitat requires a measured approach. This approach aligns with current management status, which has the potential to protect vulnerable grasslands from impact, if implemented cohesively across the partnership. While the interior core of MMWD has few populations, most of the core has less suitable habitat than areas already invaded. New populations found through the EDRR program warrant consideration as they arise.

Future Management Recommendations

MCP

- Resume control efforts in Gary Giacomini preserve to match nearby effort of MMWD.

MMWD

- Continue management of outlier populations in the interior core.
- Continue management along West Ridgecrest Boulevard and Bathtub Gap.
- Initiate treatment at Potrero Meadow.

NPS

- Continue follow-up treatment on Coyote Ridge and Homestead Valley.
- Initiate treatment on West Ridgecrest Boulevard to match effort by MMWD and State Parks.

State Parks

- Continue and augment management on grasslands of West Ridgecrest Boulevard and Pantoll Road.
- Continue to monitor population on Bootjack Trail north of Muir Woods.
- Initiate treatment on Pantoll Road at Panoramic Highway.

Critical Collaboration Zones

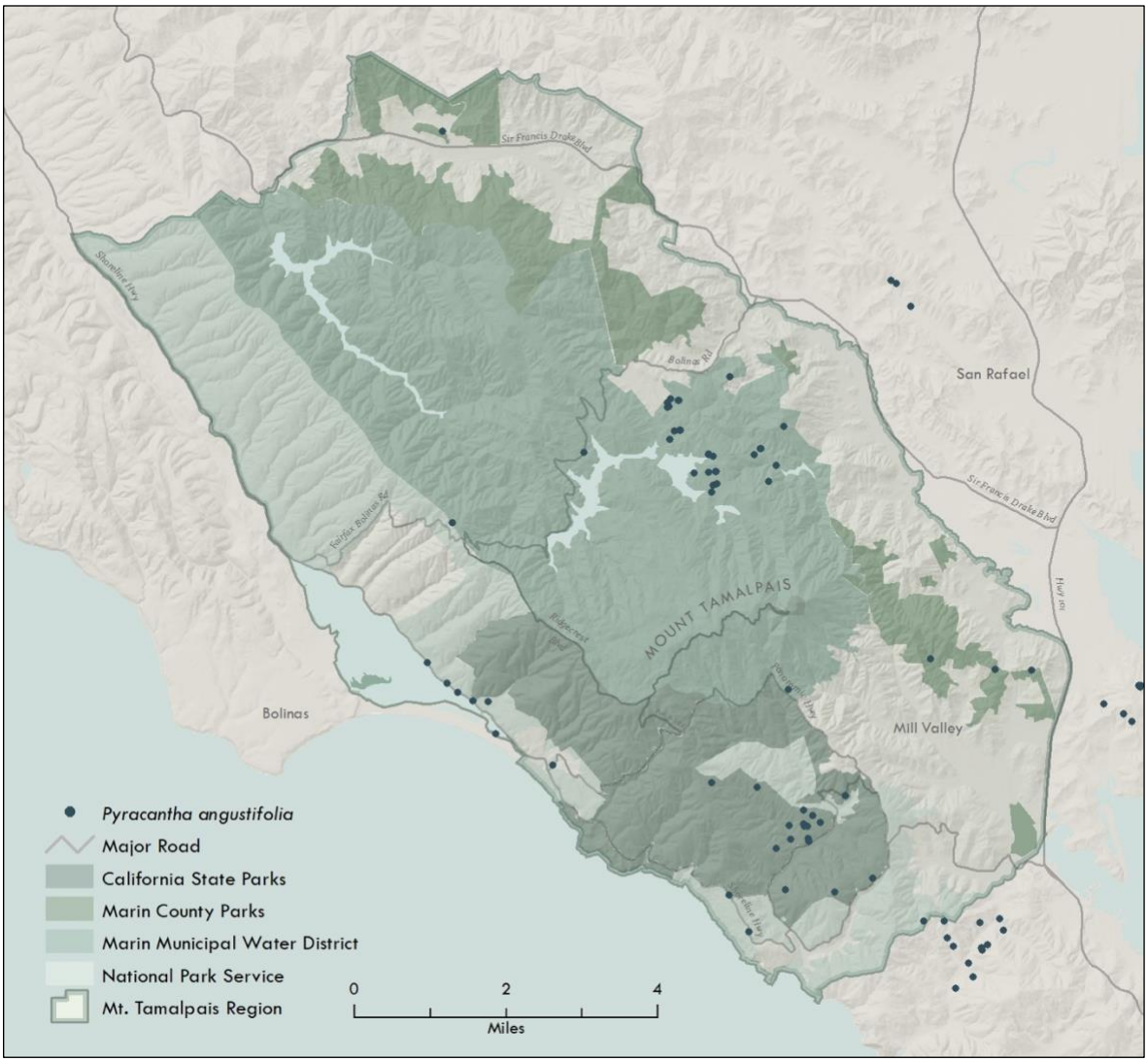
- West Ridgecrest Boulevard populations offer an opportunity for collaboration to reach successful eradication. This area sees much collaboration led by Parks Conservancy staff in Restoration, Conservation Management, and Youth Engagement around *Centaurea solstitialis* and Hardinggrass. The San Geronimo Ridge population near Bathtub Gap's rich grasslands offers another opportunity for collaboration.

PYRACANTHA ANGUSTIFOLIA

Family: Rosaceae
Cal-IPC Rating: Limited

Pyracantha angustifolia (narrow-leaved firethorn) is a spiny shrub native to China and commonly used in California as a landscaping feature for its hedge-like density, evergreen foliage, and bright red berries. It belongs to a guild of weedy roses that originate in gardens and are dispersed into wildlands by birds—as such it is often detected alongside its confamiliars.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
61	51	0.54

Narrow-leaved firethorn is found primarily in two population clusters on Mt. Tamalpais: one in the center of the Redwood Creek Watershed, and one in the lakes region of the MMWD Watershed. Records outside of these localities are exceedingly sparse.

WHIPPET Scores

4.44 – 7.35

These numbers fall across low, middle and high tiers of overall scores. Neither of the major clusters have any high-ranking points within them. The populations in Redwood Creek are largely unmanaged, but several populations on MMWD land are prioritized in meadow habitat.

Recommended Treatment Strategy

Treat in high-value areas, particularly where rare plants are threatened. Defer action elsewhere, unless as part of localized management of similar shrubs.

Justification: Narrow-leaved firethorn and other rosaceous shrubs can gain footholds in wet meadows, where they alter habitat and outcompete sensitive taxa. Treatment is recommended outside this context where similarly behaving species are slated for management already—*Pyracantha*, *Crataegus monogyna*, *Cotoneaster* spp., and *Ilex aquifolium* should all be considered together.

Future Management Recommendations

MCP

- Defer action.

MMWD

- Continue annual follow-up in Lagunitas Meadows to protect *Calochortus uniflorus*, *Perideridia gairdneri* ssp. *gairdneri*, *Castilleja ambigua* ssp. *ambigua*, and other rare wet meadow species.

NPS

- Defer action.

State Parks

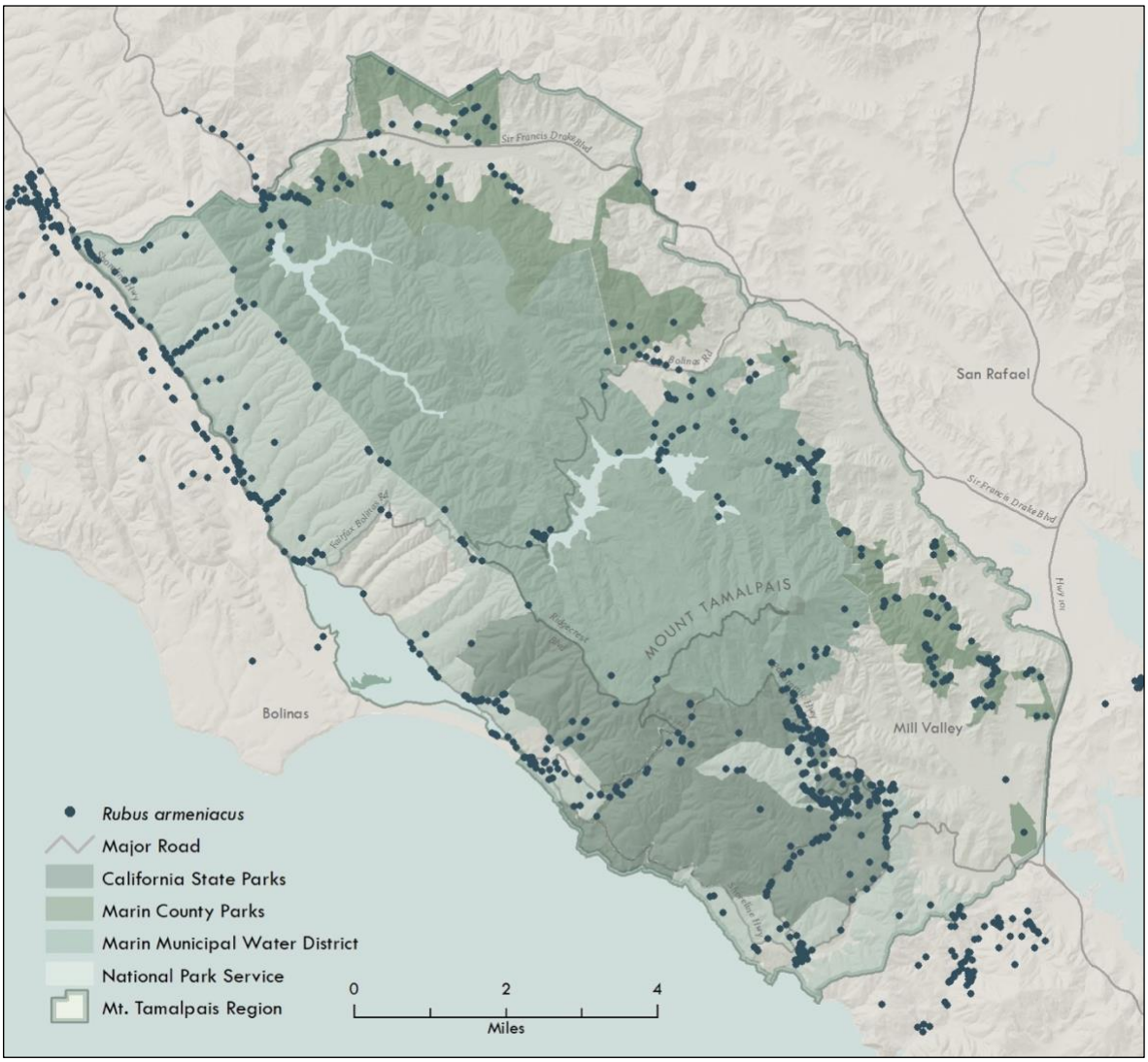
- Defer action.

RUBUS ARMENIACUS

Family: Rosaceae
Cal-IPC Rating: Limited

Rubus armeniacus (Himalayan blackberry), a rambling, thorny shrub with tasty berries, invades a variety of coast range habitats including riparian corridors, wetland margins, forests, and coastal scrub. Robust, gnarled root masses complicate manual removal of large patches, though repeated mowing can prevent fruit set, thereby reducing spread. Wildlife disperse the sweet fruits readily. Vegetative propagation occurs when heavy canes arc back to the ground and root from shoot tips.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
61	51	0.54

Himalayan blackberry distribution forms a distinctive ring around the region, likely because of its association with unmanaged private lands. It also has a strong presence along the shores and dam infrastructure areas of MMWD lands. This species is likely under-mapped in off-trail drainages within a quarter-mile or so of large infestations like those mentioned on MMWD land. Agencies have taken a cautious approach to management, leaving most areas untreated. Exceptions include Homestead Valley, 2017 treatments in Muir Woods, and treatments on surveys of patches under 5 square meters.

WHIPPET Scores

4.86 – 8.06

These scores range through all tiers with the highest scores standing out in areas in and adjacent to Muir Woods. Surprisingly, the western toe of Bolinas Ridge has many high scores. The WHIPPET model does not incorporate any topographical information into its calculations. Northern and eastern preserves also have high scores. Interior lands consistently rank lower, likely because of the treatment costs on MMWD lands.

Recommended Treatment Strategy

Treat in high-value areas, particularly in wet meadows. Continue treatment of small patches on EDRR surveys.

Justification: Himalayan blackberry has a wide distribution and strong presence. Off-trail drainages adjacent to large patches likely have additional populations, and unmanaged adjacent lands are likely to remain source populations. Where MMWD lands appear to have an intact core toward Kent Lake and Carson Ridge, treatment on surveys will slow establishment in less impacted areas. High-value areas such as wet meadows and restoration sites deserve special consideration with this species.

Future Management Recommendations

All Agencies

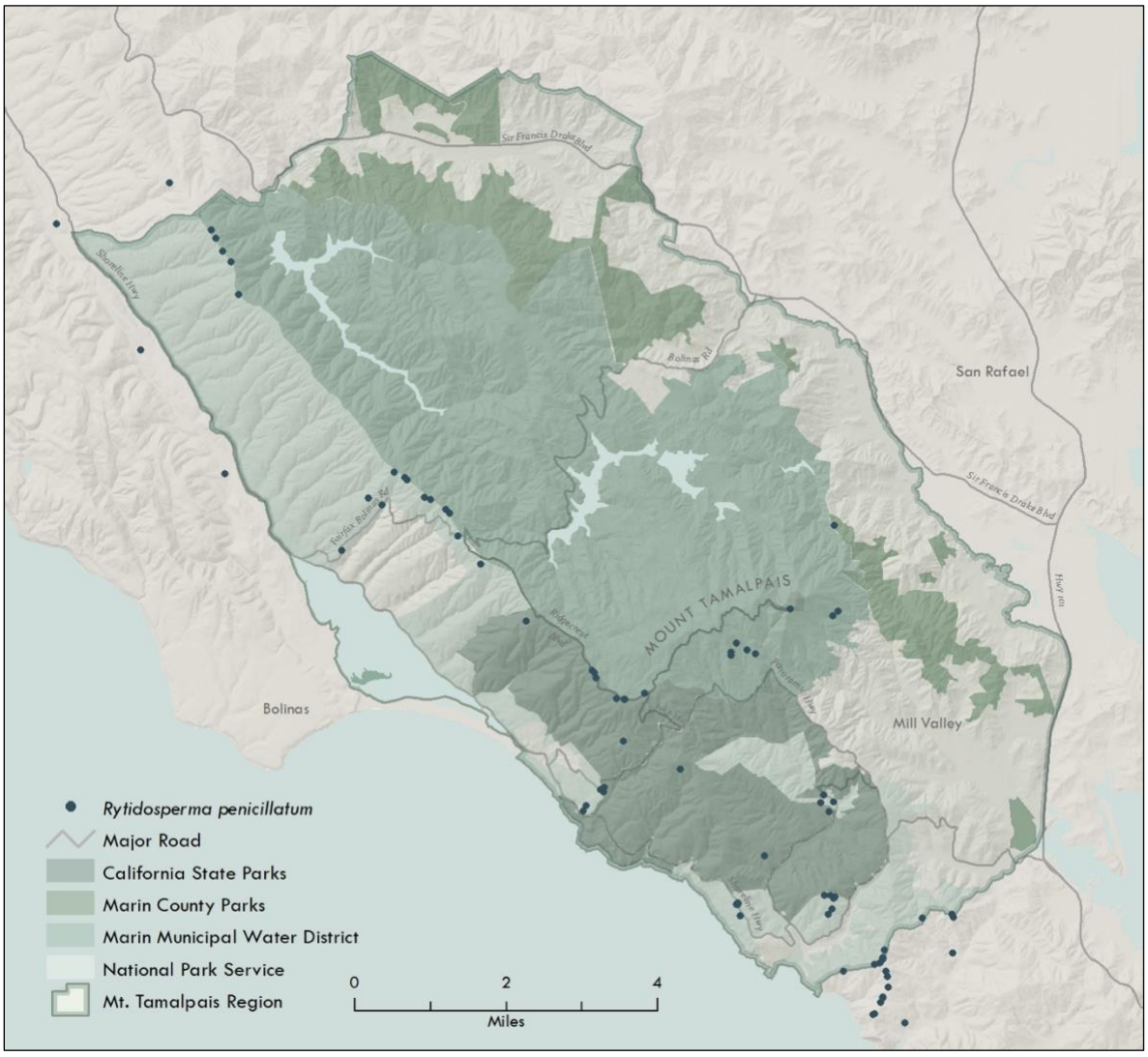
- Continue annual treatment in high-value areas as identified by vegetation management plans.
- Continue treatments on EDRR surveys for new patches in largely unimpacted areas if manageable within 10 minutes.

RYTIDOSPERMA PENICILLATUM

Family: Poaceae
Cal-IPC Rating: Limited

Rytidosperma penicillatum (hairy oatgrass) appears along disturbed trailsides in grasslands and shrublands as well as some forests in the Mt. Tam region. This easily overlooked perennial bunchgrass poses a significant detectability challenge for early detection surveyors. In at least one case, surveyors missed seeing hairy oatgrass during the survey of the road and trail network.

Regional Distribution



Occurrence Details

Patches	Populations	Gross Acres
63	48	5.13

While likely under-mapped, this species has known populations along Bolinas Ridge, East Ridgecrest Boulevard and in the Redwood Creek watershed. A small population on Kent Pump Road is known but remains unmapped. Treatment history includes sporadic management of the population at East Peak, as well as one-off treatments on EDRR surveys.

WHIPPET Scores

3.20 – 6.08

Hairy oatgrass scores place it in the middle and lower tiers among all species. A population at Dipsea Trail ranks as the highest for treatment, followed by one population on Bolinas-Fairfax Road. The latter population has several nearby patches in off-trail conditions nearby.

Recommended Treatment Strategy

Delist and defer action on all populations.

Justification: This species has limited impacts in wildlands and is likely highly under-mapped. It does not appear in many high-value areas at this time. Challenges in identification complicate successful surveys and treatment.

Future Management Recommendations

None

CITATIONS

Cal-IPC. 2014. Online WHIPPET User Guide. Version May 2014. whippet.cal-ipc.org/pages/view/guide

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Haubensak, K. A., C. M. D'Antonio, and J. Alexander. 2004. Effects of Nitrogen-Fixing Shrubs in Washington and Coastal California. Weed Technology, 18, 1475-1479. Available on www.jstor.org/stable/3989675 (accessed 19 February 2020).

Skurka Darin G.M., S. Schoenig, J.N. Barney, F.D. Panetta, J.M. DiTomaso. 2011. WHIPPET: a novel tool for prioritizing invasive plant populations for regional eradication. Journal of Environmental Management 92(1):131-139.

Appendix D. Priority Two Accounts for Species Excluded from WHIPPET Analysis

Six species on the One Tam Priority Two list were not evaluated for the California Invasive Plant Council inventory at the time of this writing. These species were excluded from WHIPPET analysis because the WHIPPET formula draws from the Cal-IPC inventory for species trait information. Some species in this list are currently under review by Cal-IPC and, pending the outcome, could be evaluated using WHIPPET in the future.

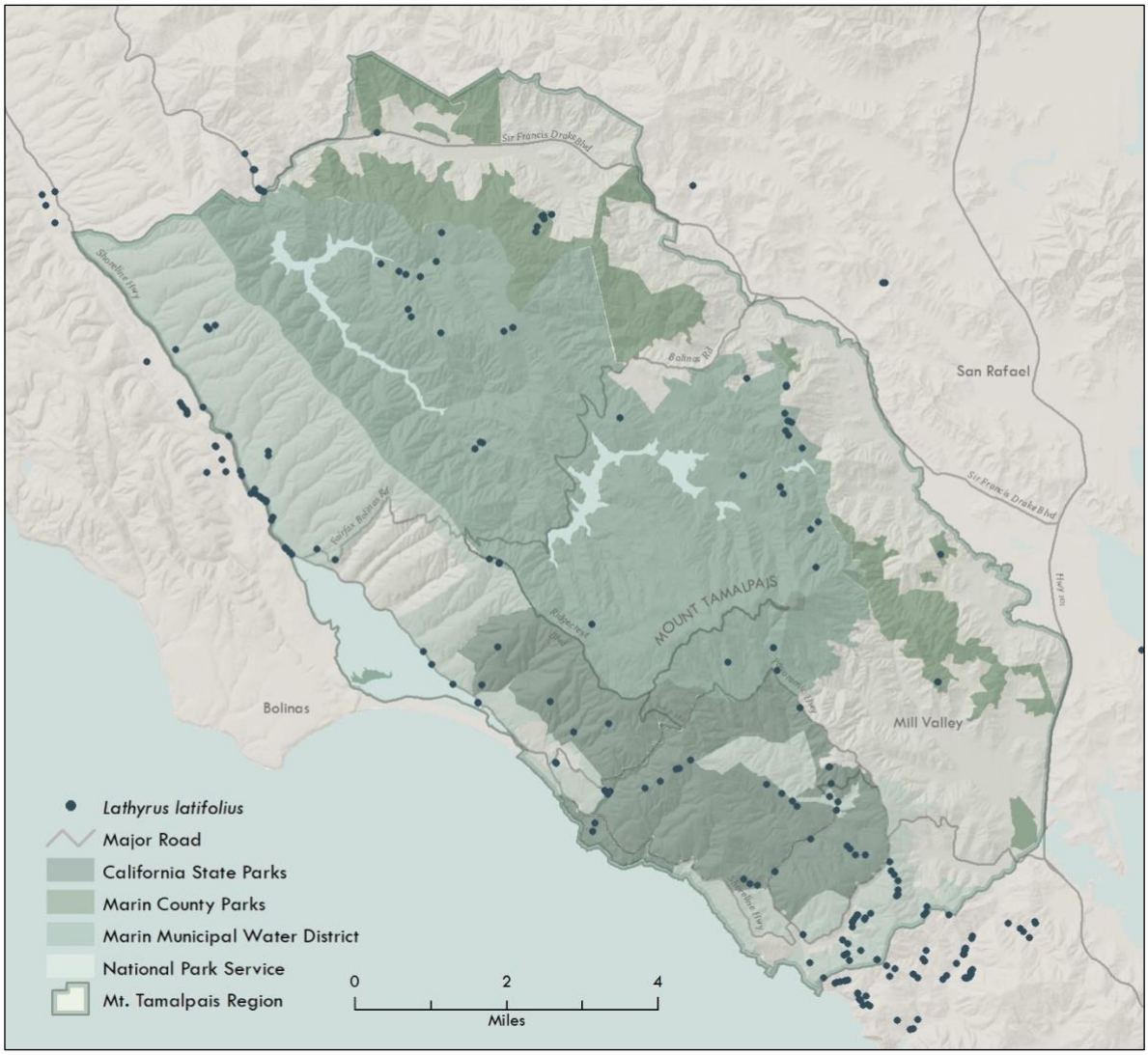
One species on the Priority Two list, *Rytidosperma caespitosum*, was excluded from WHIPPET analysis because no occurrences for this species have been mapped in Marin County to date.

LATHYRUS LATIFOLIUS

Family: Fabaceae
Cal-IPC Rating: Not ranked

Lathyrus latifolius (everlasting pea) produces bright, fragrant flowers favored by horticulturalists. With long-lived seeds and deep, extensive rhizome networks, this species spreads readily, climbing over adjacent vegetation and occasionally forming thick monocultures. Herbaceous vines die back entirely each summer. Small shoots often belie the mass of root material below the surface. Digging this species out is unfeasible beyond the first year of growth without heavy equipment. Because this species can move via rhizome fragments, excavated soil should never be moved off site unless it is into a known sacrifice area or to landfill. Chemical treatments are challenged by the low ratio of aboveground plant material to root mass.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Percent Managed
142	1.06	15.6%

Everlasting pea occurs throughout the Mt. Tamalpais region. Notable populations include the seep at upper Dipsea Trail near Veterans Bench and Worn Spring on MMWD land. Treatment for this species is infrequent. It is recommended that this species be addressed in high-value areas such as wetlands, when feasible. Because MMWD does not use herbicide, treatment options are limited to excavation with heavy equipment once established. The cost-benefit analysis of this approach will likely limit treatment on MMWD land to existing construction projects.

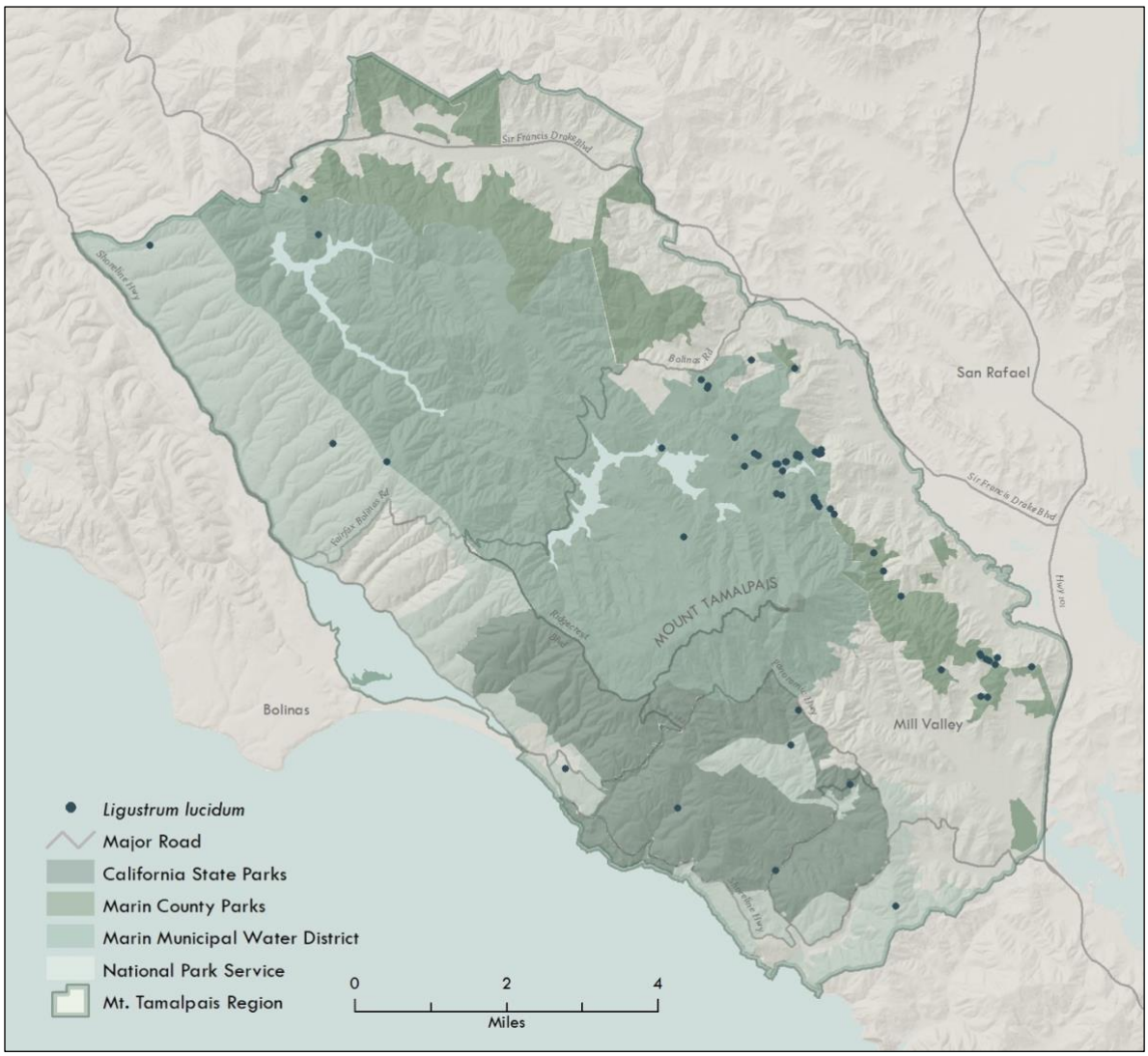
This species occurs throughout Marin and is likely under-mapped on private lands.

LIGUSTRUM LUCIDUM

Family: Oleaceae
Cal-IPC Rating: Limited

Ligustrum lucidum (glossy privet) is a favorite among horticulturalists as a garden border tree, a shade establisher, and a profuse bloomer. Such backyard plantings are the main source population for this species in Marin. Birds, readily observed eating the abundant black fruits, disperse seeds across wildlands, though usually in relative proximity to neighborhoods. New plants will then grow readily in understory or open habitats, particularly if near surface water. Fortunately, saplings tend to spend most of their time growing up rather than down—shallow roots enable easy removal of most early detections.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Percent Managed
59	0.16	23.4%

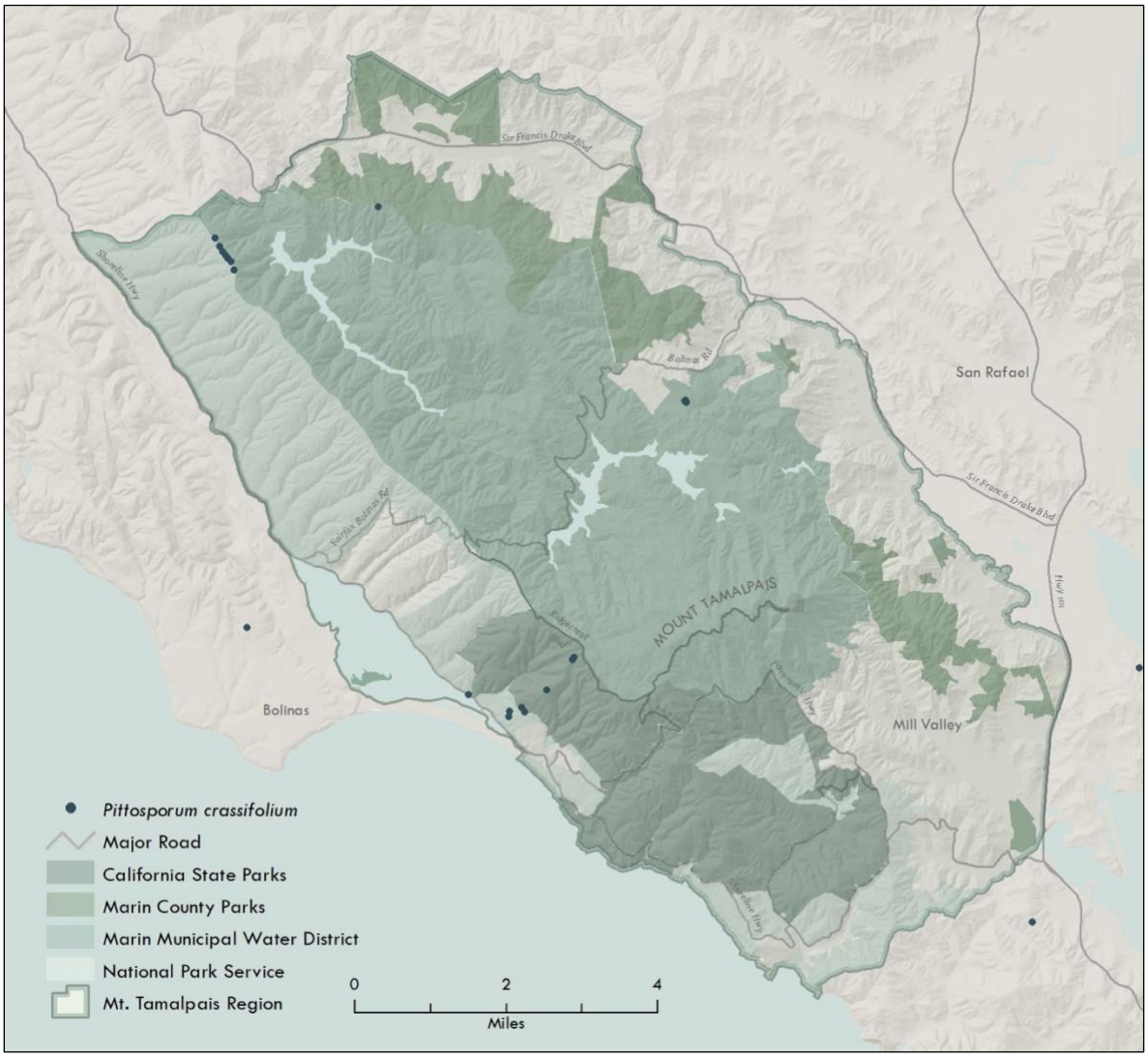
While glossy privet clusters along the eastern edge of the region adjacent to the communities of Corte Madera, Larkspur, and Kentfield, it also occurs near Stinson and Muir Beaches as well as the town of Lagunitas. This species occurs throughout Marin and is likely under-mapped on private lands.

PITTOSPORUM CRASSIFOLIUM

Family: Pittosporaceae
Cal-IPC Rating: Watch

The horticultural popularity of *Pittosporum crassifolium* (thick-leaved box) and others in its genus presents the opportunity for repeated introductions of the species. The conspicuous fleshy fruits of this widely planted tree are eaten and dispersed by wildlife.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Percent Managed
3	< 0.01	0%

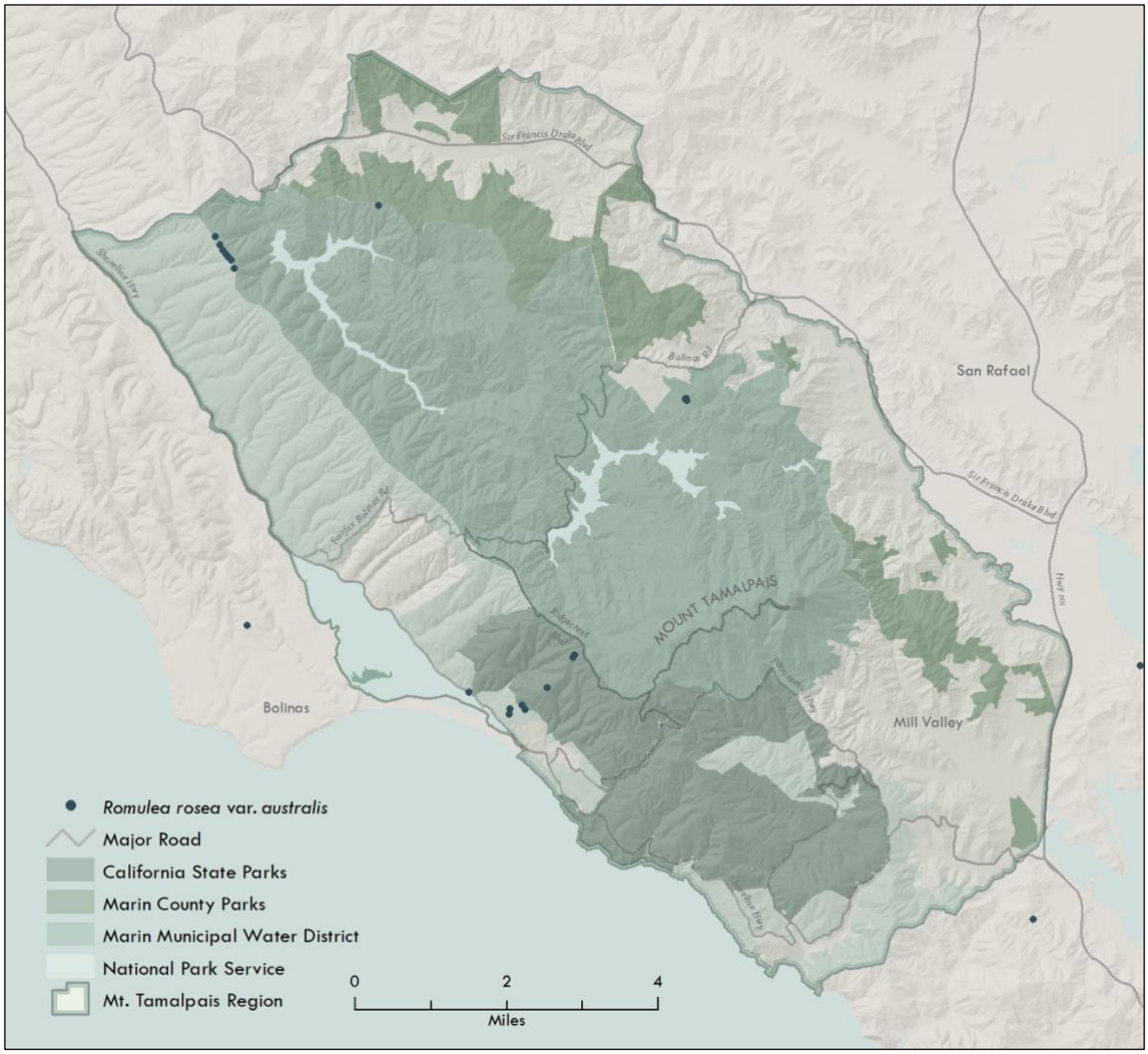
Thick-leaved box occurs very limitedly along the coast near the Muir Beach and Stinson Beach communities. One occurrence near Muir Beach occurs on private land or a Caltrans right of way.

ROMULEA ROSEA VAR. AUSTRALIS

Family: Iridaceae
Cal-IPC Rating: Watch

Romulea rosea var. australis (rosy sandcrocus) shows up in disturbed grasslands, pastures, and trail beds. Frequently overlooked, this species is most detectable during its narrow flowering window in March and April. The small pink flowers may not catch the eye of surveyors early in the day when they remain closed at the base of the plant.

Regional Distribution



Occurrence Details

Patches	Gross Acres	Percent Managed
23	2.37	2.9%

This species occurs in all quadrants of the region with a preference for open, disturbed habitats. Clusters of occurrences include the northern grasslands of Bolinas Ridge and the Willow Camp Fire Road corridor. A population at the Sky Oaks gateway is under management while many other populations are untreated. This species also occurs frequently at Point Reyes National Seashore, where it has been expertly mapped by the NPS Inventorying and Monitoring program. It likely occurs on pasture lands in north and west Marin. It is presumably vastly under-mapped on private land and much public land outside the region.

RYTIDOSPERMA CAESPITOSUM

Family: Poaceae
Cal-IPC Rating: Watch

Rytidosperma caespitosum (tufted wallabygrass) is a perennial grass known to invade some grassland and dune habitats in San Mateo and Santa Cruz counties.

Regional Distribution

Tufted wallabygrass is not known to occur on the public lands within the Mt. Tamalpais region.

Occurrence Details

Patches	Gross Acres	Percent Managed
0	0	-

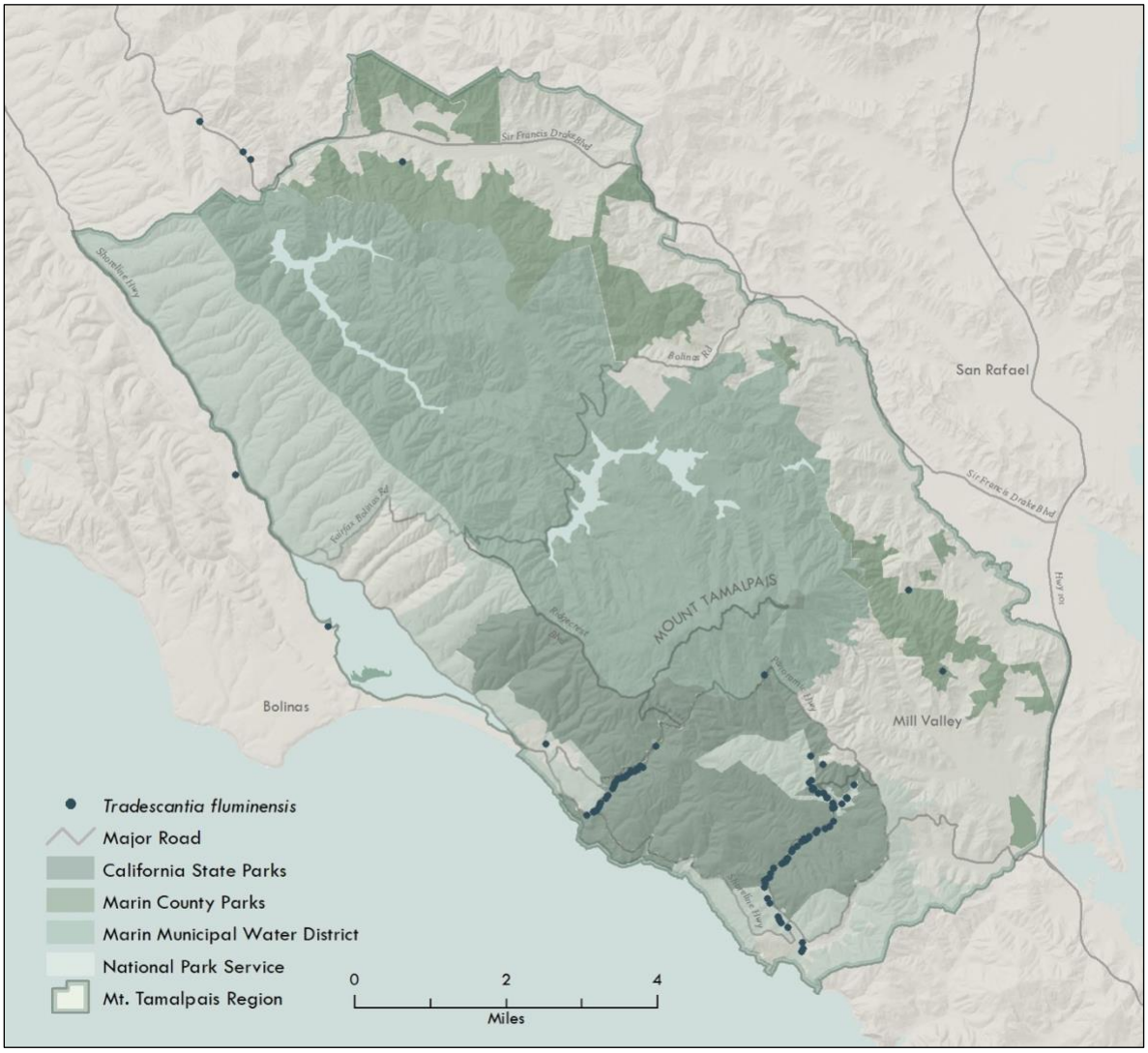
At present, tufted wallabygrass has not been mapped anywhere in Marin County. During the next protocol revision, it is recommended that the species be moved from the Priority Two list to the Priority One list to reflect its watchlist status. Another option would be to remove both *Rytidosperma* spp. from the list given identification challenges.

TRADESCANTIA FLUMINENSIS

Family: Commelinaceae
Cal-IPC Rating: Not ranked

Tradescantia fluminensis (small-leaved spiderwort) traces creek banks in several watersheds of Marin County. This plant appears to spread in riparian areas with the scouring of creek banks through the movement of rhizome and stem node material. Dense, mat-forming growth has been observed in riparian understory, including in coast redwood habitat.

Regional Distribution



Occurrence Details

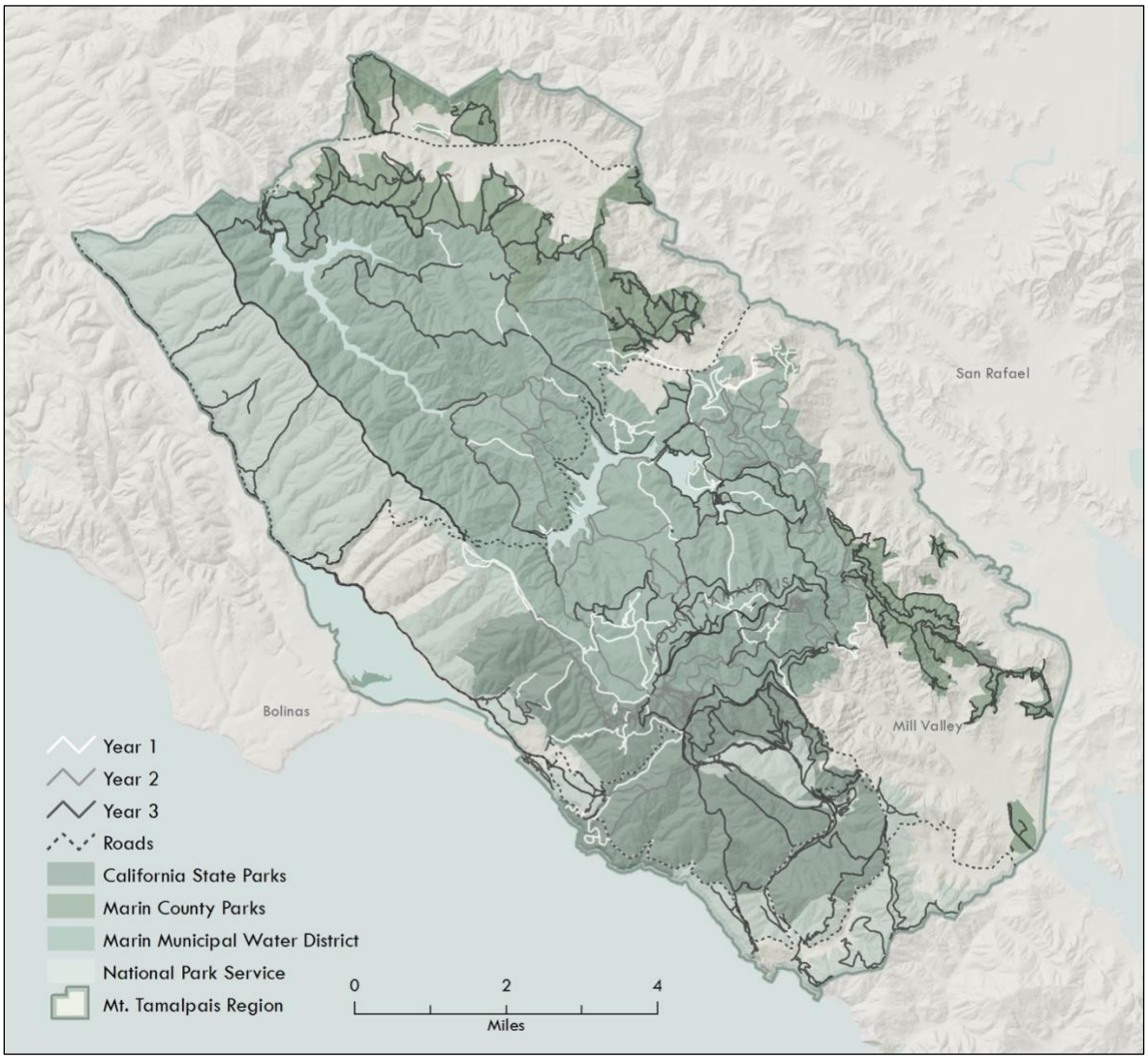
Patches	Gross Acres	Percent Managed
99	1.09	40.2%

Small-leaved spiderwort's distribution in the Mt. Tamalpais region follows obvious creek corridors including Redwood Creek and Webb Creek. Smaller patches also occur along Panoramic Highway and the eastern MCP preserves. Outside the region, small-leaved spiderwort is mapped at Pine Gulch on NPS land and along Lagunitas Creek in Samuel P. Taylor State Park. While Redwood Creek staff manage some patches, most occurrences remain untreated.

List of Appendices

Appendix E. Three-Year Survey Geography

PROJECTED ROAD AND TRAIL SURVEYS



All roads and trails that can be safely traversed by foot are surveyed over the course of three years.

List of Appendices

Appendix F. Data Collection Fields In Observer Pro

Fields without Domains

Observer *	**Observation Date ***
Specimen Photo	**Habitat/Overview Photo**
Treatment Notes	**Radius (m)**
Generate a Polygon	**Location Description**
Percent Treated	**Number of Plants Treated**
Total Number of Labor Hours	

Fields with Domains

Species*	Region	Under Management?	Treatment?	Crew
Choose from Plant List or enter manually	*Choose from list or let auto-populate*	Verified	none	*Choose from list*
		Searched for but not found	Mechanical	
		Under management		
		Extirpated		

*Mandatory field

Fields with Domains (continued)

Habitat	Number of Plants*	Percent Cover	Distribution	Phenology	Mechanical Method
Riparian forest / shrubland	0	0	Single Plant	Seedling / rosette	Hand Pull
Hardwood forest	1	0-1	Isolated Patch	Bolting	Hand Cut
Douglas fir / coast redwood	2-10	1-5	Scattered Plants	Leafing out	Hand Tools
Bishop pine	11-50	5-25	Dense Monoculture	Flowering	Power Tools / Chainsaw
Coastal scrub	51-100	25-50	Scattered Dense Patches	Fruiting	Machine Pull / Dig
Coastal dunes	101-1000	50-75	Linear	Mature	Brushcut / Mow
Grassland	1001-10000	75-95	Uniform	Vegetative	Plough
Herbaceous wetlands	>10000	95-100	Satellite	Dormant	Mulch
Disturbed	*Type here*	*Type here*	*Type here*	Dead / skeleton	Tarp
Beaches or mudflats				Sapling	HMO
Non-native forest					Girdle
Urban					Flower / Seed Removal

*Mandatory field