Clematis vitalba: Best Management Practices

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Photo credits: photos taken by Ian Bornarth Photography, Keir Morse, and report authors.

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Chapter 1 – Introduction

This report focuses on the non-native, invasive weed *Clematis vitalba*, and the best management practices for identification, treatment, and control of the species garnered from a successful four-year removal project at the San Vicente Redwoods property near the town of Davenport in northern Santa Cruz County, CA. The report provides insight and protocols that proceed through a typical management pathway that was utilized at San Vicente Redwoods from identification and initial control, to broader project planning, to eventual treatment strategies and effective monitoring techniques. The report is also accompanied by a two-page summary document. Additional information, data, and results from the project can also be made available by request from Sempervirens Fund and/or the California Department of Fish and Wildlife (CDFW) if desired.

San Vicente Redwoods is an 8,532-acre conservation property owned by Sempervirens Fund (Sempervirens) and Peninsula Open Space Trust (POST), with a conservation easement held by Save the Redwoods League. Management of the property combines a range of restoration activities, sustainable timber harvest, and future public access led by the Land Trust of Santa Cruz County. To control a 70-acre infestation of *Clematis vitalba* in the San Vicente Creek watershed with 30 acres located on San Vicente Redwoods and an additional 40 acres on the downstream Bureau of Land Management (BLM) property, Sempervirens and POST sought and received funding in 2016 from CDFW through the Watershed Restoration Grant Program to treat and eventually eradicate the 30-acre portion on San Vicente Redwoods, and inform additional future phases of work to eliminate the remaining downstream portion.

Clematis vitalba is an extremely aggressive, invasive, non-native plant that grows quickly and spreads easily, creating thick tangled vining vegetation that covers the ground and climbs upwards along the trunks of trees, eventually outcompeting native vegetation and threatening native biodiversity. The vine can grow up to seven times faster than ivy and each plant can produce over 100,000 seeds, which are then spread by wind, water, wildlife, and human interaction. *Clematis vitalba* can also sprout from stem fragments, making control and eradication particularly challenging.

At the time of the project initiation, there were only two documented infestations in the state: one in Marin County in Muir Woods National Monument, which was reported to Calflora in 2015, and the second in the San Vicente Creek watershed. The California Invasive Plant Council (Cal-IPC) lists *Clematis vitalba* as a “Moderate- Alert”, but because the species is not yet widespread in California, regional treatment protocols and best practices for control of the plant have not been well documented. *Clematis vitalba* is listed as a Class B noxious weed by the Oregon Department of Agriculture and as a Class C noxious weed by the Washington State Noxious Weed Control Board, however practices developed in those regions may not be appropriate for the San Vicente Creek watershed because of differing growth patterns, climate differences (e.g., higher average rainfall in Oregon and Washington) and other variables. Most significantly, the San Vicente Creek watershed, which has been recognized for its role in the recovery of Central California Coast (CCC) Evolutionary Significant Unit of coho salmon (*Oncorhynchus kisutch*) and CCC steelhead (*Oncorhynchus mykiss*) is currently threatened by the infestation in the lower and reaches.

For the project on San Vicente Redwoods, treatment and monitoring efforts took place from spring 2018 through 2021, and across the four years of treatment the project successfully reduced *Clematis vitalba* cover and constancy levels from as high as 90% to near 0% throughout the project area, with subsequent increases in native plant species diversity and cover as well. The work also integrated detailed monitoring into its design to inform adaptive management techniques, and the primary subcontractor, Go Native Inc., utilized manual removal and judicious herbicide treatment methods for control.

Chapter 2 – Identification and Initial Control

2.1 Identifying *Clematis vitalba*

Before initiating any treatment work on a potential *Clematis vitalba* outbreak, the first step is to positively identify that it is in fact the correct species. In Northern California there are two native *Clematis* species, *C. lasiantha* and *C. ligusticifolia*, which have many characteristics that overlap closely with *Clematis vitalba*. Similarly, any collection or propagation work with the native *Clematis* species should also verify that there isn't any accidental spread of unidentified *Clematis vitalba*. Due to the difficult nature of distinguishing *Clematis vitalba* from the native *Clematis* species, it is essential to consult with a botanist familiar with the various *Clematis* species to positively confirm the correct identification.

2.1.1 Comparison of *Clematis vitalba* with native Northern California *Clematis* species

Below, non-native *Clematis vitalba* is compared with the two native Northern California Clematis species (*C. lasiantha* and *C. ligusticifolia*) for field identification purposes based on species descriptions from the Flora of North America (accessed online) and supported by personal observations made over the course of the San Vicente Redwoods *Clematis* project. Characteristics that seem to most reliably differentiate *Clematis vitalba* from either *C. lasiantha* or *C. ligusticifolia* are described below. Key distinguishing characters for *Clematis vitalba* are indicated in bold font.

Foliage

Clematis vitalba leaflets (Figures 1, 2) are generally **cordate** (heart shaped), creating a leaflet **base** that is **broadly two lobed**. Leaflet margins are **often entire** (without teeth or lobes) but may also be crenate (rounded teeth) or dentate (coarse pointed teeth).

Leaflets of the two native species vary from lanceolate to broadly ovate, **not cordate**, leaflet margins are variously toothed or lobed (occasionally entire), and leaflet bases are generally tapered, rounded or truncate (Figures 3, 4).

Figure 1: *Clematis vitalba* – cordate leaflets with entire margins

Figure 2: *Clematis vitalba* – cordate leaflets with crenate margins

Figure 3: *Clematis lasiantha* – leaves not cordate

Figure 4: *Clematis ligusticifolia* – leaves not cordate
Credit: Keir Morse, 2009, Cal Photos

Flowers

Individual *Clematis vitalba* flowers are **bisexual**, with each flower containing both male parts (stamens) and female parts (pistils) (Figure 5).

Individual flowers of the two native *Clematis* species are **unisexual**, with each flower containing only male parts (stamens, or stamens and sterile staminodes), or containing only females parts (pistils) (Figure 6).

Clematis vitalba and *C. ligusticifolia* are summer blooming (June-August/September), *C. lasiantha* is winter/spring blooming (January-June).

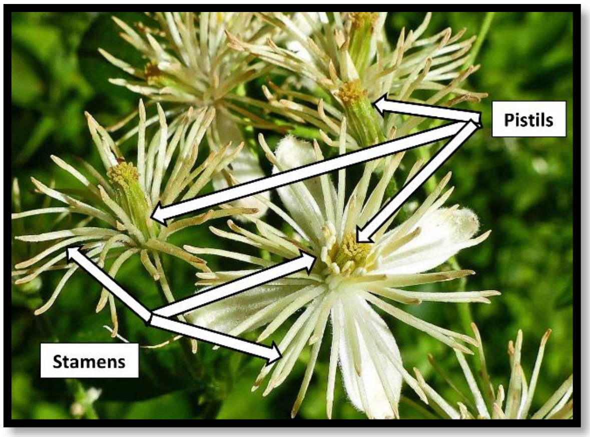

Figure 5: Bisexual *Clematis vitalba* flowers showing both stamens and pistils

Figure 6: *Clematis lasiantha* – unisexual male flowers with stamens only

Stems

Clematis vitalba's older climbing stems can reach **heights of up to 40 feet**, and woody stems may be **4 inches** or more in **diameter** (Figures 7, 8).

Stems of the native *C. lasiantha* and *C. ligusticifolia* species are generally less than 20 feet long.

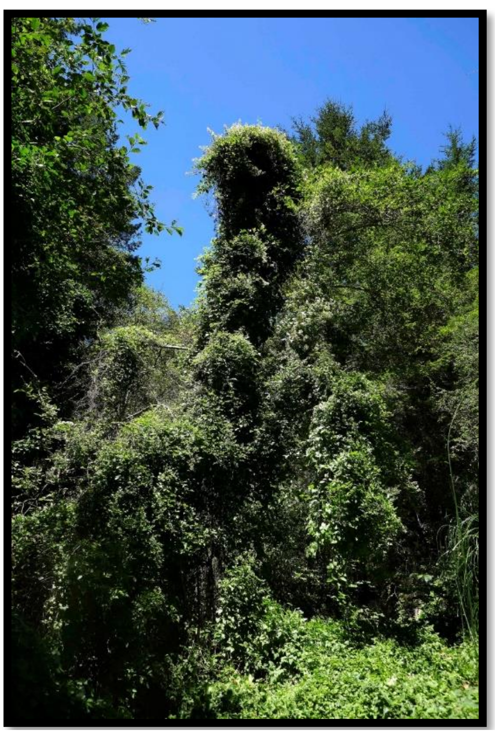

Figure 7: *Clematis vitalba* high in the top of an alder tree

Figure 8: Large, woody *Clematis vitalba* vine

2.2 Identifying Distribution Vectors

When first identifying a *Clematis vitalba* outbreak, it's essential to locate the key vectors of spread as the species can expand rapidly via multiple pathways. As an initial step, it's useful to figure out how it got there and from where as best as possible, since that can shed light on possible future reintroductions that could be mitigated and other disparate populations that may currently exist. As *Clematis vitalba* is grown and used horticulturally, it may be that the outbreak stems from single or multiple introductions at varying times, as the San Vicente Redwoods population is believed to have come from an escaped planting multiple decades ago.

Discovering the primary vectors of *Clematis vitalba's* spread is critical to be able to craft a broader treatment strategy and to take effective initial action. *Clematis vitalba* can grow vines that extend up to 100 feet sometimes just below the soil surface, so tracking where these lead can help in seeing the extent of the existing population and where it might emerge in the near future. The vines can also climb high into the canopies of trees, which coupled with the large volume of windborne seeds it produces can rapidly spread the plant. Once it reaches the canopy, the increased sunlight appears to spur the development of seed, so depending on the location and prevailing wind patterns can be a major vector for spread (Figure 7). More open areas that get ample sunlight also allow for significant seed production, so depending on the surrounding habitat this may also lead to rapid expansion.

Clematis vitalba readily grows from fragments and resprouts, which can open up multiple routes for spread to be aware of. As the species thrives in riparian habitats, even growing into the sandbars of creeks, portions of vines or leaves can be carried downstream and take hold on the banks. If the population is adjacent to a road or other vegetation management work, this can also lead to inadvertent spread by human or vehicle, especially since the species is deciduous and can go easily unnoticed during the winter months.

In the case of San Vicente Redwoods, it appears that the population spread slowly until it reached riparian habitat, where the population then exploded to cover nearly 70 acres. Assessing if such ideal conditions are near the outbreak could also help in prioritizing treatment.

2.3 Population Mapping

As part of initial planning and ideally done concurrently with identifying the correct *Clematis* species and determining the key vectors of spread, detailed mapping of the *Clematis vitalba* population is critical to help select the preferred initial and long-term control strategies. Since *Clematis vitalba* can spread rapidly and via multiple pathways, frequently updating maps and checking beyond the previously mapped population boundaries as well as along nearby roadways and streams can ensure that outlier populations aren't missed. Comparing the mapping results with available resources and other treatment priorities should inform what type of action is taken.

At San Vicente Redwoods, initial mapping efforts began in 2012-2013 as part of the development of the San Vicente Creek Watershed Plan for Salmonid Recovery. This entailed basic GPS location recording along with the use of occurrence sheets to gather info on percent cover, native species presence, access constraints, and initial treatment prioritization. Along with early control efforts to minimize further spread, this data was updated in 2016 with GIS polygons to better track population footprints. With the initiation of this project and the resources to treat the entire infestation on the property, more in-depth mapping was done to not only refine population locations and boundaries but also to establish population density classifications and lay out management units. This formed the basis for treatment planning and monitoring transect locations, as the density of *Clematis vitalba* cover determined types of treatment needed. Initially densities were denoted as Low (1-25% cover), Medium (26-50% cover), and High (51-100% cover) for assessing treatment strategy, while monitoring classifications entailed a more detailed structure of Trace (<1% cover, solitary or scattered individuals), 1 (1-5% cover), 2 (5-25% cover), 3 (25-50% cover), 4 (50-75% cover), and 5 (>75% cover).

2.4 Initial/Emergency Procedures

In the case where a *Clematis vitalba* population is too large to tackle entirely or initial resources are limited, there are treatments that can be taken to efficiently mitigate the spread as much as possible while establishing a more holistic approach. At San Vicente Redwoods, this meant focusing on areas of easy spread and efficient control.

While removing large volumes of *Clematis vitalba* that form near monocultural stands requires significant effort, severing vines that have grown into canopies allowed for quick and effective control that also tackled a primary vector of spread as seasonal onshore winds and early winter storms could rapidly spread seed, and much of the flowering *Clematis vitalba* was in tree canopies. Key in this effort was ensuring that every connection to the ground was cut, so that the vines would desiccate and die while still attached to the tree. Creating a sufficient 'air gap' between the lowest vine sections and the ground was vital, as the vines would often sag following cutting and could then resprout if they came in contact with the ground. Ensuring that the vines don't expand across multiple canopies and trunks is also important to make sure that any root connections aren't missed, as there were some instances where vines had grown into canopies and rooted on opposite sides of a creek.

Figure 9: Cutting vines far enough above the ground helps limit resprouting

In addition to focusing on cutting vines growing into trees, initial efforts were also focused on edges of the population where control was more manageable and could limit other vectors. This was primarily centered around the primary access road, as the more compacted surface limited vines growing underneath it while removal near there also reduced potential long-distance spread by vehicle. While at San Vicente Redwoods it was already known that the population extended across multiple properties, identifying if a cross-boundary population exists is essential for being able to plan and be effective.

Chapter 3 – Project Planning

3.1 Permitting and Special Status Species Considerations

While each project and site has its own set of considerations and applicable permits, at San Vicente Redwoods the presence of special status species was a key consideration.

Around 2015, the Army Corps of Engineers (ACOE) began further limiting their jurisdiction to only portions of projects that result in the placement of fill in Waters of the US, under the Clean Water Act. As such, many invasive plant management projects do not require a permit from ACOE and therefore lack a federal nexus with the United States Fish and Wildlife Service under the Endangered Species Act (ESA).

The only mechanism for an individual or private citizen to "take" a listed species under Section 10 of the ESA is to develop a Habitat Conservation Plan (HCP). The development of an HCP is estimated to take 3 to 10 years. This is in contrast to Section 7 of the ESA, which regulates federal government actions and take of federally listed species can be authorized through the issuance of a biological opinion (usually issued in less than 1 year).

To address this limitation and gain federal authorization for take of the federally threatened California red-legged frog (CRLF) (*Rana draytonii*), the project was permitted under a Federal Fish and Wildlife Permit (TE- 61720B-O). This permit allows for take of endemic amphibians when a proposed project encompasses aspects of species recovery, including, upland habitat management (vegetation removal and planting).

For compliance with local and state regulations, Sempervirens obtained a 401 Water Quality Certification from the Regional Water Quality Control Board, a Lake and Streambed Alteration Agreement from CA Dept of Fish and Wildlife, and a Riparian Exception, Land Clearing and Coastal Development from the County of Santa Cruz. In addition, the County was the CEQA lead agency and filed a Negative Declaration for project activities.

3.2 Treatment Approach for Large-scale Projects

Decisions on how to approach an invasive control project are often driven by the physical situation and resources available. The *Clematis vitalba* population at San Vicente Creek ranged across 30 acres of riparian habitat, with approximately 7+ acres rated medium-high density (>50% cover), and about half of that concentrated in the confluence area of San Vicente Creek and Mill Creek, and the rest spread out into three other areas upstream from the confluence or uphill from the riparian corridor.

A classic approach to tackling a wide-area invasive plant infestation is to start at the outlying areas and work inward toward the heavier populated areas. This is most practical when resources (personnel, equipment/tools, and time) are limited, and allows the infestations to be contained within known areas. But it leaves large areas of the plant growing wild, producing seed and stem break-offs that can continue spreading to other areas.

Sufficient grant funding opened the possibility of bringing in a crew from the California Conservation Corps (CCC) for a 4-day work “spike”, which was used to focus on clearing out as much of the above ground vegetation in the heavy-density areas as possible. This area was in the higher flood plain of the confluence, with minimal hazards, and had easy access and movement throughout. This approach offered a number of benefits:

- Although the CCC crews were not particularly experienced in these types of invasive control projects, the straight-forward goal of removing above-ground vegetation of an easily identifiable species kept the crew busy and focused with minimal training required.
- The approach helped with management of a large crew of workers by keeping them in the same area working on a singular goal.
- The immediate positive result of clearing large areas helped the work crew’s motivation and sense of accomplishment.
- The clearing of the large infestation areas exposed the underlying rooting and growth structure of the *Clematis vitalba*, which helped in formulating work approaches for more experienced personnel for removal/control of the remaining active root system.
- Clearing of large areas also contributed to an immediate activation of the existing underlying seed bank and plant development that had been suppressed by the heavy *Clematis* coverage. This produced a head start on the recovery of native plant species as well as showing what other non-native invasive plant (NNIP) species were in the area. These other invasives were easier to remove and control when remaining small and un-established.

In general, if resources and conditions are favorable, starting in the middle can be a productive approach if a large crew of workers or volunteers is available for a concentrated work spike in the area.

3.3 Preventing Spread from Field Crews

Standard protocols of limiting spread of invasive plant material should always apply to any area where containment of an invasive species is required. These typically include avoiding picking up seeds or pieces of live plant material on clothing, tools, and vehicles that might unintentionally transport them to un-infested areas. Specific to *Clematis vitalba*, it is important to understand the plant’s methods of spreading - by seed, and by live plant pieces.

Clematis vitalba seeds mature in the late fall and through the winter – the seeds are attached to strands of fluffy material that allow them to be carried by the wind. Frequently they will drop into creeks to be carried downstream or settle on the ground where they can be picked up on the feet of humans or animals.

Clematis vitalba also spreads vegetatively – broken off sections of the green growing stems, or pieces of root stock, can take hold and re-root in damp areas. These can be picked up on clothing or on feet in damp or muddy areas.

In addition to standard protocols to prevent spread of invasive plants, the following procedures should be followed when working in areas with *Clematis vitalba*:

- Shoes, clothing and tools should be checked for any mud, seeds, or plant material and cleaned before leaving the area.

- When removing *Clematis vitalba* by manual methods, ensure that all parts of the plant have been removed and contained.
- When manually removing *Clematis vitalba* plants that have developing seeds or mature seed heads on them, the seed heads should be carefully removed from the rest of the plant and bagged or placed in a sealed container.

Care should also be taken to avoid bringing in any outside NNIPs into the *Clematis* work area. As *Clematis* removal often involves clearing large areas down to bare dirt, it is important that other NNIPs are not introduced. At the San Vicente Creek site, the roads that lead to the *Clematis* area travel through areas with heavy infestations of poison hemlock, French broom, jubata grass, thistles, and other aggressive weedy species. Care should be taken, especially during times when these species are producing seed, that transporting another invasive into the area is avoided.

3.4 Containment Structures

Containment areas should be set up to collect all the removed *Clematis vitalba* plant material. Tarps or sheets of nursery ground cloth can be used for smaller piles, as long as the removed material cannot contact moist soil. Any seed heads that have been removed can be buried inside the cut plant material. *Clematis vitalba* desiccates fairly quickly and does not compost into anything resembling useable organic material, so the green stems do not form roots and any seed within the material does not germinate.

For larger quantities, larger containment structures (Figure 10) were built using 30" tall silt fencing rolls for walls and nursery ground cloth for the floor.

Figure 10: Large containment structure located on an existing road

After the bulk of the vegetation is removed, the area should be surveyed for root remnants. If possible, they can be dug up and pulled out (Figure 11).

Figure 11: CCC crewmember digs out a large *Clematis vitalba* root structure

For those that cannot be removed by hand, the stem should be cut as close to the root base as possible, and the cut area immediately brushed with an appropriate herbicide.

Sites where extensive clearing has occurred should be assessed for potential erosion problems. In areas where there was a likelihood of winter flooding, woven coir blankets were installed for erosion control to protect soil from washing away and also to encourage fresh sediment deposition from flooding.

Chapter 4 – Treatment Strategy and Methods

4.1 High-density Removal Methods

Clematis vitalba can form very dense populations in the right conditions, resulting in coverage of up to 100%, effectively shading out any other plants from germinating or growing. It seems to prefer damp riparian areas with high canopies and a certain amount of open area for ground spreading. It spreads rapidly in shaded understory, but needs light to flower and produce seed, and so will climb trees up to 50 feet tall to reach light.

The initial action is to cut any climbing vines to help stop blooming and seed development – stems should be cut about six feet above the ground, and trimmed back to ground level so that new growth cannot reach the old vines. The cut vines will wither and die off within the year. *Clematis vitalba* stalks have a unique internal hydraulic system that enables the stems to raise up to grab onto higher branches. Unlike other climbing vines, they do not have separate tendrils for climbing but instead extend their leaf petioles to wrap onto small twigs and branches.

After cutting climbing stems, all above ground vegetation should be removed. When feasible, the plants should be pulled out by the roots; if the root structure is too large or the ground too hard, the plants should be cut a few inches above the surface and the cut area immediately brushed with an appropriate herbicide.

4.2 Herbicide Use

Clematis vitalba tends to grow in riparian areas, often within established communities of riparian vegetation and sensitive wildlife habitat, areas where herbicides should be used carefully and sparingly. Consideration should be given to native species (fish, reptiles, amphibians, birds, insects, etc.) that could be impacted, as well as the overall health of the natural biome. Factors such as chemical persistence, movement through soil, and groundwater contamination should also be taken into account.

In coordination with CDFW, targeted Pest Control Recommendations (PCRs) were crafted that gave the level of efficacy needed to control *Clematis vitalba* and other NNIPs with minimal impact on non-target species. In general, foliar spray treatment was avoided except in areas where no native plant or animal species would be impacted. Foliar spray was only used in areas such as roadsides, quarries, and already disturbed areas like utility right-of-ways with no native vegetation.

Across the years of treatment, the most useful and effective formulation was a mix of 0.5% Milestone VM (Aminopyralid), 1.5% Garlon 3A (Triclopyr), and 0.5% R-11 or other vegetable oil surfactant for foliar spray. It was very effective on *Clematis vitalba* as well as other woody vine-like NNIPs. Because of issues with soil persistence and potential harm to amphibious species, foliar spray was only used in disturbed areas away from water.

The majority of *Clematis vitalba* herbicide treatment was the "cut stem" application method, in which the stem was cut as close to the root crown as possible, and the fresh cut was painted shortly after with a mixture of 50% Garlon 3A or 10% Milestone VM (Figure 12). This technique resulted in no overspray and minimal exposure to soil and was allowed to be used within 5 feet of water. Over 100 cut stems were flagged after treatment and checked each year afterward, and efficacy was 100% with no resprouting found.

Figure 12: Closeup of a recently painted *Clematis vitalba* “cut stem”

4.3 Low-density Removal Methods

Outside of the high-density *Clematis vitalba* zones there were many smaller populations scattered throughout the 30-acre project area, ranging from only one to a few dozen plants. The approach for treatment was similar to higher density areas:

- Any climbing vines were cut at a six foot height level, and the base of the plant was dug out if possible. Larger, heavier and deeper roots were cut and treated with the cut-stem herbicide application.
- Most of these smaller populations were uphill from the main riparian area, growing in forest duff, and as such were easy to pull out by the root. Removed vegetation was bagged and transported to one of the existing containment areas in the denser growth zones.
- Occasionally, these smaller populations were in highly disturbed areas away from the creeks, with little or no native vegetation growing with them, and it was easier and faster to apply a foliar spray treatment.

These outlier populations were also flagged and noted on maps, so that they could be checked in subsequent years to ensure they were not neglected, there was no reoccurrence or seedbank, and that removal was complete.

4.4 Simultaneous NNIP Treatment

Clematis vitalba would often be found growing with other NNIPs with similar climbing and vining characteristics. Particularly at San Vicente Creek, the most common were English ivy (*Hedera helix*), periwinkle (*Vinca major*), and spiderwort (*Tradescantia fluminensis*).

The areas where *Clematis vitalba* had mixed in with English ivy were near older industrial structures from previous quarry activities. In areas that were right near the creek, both plants needed to be hand-removed together, and where needed, the roots treated with the cut-stem approach. In more upland areas where the plants had established a duo-culture, the foliar spray mixture of Milestone VM and Garlon 3A was used to good effect.

Clematis vitalba and periwinkle were found growing together near the site of a former small town that had been active until the 1950s-60s. This site is suspected of being the origin of *Clematis vitalba* in the watershed, and it was typical to find other garden and landscape plants persisting in the area. A main high-voltage line had been installed adjacent to this area, creating a large ruderal area with little native vegetation. With its location well uphill from the riparian corridor and the highly disturbed landscape, the foliar spray mixture of Milestone VM and Garlon 3A was again utilized effectively.

Clematis vitalba and spiderwort were found growing together along Mill Creek, above the San Vicente Creek confluence area where the largest *Clematis vitalba* population was. Unlike the other NNIPs, spiderwort is very water-dependent, needing to grow on the edge or in the creeks and ponds. It spreads mainly from vegetative breaks that flow downstream and take root along the banks. It is also extremely hard to kill, which makes it a favored house plant. Spiderwort that was pulled out of Mill Creek and left in one of the containment areas to dry out was found to still be alive and growing 8 months later.

Because it grows immediately on or in the water, herbicide application is not an option. We did learn that it can be treated effectively by uprooting it from the water, along with any *Clematis vitalba* it might be growing with, and laying it out in a dry upland area away from the water and then spraying it with the Milestone VM/Garlon 3A formulation.

Simultaneously treating NNIPs alongside *Clematis vitalba* helped reduce future infestations while increasing the likelihood of native plant recruitment in cleared areas, while also exposing *Clematis vitalba* seedbank areas that otherwise may have gone unnoticed until future conditions were adequate.

Chapter 5 – Monitoring and Adaptive Management

5.1 Monitoring Structure

Across the four-year time horizon of the removal efforts, vegetation monitoring was an essential component that contributed significantly to overall project success. Monitoring strategies were guided by a Monitoring Plan designed to measure the effectiveness of *Clematis vitalba* treatment methods, evaluate the need for follow-up treatments, help measure the recovery response of native vegetation in affected habitat, and guide adaptive management strategies.

Development of the Monitoring Plan considered the overall goal of treating and controlling *Clematis vitalba* on San Vicente Redwoods, as well as more specific objectives like controlling new occurrences of other NNIPs, enhancing the diversity and cover of native vegetation, and identifying and informing best practices as work proceeded as well as for future efforts.

Monitoring Methods

- Schedule: monitoring events were conducted 2 times each year. Once in the spring prior to any annual treatment activity, and a second time in the fall after all treatment for the year was complete.
- Fixed monitoring transects: a system of fixed transects guided systematic sampling over time.
    - Point-intercept sampling along each monitoring transect provided an efficient means of providing a reasonable cover estimate for individual species.
    - 1-meter quadrats sampled along the same transects, with cover classes recorded for each species encountered, provided supporting data for species densities and overall species diversity.
    - Photo documentation: photos taken during each monitoring event, at both ends of all fixed transects, created a visual record of each transect over time.
    - Control transects were established in two locations adjacent to but outside treatment areas, allowing a comparison of the treated *Clematis vitalba* areas with untreated areas. One control transect represented an untreated *Clematis vitalba* infested area located just past the property boundary, while the other represented an area of natural riparian vegetation typical of the area that had never been infested with *Clematis vitalba*.
    - Data sheets were created specifically for the project, which provided a systematic framework for consistent data collection over the course of the treatment.

5.2 Adaptive Management Techniques

Monitoring data provided valuable feedback regarding treatment methods throughout the course of the project, creating opportunities for adaptive management strategies before, during, and after each treatment season. The data gathered offered information on treatment timing, work practices, treatment areas requiring special attention, NNIPs requiring special focus, activation of seedbanks, as well as the recruitment of native plant species. Monitoring data gathered each spring prior to initiating treatment helped guide treatment strategies, while post-treatment data shed light on effective techniques and real outcomes.

In addition to the monitoring along fixed-transects, a broad sweep of each treatment area was made during each monitoring event to identify pre-existing NNIPs and/or the emergence of new NNIPs on treatment areas over the course of the project. Selected NNIP species encountered were documented with an "infestation severity" ranking of Trace, Low, Moderate or High during each monitoring event. This information allowed the treatment crews to incorporate removal of undesirable species during subsequent treatment events, helping to keep the non-native species in check.

Overall, the emphasis on integrating monitoring into the treatment strategy allowed for a honing of methodology over time, as well as a trove of information that allowed us to share out the best strategies for tackling the pernicious *Clematis vitalba.*