THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
HYDRILLA ERADICATION PROGRAM
ANNUAL PROGRESS REPORT 2011

PROTECTING CALIFORNIA'S WATERWAYS

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INTRODUCTION

This report covers the work of the California Department of Food and Agriculture (CDFA) Hydrilla Eradication Program in 2011. It begins with an introduction to hydrilla and a brief history and overview of the program. A section follows on "highlights and lessons" of the season, touching briefly on events of most importance or interest. The report then describes each of the current active eradication projects in detail, including a section on CDFA's annual survey of the Sacramento/San Joaquin River Delta.

CDFA is the lead agency in California on hydrilla[1]. The Hydrilla Eradication Program's mandate is to protect the state's water systems from this weed by finding and eradicating it. As the lead agency, the CDFA runs the Program, but does so in cooperation with county agricultural commissioners and other federal, state, county and city agencies, Native American tribes and private individuals and entities. In addition, the Program received financial and in-kind support in 2011 from the California Department of Boating and Waterways, California Department of Water Resources, United States Department of the Interior-Bureau of Reclamation, the Lake County Department of Agriculture the Lake County Department of Public Works, and the Sutter-Yuba Weed Management Area.

The CDFA is committed to an 'early detection and rapid response' strategy for the eradication of hydrilla. When an infestation is found at an early stage, the population is still small, so eradication efforts cost less and result in less environmental impact than if infestations were detected later when populations are larger and more widespread. 'Rapid response' involves bringing the most effective eradication methods to bear as quickly as possible. There are many examples of the Program's history of 'early detection and rapid response' and the CDFA considers this to be one of the keys to its success.

THE THREAT OF HYDRILLA

Hydrilla (*Hydrilla verticillata*) is a non-native, aggressive, submerged water weed. Once hydrilla invades an aquatic ecosystem it drives out all native and introduced aquatic plants, creating a pure stand. Its competitive edge comes from several different mechanisms. For one, hydrilla can grow under lower light conditions than nearly any other species (only one percent of sunlight), allowing it to grow up underneath other plants and to survive at greater depths. Its ability to use low light also lets it start photosynthesizing earlier in the morning than other plants. This allows it to capture most of the carbon dioxide that has entered the water during the night. For plants growing under water, the availability of carbon dioxide often limits their growth.

[1] California Food and Agricultural Code, Sections 6048 and 7271.

Hydrilla can also use bicarbonate as a carbon source, in addition to carbon dioxide. When it uses bicarbonate it increases the alkalinity of the water which also inhibits native species.

Hydrilla also has excellent survival and dispersal strategies. Seeds play a very small role in its spread, and most populations do not produce any seed at all. Instead, the plant breaks apart very easily and small pieces of stem, no more than one inch long, can produce entirely new plants. Hydrilla also produces special survival structures on the stems (called "turions") and roots (called "tubers"). The turions break off the stems in the fall and can drift for long distances before sinking to start a new plant. Each tuber also produces a new plant and a single tuber can lead to the production of several hundred others in the course of one growing season. The tubers can survive for four to seven years in the sediment before sprouting, even if no water is present for much of that time. The long survival time of the tubers creates the major challenge in eradicating the plant.

Hydrilla's speed of growth is also impressive. The plant is between 93 to 95 percent water, so it can create huge volumes of biomass with very few resources. As a result, it can grow very rapidly, doubling its biomass every two weeks in summer conditions. Hydrilla also branches profusely as it approaches the water surface, densely filling the entire water column up to 20 feet deep and shading out other plants. Recent research has shown that, when a hydrilla plant begins to grow to the surface, it can grow 10 feet in eight days. The same study showed that on average, by the end of five weeks of growth, a single nine-inch rooted shoot (a stem with growing tip), produces a total of over 3,200 inches (267 feet) of stems and tips. This is an increase of 356 times in five weeks. This was, of course, under good growing conditions.

As a final competitive edge, when hydrilla was introduced into the United States, it came without the various natural enemies that evolved with it, such as insects and diseases specialized for attacking it. It grows very aggressively in a wide variety of water conditions and temperatures so few habitats are safe from it. The tangled mats that it forms have a variety of economic and ecological impacts.

Many of the potential economic impacts of hydrilla have not been fully studied, but even if a small fraction of the potential were realized the results would be very alarming. In particular, mats of hydrilla can reduce the flow of water in canals and ditches up to 85 percent, which would devastate a society that survives by moving large amounts of water. Similarly, the mats can clog and damage dams, power plants and other water control structures. In one documented instance, hydrilla blocked the intakes of the St. Stephen hydroelectric facility on Lake Moultrie, South Carolina, in 1991, forcing repairs and causing loss of power generation that cost $4,650,000. In addition, the infestation cost $1.2 million for emergency treatment alone. Hydrilla also seriously interferes with boating and fishing and heavy hydrilla infestations decrease fishing stocks. The plant can also increase the risk of drowning. These various impacts can seriously damage tourism and the economies it supports. In one analysis, hydrilla coverage increased 400 percent between 1983 and 1992 on Lake Seminole in Georgia, leading to reduced tourism with an estimated loss of about $13 million per year to the local economy.

The ecological impacts of hydrilla are several. Because of its rapid and dense growth, it drives out all other plant species and destroys any existing native plants. Many people do not realize this but plants only give off oxygen and use CO_2 when there is light, which is to say, in the day time. At night, plants use oxygen and give off CO_2, just like animals. Beneath a heavy stand of hydrilla, oxygen levels in the water fall so low at night that fish could not survive there very long. Similar effects on oxygen and acidity can contribute to increased releases of nutrients from

sediments. Such increases can lead to algae blooms and die-offs, which are signs of a polluted lake.

Aside from effects on water chemistry, the dense mass of plant material in the water alters habitat structure and food-web relationships for fish, which can lead to changes in fish populations. For instance, sunfish and bass are ambush-type predators that attack from cover. Increased plant cover can lead to larger numbers of these species, which can lead to lower salmon and trout populations. At some point, hydrilla infestations become so dense that they even interfere with hunting by bass and sunfish so fish populations tend to decline in general in very heavy infestations.

Although some birds feed on hydrilla, generally bird populations also decline in a heavily infested area. Through a biological quirk, hydrilla even threatens bald eagles. Hydrilla encourages the growth of certain toxic blue-green algae. Coots eat the poisonous hydrilla, and then eagles eat the poisoned coots. Biologists have documented over 100 eagles killed by poisoned prey animals.

Fishermen and wildlife enthusiasts sometimes argue that hydrilla improves habitat for fish and other wildlife. While it is true that some cover with hydrilla, up to 30 to 40 percent of an area, will often provide food and shelter for various animals, the plant usually does not trouble itself to stay at a population level where it is helpful. Instead, it continues to expand until it monopolizes nearly every resource to itself. In addition, there are native species of underwater plants that are just as good or better for wildlife without the threat of runaway population explosions.

Hydrilla has two forms, monoecious and dioecious. The definition of the two forms depends on the distribution of male and female flowers among the individual plants, but more importantly for human concerns, they also have differing and complementary environmental requirements. The monoecious form appears to prefer more northern conditions, while the dioecious form is prevalent in the south. Both forms seem to do well in much of California.

HISTORY AND OVERVIEW OF THE PROGRAM

Hydrilla has been found in various places in the United States as well as California. The dioecious[2] form of hydrilla was first identified in Florida in the 1960's, where it is believed to have been introduced in the 1950's. The infestation spread rapidly throughout the southeastern states and into Texas and Arizona. The dioecious form first appeared in California in 1976 in a 31-acre man-made lake in Marysville in Yuba County. The monoecious form was first detected in the United States in the Potomac River, near Washington, D.C., in the 1980's. It has since spread into a number of the southern and eastern states, into Washington State, and was first found in California in 1993 at an aquatic nursery in Visalia in Tulare County.

In 1977, after the first California hydrilla find, the California Legislature mandated[3] that the CDFA Secretary initiate a survey and detection program for hydrilla and eradicate it wherever

[2] The dioecious form of hydrilla has flowers of one sex only on each genetic individual. Monoecious individuals have individual flowers with only staminate or pistillate parts, but these occur on the same plant. Dioecious plants often branch freely near the water surface, forming large submerged mats near the water surface. In contrast, monoecious plants tend to branch freely near the rooting point, producing many stolons and a forest of vertical shoots, which can fill the entire water column with plant material. The genetic or ecological significance of this apparent dimorphism is unknown.

[3] California Food and Agricultural Code Article 9, Section 6048.

feasible[4]. In 1985, after hydrilla was found in Redding next to the Sacramento River, the Governor of California declared a "State of Emergency" for the eradication of that infestation[5]. In 1994, the CDFA Secretary also declared an "emergency situation" in regard to the hydrilla infestation discovered that year in Clear Lake[6]. Similar declarations have been issued for most of the current hydrilla infestations[7].

Since 1976, hydrilla has been introduced into California waterways 29 separate times in 18 counties[8] (not counting detections in plant nurseries-see below). Of these 29 separate hydrilla introductions, the Hydrilla Eradication Program has eradicated hydrilla from 20 sites in the following 14 counties: Los Angeles, Madera, Mariposa, Monterey, Riverside, San Bernardino, San Diego, San Francisco, Santa Barbara, Shasta, Sonoma, Sutter, Tulare and Yuba (Table 1, Plate 2). The Hydrilla Eradication Program is currently eradicating[9] hydrilla from nine locations in the following seven counties: Calaveras, Imperial, Lake, Nevada, Shasta, Tulare and Yuba. In 2010, with the declaration of eradication of the Chowchilla River / Eastman Lake infestation, Madera and Mariposa Counties move from the "infested" to the "uninfested" category.

Plate 1. The "hydrilla hook", a small grappling hook, with hydrilla

Hydrilla has been detected in plant nurseries and aquaculture vendors five times, the last two occurring in 2004. In March 2004, hydrilla was detected in a plant nursery in northern Los Angeles County and in November, hydrilla was also detected in an aquaculture wholesaler in Alameda County. In each case the county department of agriculture took the lead on removing all hydrilla plants and plant parts from the infested area, and the CDFA Pest Exclusion Branch and Hydrilla Eradication Program personnel worked with the vendor to prevent reintroductions.

Every year, Program crews survey all known infested waterways and many high-risk lakes[10], ponds, reservoirs, streams, canals and other waterways in the state. High-risk areas include the Sacramento/San Joaquin River Delta and other high recreational-use water bodies and waterways within quarantine zones[11]. Surveys generally employ two methods. Working from either the shore or from boats, crew members visually scan the water surface and water column for suspicious plants. They supplement the visual scan by throwing a small grappling hook (Plate 1), which is dragged

[4] A Hydrilla Science Advisory Panel was convened after each hydrilla outbreak. These panels have always found hydrilla eradication to be feasible.

[5] "Proclamation of a State of Emergency," issued by Governor George Deukmejian, October 23, 1985; terminated October 23, 1989.

[6] "Proclamation of a Project Regarding the Eradication of Hydrilla," issued by CDFA Secretary Henry Voss, August 12, 1994.

[7] Calaveras, Madera, Mariposa, Nevada, Shasta, and Tulare counties.

[8] The CDFA considers hydrilla infestations to be separate introductions if they appear more than two or three years apart.

[9] California Code of Regulations, Title 3, Division 4, Sections 3281 and 3410; California Code of Regulations, Section 3962; CDFA Plant Quarantine Manual, Section 3410.

[10] High-risk lakes, streams, etc. are those within five miles of Clear Lake, one mile either side of the Sacramento River near the Riverview Golf Course, three miles of the Yuba canal, and one mile of Bear Creek, the west fork of the Chowchilla River, and the Springville ponds.

[11] Quarantine zones are established by declaration of the CDFA Secretary and are areas within eradication areas that have restrictions as to water use, access, or the intensity of survey.

along the bottom and through the water to snag any long-stemmed vegetation such as hydrilla. Occasionally, divers conduct underwater surveys[12]. Surveys generally start when the water temperature climbs above 10 degrees Celsius[13] (50 degrees Farenheit[14]) in the spring and streams fall to a safe level. They generally end when water temperatures fall below 10 degrees Celsius in the fall. Active growth of hydrilla occurs between 10 degrees Celsius and 35 degrees Celsius (DiTomaso and Healy 2003, page 102). The Hydrilla Eradication Program also follows up on all reports from the public on potential new infestations. The last finds of hydrilla were in 2004 and 2005 when three infestations appeared in Nevada County. No new hydrilla infestations have appeared since then.

The Hydrilla Eradication Program uses an integrated pest management approach to eradicate hydrilla. In 2011, the Program used (alone or in combination) manual removal, small scale dredging, lining of water bodies, biological control and aquatic herbicides. The major aquatic herbicide was a fluridone slow-release pellet formulation[15] applied at 90 to 150 ppb[16], depending upon the size of the water body. Other herbicides used in particular situations include a copper ethylenediamine liquid formulation[17] (applied at one ppm[18]) and a fluridone liquid formulation[19]. In the past, the Program has also used water draw down and drying of the hydrosoil followed by soil fumigation, large and small scale dredging, and burying.

Based upon recommendations from science advisory panels, the Hydrilla Program has generally followed a standard protocol in determining eradication. Program staff intensively treat and survey an infested site for a minimum of three growing seasons after the last hydrilla detection, followed by a minimum of another three seasons of intensive survey without treatment. Therefore, the CDFA considers hydrilla eradicated from a site only after a minimum of six years without finding any plants. Longer periods of negative surveys may be warranted, depending upon the circumstances. The most recent Technical Review Panel, in October 2009, suggested that three years of follow-up treatment is probably not long enough, especially in large infestations and when depending solely on herbicides. This is because herbicides do not affect the dormant tubers. An herbicide must simply lay in wait for the tubers to sprout and the plants to appear above the sediments. It is unclear just how long tubers can remain dormant, but four to seven years is an often quoted figure. The last panel suggested that eradication should not depend on any fixed time criterion for follow-up treatment. They suggested instead trying to follow tuber health and depletion in the eradication site and using the disappearance of tubers as a guide for the time of follow-up treatment. This approach presents challenges, both in accurately following tuber depletion and in relating this to the absolute absence of plants. It is

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[12] Surveys are conducted by two methods, visual search of the water column and physical samples. Trained biologists and support staff conduct visual searches to locate individual plants or mats that are visible in the water column or on the water surface. The crews conduct the visual searches from boats, canoes, or kayaks; by wading in shallow streams and lakesides; and by swimming using sight buoys and face masks, depending upon the circumstances. Because visual searches from the surface are sometimes hampered by poor visibility, the Program occasionally contracts divers for underwater surveys. Physical samples are taken using a modified grappling hook, usually thrown from a boat or canoe. Personnel trained in identifying hydrilla carefully examine the retrieved plant material. In either case, visual searches or bottom samples, if hydrilla is found, the number of plants or size of the infestation is recorded along with the physical location (by using a global positioning system technology and measured from known landmarks). Representative specimens from new locations are sent to the CDFA Plant Pest Diagnostic Center, Botany Laboratory for confirmation.

[13] C = Centigrade

[14] F= Fahrenheit

[15] Sonar® SRP brand, SePRO Corporation.

[16] One ppb = one part per billion = one microgram per liter.

[17] Komeen® brand, Griffin Corporation.

[18] One ppm = one part per million = one milligram per liter.

[19] Sonar® AS brand, SePRO Corporation.

not uncommon in tuber surveys to take a large number of sediment cores without finding any tubers, yet plants may be clearly visible in the area. However, the suggestion is a worthy one, as any information about tuber depletion is clearly better than none.

In addition to surveying and treating for hydrilla, the Hydrilla Eradication Program monitors aquatic herbicide concentrations in water in order to protect the state's waters. The CDFA performs monitoring as policy, and also to comply with the National Pollution Discharge Elimination System (NPDES) General Permit issued by the State Water Resources Control Board. The NPDES is a provision of the Clean Water Act to regulate and protect "waters of the United States" from pollution caused by point sources. This system was extended to aquatic pesticide applications by the Ninth Circuit of the United States Court of Appeals in its decision in *Headwaters, Inc. et al. v Talent Irrigation District*, March 12, 2001. To comply with the NPDES General Permit, the Hydrilla Eradication Program monitors fluridone concentrations in Clear Lake and in the Riverview Golf Course Ponds in Shasta County, copper concentrations in Clear Lake and in Bear Creek in Calaveras County, diquat concentrations in Island Drive Pond in Redding and triclopyr concentrations in Clear Lake or in the Anderson Park Ponds. The Hydrilla Eradication Program also monitors individual treatments to confirm that concentration targets are attained and at the request of the public in regards to the use of treated water. The monitoring results for the NPDES General Permit are published in a separate report.

The status of all current and historical sites in the Hydrilla Eradication Program is summarized in Table 1 and Plate 2.

Plate 2. Current Hydrilla Eradication Projects, 2011

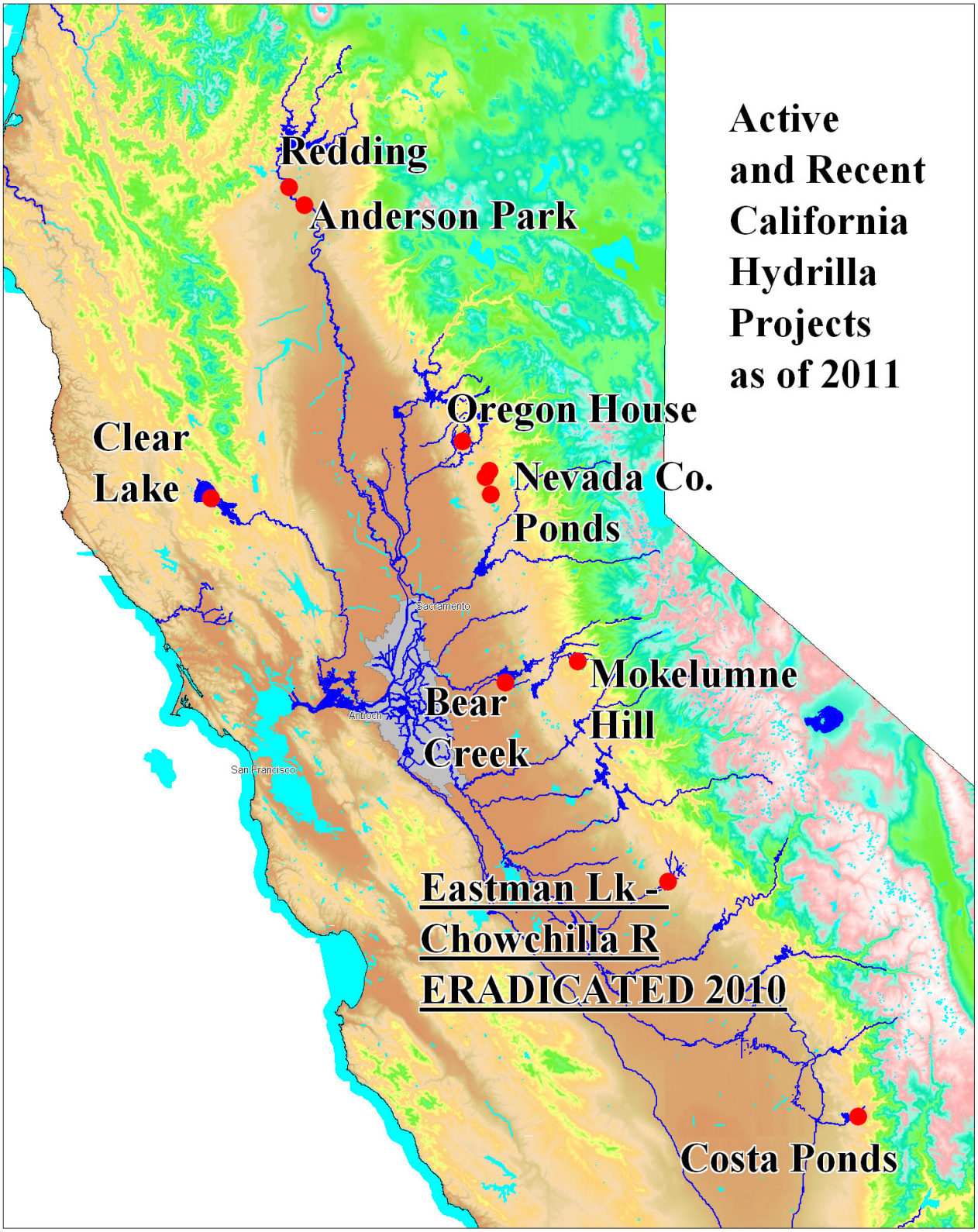


Table 1. Status of Hydrilla in California, by County, 1977 – 2011

COUNTY	YEAR*	DESCRIPTION OF WATERWAY	SIZE	STATUS**
Calaveras	1988	Bear Creek, Units 2 to 11	5 miles	Survey
	1988	Stock Pond	0.5 acres	Active
	1996	Bear Creek, Unit 1	0.75 miles	Active
Imperial	1977	Imperial Irrigation System	270 acres of ponds, 600 miles of canals, drains	Survey, Survey, Active
Lake	1994	Clear Lake	739 of 43,000 acres	Active
Los Angeles	1980	Eight ponds	2 acres	Eradicated
	1983	One pond	< 1 acre	Eradicated
	1985	One pond	< 1 acre	Eradicated
	2004	One pond (nursery)	< 0.5 acre	Eradicated
Madera/ Mariposa	1989	Eastman Lake /Chowchilla River	1800 acres and 26 miles of river	Eradicated
Monterey	1978	Pond	0.01 acre	Eradicated
Nevada	2004	One pond	0.6 acres	Active
	2005	Two ponds	2.8, 0.1 acres	Active
Riverside	1977	One pond	< 1 acre	Eradicated
	1984	One pond	< 1 acre	Eradicated
	1985	Three ponds	< 1 acre	Eradicated
San Bernardino	1988	One pond	< 0.01 acre	Eradicated
San Francisco	1988	One pond	2 acres	Eradicated
San Diego	1977	Lake Murray	160 acres	Eradicated
	1977	One pond	<1 acre	Eradicated
Santa Barbara	1977	One pond	0.12 acre	Eradicated
	1993	One pond	< 0.01 acre	Eradicated
Shasta	1985	Seven ponds	133 acres	Eradicated
	1986	Four ponds	23.5 acres	Eradicated
	1994	Two ponds	13 acres	Active
	1996	Four ponds	39 acres	Active
Sonoma	1984	Spring Lake	72 acres	Eradicated
Sutter	1985	One pond	< 0.01 acre	Eradicated
Tulare	1993	Three ponds	0.6 acre	Eradicated
	1996	Seven ponds	20 acres	Active
Yuba	1976	Lake Ellis	30.8 acres	Eradicated
	1990	One pond (Shakey's)	6 acres	Re-activated 2007
	1997	13 ponds	20 acres	Active
	1997	Canal	3 miles	Active

*Year first detected at a given site.
**Eradicated = No hydrilla found at site in six or more years of intensive survey following the last treatment.
Survey = No hydrilla found at site in last three to six years, intensive surveys continue.
Active = Hydrilla detected within the last three years, an active treatment program continues.

2011 SEASON HIGHLIGHTS AND LESSONS

1) After declaring eradication in the Chowchilla River / Eastman Lake infestation in 2010, three more hydrilla projects are reaching the threshold. At the end of the 2011 season, seven years have passed with no plants in the Mokelumne Hill and Bear Creek infestations in Calaveras County, and in the Costa Lakes infestation in Tulare County. These infestations will be monitored for one more year and then eradication will be declared.

2) Five seasons with no plants have now passed for Shasta County's Riverview Golf Course and Anderson City River Park infestations. The ponds have been under treatment with herbicide all that time, and for many of the previous years. In 2012 the ponds will enter the three-year non-treatment survey phase of the projects.

3) The Clear Lake project continues a satisfying decline in plant numbers this year. By contrast, in 2008 the situation was threatening. Project crews found 196 "spots" with hydrilla as compared to 72 in 2007, and many of the plants were large and reached the surface. Over 20 of the 2008 finds were near the outlet of the lake, which was particularly troubling. However, in 2009 the crews could find only 76 spots with hydrilla and the plants were much smaller and sicklier than in 2008. In 2010, there were only 12 plants, and only six in 2011. No plants have been found near the outlet since 2008. The number of new acres brought under treatment each year was 350, 249 and 120 acres in 2007, 2008 and 2009, respectively. By comparison, we added only 20 acres in 2010 and only 10 in 2011.

4) After the results of 2011 and in anticipation of starting to dredge in Clear Lake, the Program plans to take some treatment areas out of herbicide treatment in the 2012 season. All the candidate areas have been in treatment for at least consecutive four years and have gone at least four years without plants. About 90 acres have been identified to be shifted to dredge treatment for any remnant plants that appear.

5) CDFA disbanded its longtime weed programs in 2011 due to declines in the State's General Fund, and with them went the six District Weed Biologists. The Weed Biologist in the Northwest District, Ed Finley, had been taking care of the hydrilla and spongeplant infestations around Redding, but that ended with his retirement as of June 30. His role has been picked up by Jonathan Heintz and Patrick Akers, working out of Sacramento, with help from the seasonal crews in Clear Lake or Fresno. The change in staffing will lead to a change in strategy for surveying the ponds. Rather than surveying lightly many times during the season, crews will visit the ponds only twice, probably in the first weeks of July and September. However, they will spend several days surveying the ponds each time.

6) Despite the loss of the other weed programs, the Hydrilla Program continues, as it has funding outside the General Fund. CDFA management did remove all General Fund support from the Program. However, the Program approached the Departments of Boating and Waters and Water Resources, and they agreed to make up the shortfall.

7) The three separate infested ponds in Nevada County also have had no plants for five years. For the 2012 season the project managers will consider whether to treat for one more season, or to move to survey with possible dredging for any plants that appear.

8) Inspired by the concrete lining of the infested section of the Oregon House canal in 2008, the Yuba County Weed Management Area, the Agricultural Commissioner's Office and the Resource Conservation District undertook the lining of another 1,500 feet in 2009, with contributions from CDFA. Undaunted by the experience, they initiated new efforts in 2010 and lined another 3665 feet in October, 2011, bringing the total to about 9100 feet.

9) Based on recommendations from the Technical Review Panel at Clear Lake in 2009, the Clear Lake Project started several new initiatives to better follow the infestation in the lake and to improve treatments.
    a. In 2010, Project staff developed an artificial target to represent young hydrilla plants and used it to estimate the probability of hooking a plant. Preliminary results indicated that there was about a 13 percent chance of hooking a plant in any one survey, or about a 65% chance in a year with seven surveys.
    b. In 2011, the Project crew used a modified suction dredge to look for tuber beds for potential monitoring. They took 875 four-inch core samples from three locations with the highest density and vigor of plants, totaling about 1.2 acres and 30 plant sites. They found no tubers at all after three weeks work, leading to the decision that it was not cost-effective to find tuber beds and monitor them for a decline in tuber density.
    c. The Project is working with the manufacturer of Sonar herbicide to modify the SRP pellets to provide a more even distribution of the herbicide on the bottom of the lake.
    d. Finally, the Program contracted with a Lake County biologist to put in place all the regulatory and permitting requirements so that the Project will be able to do small-scale dredging of plants to remove tubers. Those permits are in hand and a contract has been submitted to request bids for a company to provide the necessary small-scale dredging.

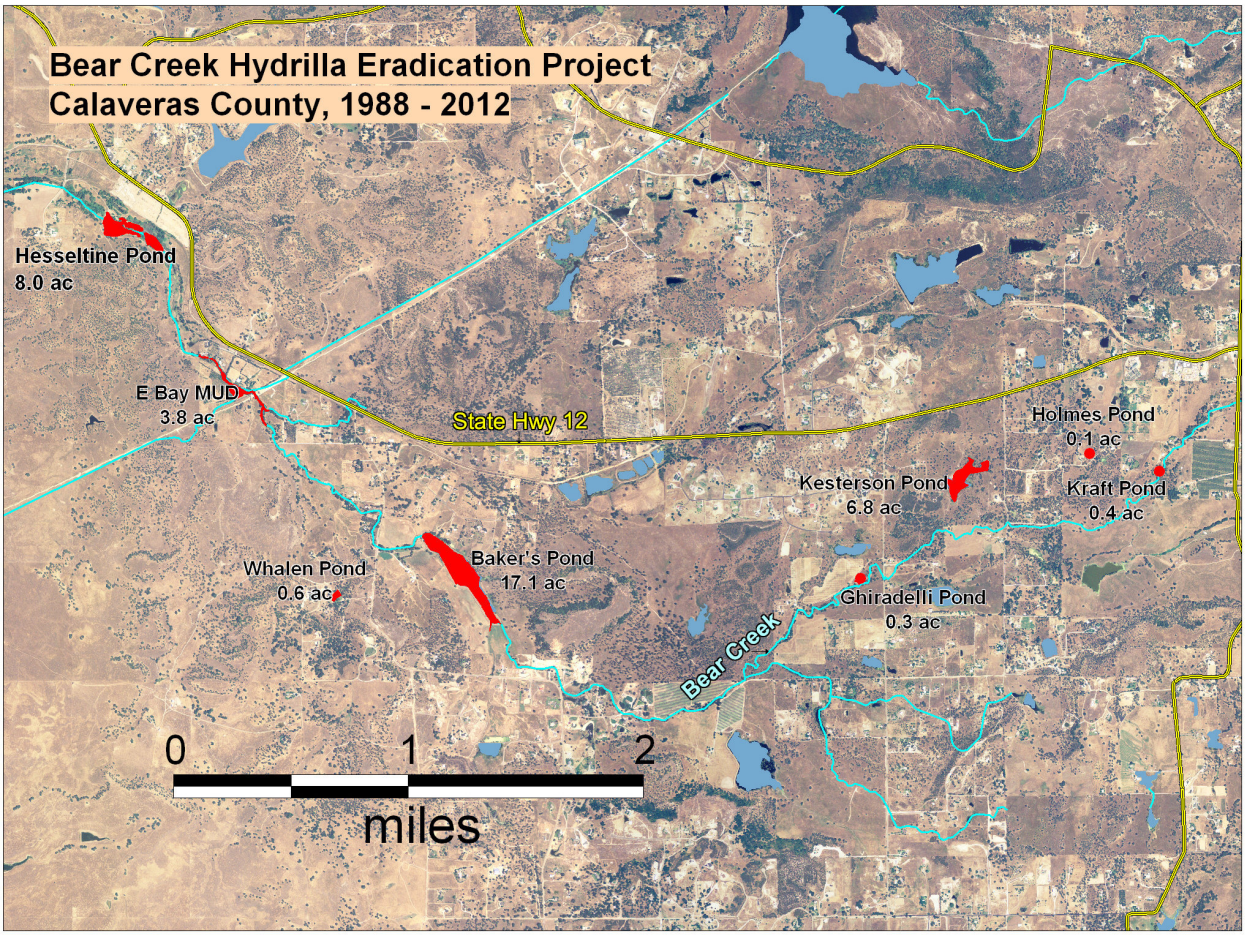
10) The Hydrilla Program received some extra funding from the CDFA Emergency Fund to do extended survey for spongeplant, particularly in the Delta. As a result, in May and June two to three crews boats spent approximately 20 days each on the water in the Delta. The crews radiated out along waterways from the known epicenter of the infestation near Brannan Island in the northwest part of the Delta, and also searched along the San Joaquin River as it enters the Delta from the south. The survey indicated that spongeplant is still relatively confined to that northwest area and has not yet spread widely in the Delta. It was not found in the San Joaquin where it enters the Delta.

ACTIVE, ON-GOING SURVEY AND ERADICATION PROJECTS, IN DETAIL

CALAVERAS COUNTY *(Lead: Florence Maly)*

CDFA biologists believe that there have been two separate infestations of dioecious hydrilla in Calaveras County based on the separation by distance and watershed between the two locations. The first infestation was detected in May 1988 and was in ponded areas along Bear Creek between the towns of Burson and Wallace, as well as in three isolated ponds (Plates 3,4). The Calaveras County Hydrilla Eradication Project (Calaveras Project) began soon after the plants were found.

Plate 3: Extent of Bear Creek Infestation when Found



The Project is a cooperative effort between the CDFA and the Calaveras County Department of Agriculture. The CDFA convened a Scientific Advisory Panel that made recommendations as to survey, treatment and public education (Stocker. R.K. and L.W.J. Anderson *et. al.* 1988). The Bear Creek infestations are of particular concern because Bear Creek enters the Sacramento-San Joaquin River Delta at Disappointment Slough in San Joaquin County, only about 26 miles downstream.

Later in 1988, the survey crews discovered a separate infestation in two ponds located near Mokelumne Hill, about 30 miles from the Bear Creek area (Plate 5). The two Mokelumne Hill ponds are 0.45 and 0.15 acres in size and are used for watering cattle. Six other cattle ponds surround them.

Plate 4. Active Bear Creek Hydrilla Infestation Area, near Lake Comanche

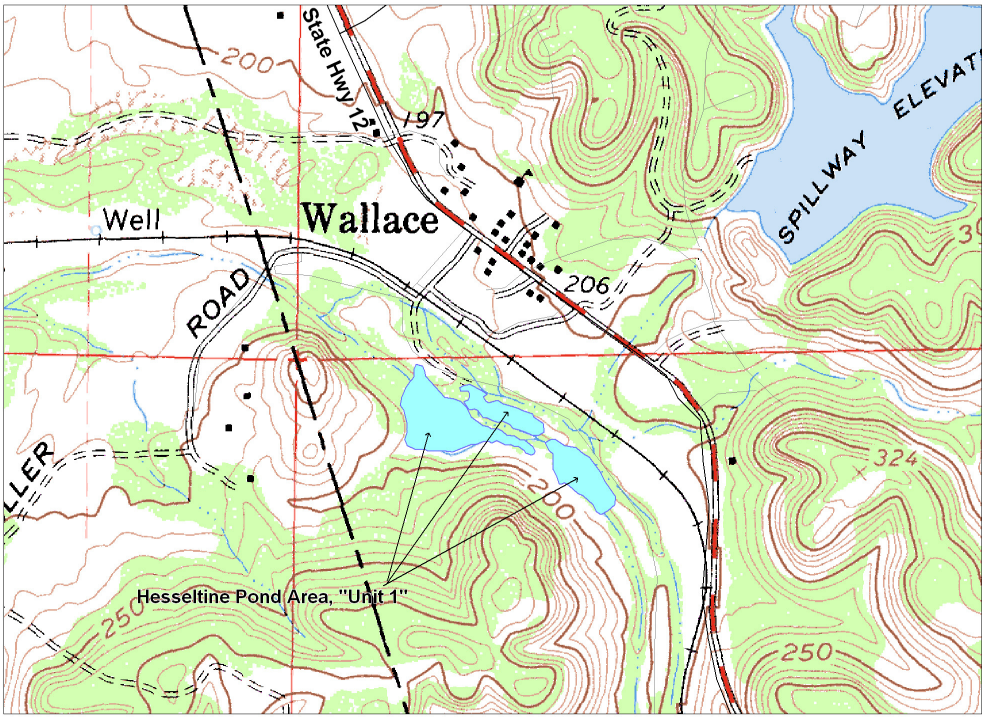
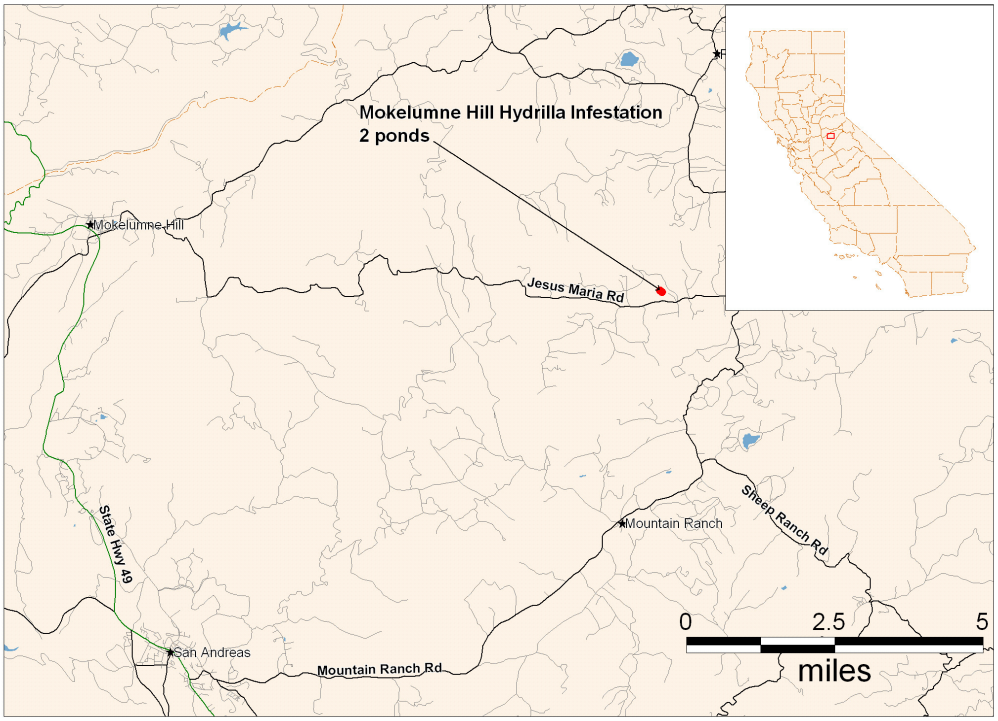


Plate 5. Mokelumne Hill Infestation Site



Survey of the Bear Creek Drainage

To track the work on the project, project biologists divided the Bear Creek drainage into 11 management units. All of the originally infested isolated ponds and ponded areas in the Bear Creek drainage project are approaching eradication. Project crews have not detected any hydrilla plants in Management Units 6 through 11 of Bear Creek since 1996. They have not detected any hydrilla plants in Units 3 through 5 (the Perock and Baker ponded areas) since 1998. In addition, no hydrilla has been detected in Unit 2 since July 1999. In 2011, the crews surveyed two times in Units 2, 3 and 5, finding no hydrilla. No surveys occurred in the other units as these were dry for most of the summer.

While upstream management units are approaching eradication, the Hesseltine area (Unit 1) has had more recent hydrilla detections. Unit 1 is a series of ponded and swampy areas, totaling approximately 10 acres (Plate 4). The main ponded area (Hesseltine "main pond") is located about half a mile downstream from Unit 2 and measures approximately 3.6 acres. The pattern of water flow through the area underwent some changes several years ago, which caused the expectations for the main pond to also alter a few times. Until about 2005, a large leak in the East Bay Municipal Utility District (EBMUD) aqueduct kept water flowing in Bear Creek from about Perock Pond (Unit 3) down and kept Hesseltine Pond from ever drying up. EBMUD repaired the leak in late 2004, causing the areas in Hesseltine Pond that once had hydrilla to thoroughly dry out in 2005. Program staff accordingly believed that this particular infestation was doomed.

However, the property owner blocked the outlet to the pond during the winter of 2005-06, trying to maintain its volume. With the good rainfalls of that year, the water levels in the pond stayed high all through the summer and fall of 2006, although the creek completely dried up just upstream and downstream of the pond. With this new development, Program staff returned to the usual survey-and-treat strategy. The main 3.6-acre pond was able to maintain its size and depth during dry 2007, although the swampy areas just upstream of the "main pond" dried out by mid summer. 2008 and 2009 were also very dry, and all the area dried out to a large extent each year by mid summer. Even the main pond was much reduced in size and depth.

In contrast, 2011 was a very wet year. By late September only the outlaying sections of the Hesseltine Unit were dry or very low. Most swampy areas and stream sections upstream of the main pond were dry or had only a few puddles. The deeper main pond and adjacent swamp 1, however, had fairly high water levels. Water levels in Hesseltine, and Baker Pond in Unit 5, remained static until early December when pond levels started to come up. Previous hydrilla find sites remained wet, unlike the past several years when they dried completely.

In 2004, project crews detected two hydrilla plants in Unit 1 (Table 2). The crews surveyed Unit 1 seven times in 2005, five times in 2006, three times in 2007 and 2008, twice in 2009 and 2010, and three times in 2011, finding no hydrilla. In 2011, the first survey was conducted on June 13 when the water temperature was 25 degrees Celsius (77 degrees Farenheit). The last survey was conducted on December 13; the water temperature was 7.2 degrees Celsius (45 degrees Farenheit). Other aquatic vegetation detected in the Hesseltine ponded area included coontail (*Ceratophyllum demersum*), elodea (*Elodea canadensis*), naiad (*Najas* species), mosquitofern (*Azolla* species*)*, various pondweeds (*Potomageton* species), duckweed (*Lemna* species), chara, water primrose (*Ludwigia* species), watermilfoil (*Myriophyllum* species), parrotsfeather (*M. aquaticum*) and cattails (*Typha* species).

Table 2. Number of Hydrilla Plants and Tubers Found and Removed from Bear Creek, Calaveras County, 2000 - 2011

Unit 1 – Hesseltine Ponded Area

YEAR	2000	2001	2002	2003	2004	2005-10	2011
Mats	0	0	5	0	0	0	0
Plants	0	10	18	3	2	0	0
Tubers	-	46*	69*	-	2**	0	0

*Most tubers were recovered by dredging operations
**1 plant from tuber, 1 plant from turion.

Treatment of the Infested Management Unit in the Bear Creek Drainage

Since the first hydrilla find in Unit 1 in 1996, Project personnel have treated all find sites with various combinations of physical removal and applications of copper ethylenediamine and/or fluridone herbicide. Areas immediately surrounding locations where plants have been detected were dug out and treated with fluridone herbicide, in a quick-release pellet formulation (Sonar PR) to provide rapid build-up of the herbicide while still taking advantage of its long residual effectiveness. This year was the seventh without plants, so there was no treatment.

Survey and Treatment of Mokelumne Hill

The Mokelumne Hill infestation has been troublesome, with hydrilla re-appearing after absences of one to a few years, ever since it was first found in 1988. No hydrilla plants have been found in the smaller of the infested ponds since 1998, but plants were detected in the larger pond in 2002, 2003 and 2004. No plants appeared in either pond in 2005-10 or in 2011, making this the seventh year without plants.

Calaveras Project crews surveyed all ponds on the property two or three times in 2011. The first survey was on June 16, when the water temperature was 22.2 degrees C (72 degrees F). The last survey was on December 14, when the water temperature was 3.9 degrees C (39 degrees F). In 2004, 10 hydrilla plants were detected in pond three, the main infested pond (Table 3). None have been found in the last seven years. Other aquatic vegetation detected included chara, naiad, watershield (*Brasenia schreberi*), coontail, water primrose, American, slender and curly leaf pondweed (*Potamogeton crispus*) and cattails.

The infested pond was not treated in 2011.

Table 3. Number of Hydrilla Plants and Tubers Found and Removed from the Stock Pond Near Mokelumne Hill, Calaveras County 2000 - 2011

YEAR	2000	2001	2002	2003	2004	2005-10	2011
Mats	0	0	4	0	0	0	**0**
Plants	0	0	1	22	10	0	**0**
Tubers	0	0	49	2	24	0	**0**

Surveys outside the Quarantine Zone

Calaveras Project personnel surveyed all access points on Bear Creek from the Calaveras-San Joaquin County line west to Thornton Road in Stockton, approximately 26 miles. No hydrilla was detected.

FRESNO OFFICE GENERAL DETECTION SURVEYS *(Lead: Florence Maly)*

The Hydrilla Program crew in Fresno takes care of the Calaveras, Chowchilla/Eastman and Tulare Springville projects, as well as working on occasion in Imperial County. With the Chowchilla project beginning to taper off, the crew has had more opportunity to expand its detection efforts. Much of this work has been in conjunction with survey and control work for the South American spongeplant which has appeared in a number of locations around the San Joaquin Valley. This work has focused on the San Joaquin River drainage below Friant Dam, the Kings River drainage and associated canals near Reedley and in canals and ditches in the Firebaugh to Crows Landing area. The crew detected no hydrilla.

IMPERIAL COUNTY *(Lead: Imperial Irrigation District)*

Imperial Irrigation District (IID) personnel first detected dioecious hydrilla in Imperial County in June 1977 in the All American Canal. The IID is a gravity-fed irrigation system that delivers water from the Colorado River via the All American Canal through a network of lateral canals, ponds and reservoirs to farmers' ditches, which in turn, water the farms of the Imperial Valley. Drainage canals (drains) then carry the runoff and seepage to the New and Alamo Rivers. IID personnel conducted surveys in 1988 and found that the hydrilla infestation covered, to a greater or lesser degree of plant density, 320 canals extending approximately 600 miles, 32 ponds comprising 161 surface acres and 79 privately owned delivery ditches (farmers' "sides").

The CDFA, IID, USDA-Animal and Plant Health Inspection Service, California Department of Fish and Game (CDFG), and Imperial County Department of Agriculture formed a cooperative agreement in 1981 to research and develop control and eradication methods for the IID. Between 1981 and 1984, the main control methods were mechanical removal of plant mats and mechanical dredging. In 1984, the IID received permission from the CDFG to stock the west side of the IID (the infested area) with triploid grass carp (*Ctenopharyngodon idella*) (TGC)[20]. The TGC has been the main control and eradication method since that time, supplemented by hand removal of individual plants, sealing of cracks in concrete-lined canals with epoxy to prevent hydrilla emergence and mechanical dredging when necessary. The IID stocks the TGC on a yearly basis at a target rate of up to 100 fish per mile for canals infested with aquatic vegetation, and up to 100 fish per acre for infested ponds.

[20] The biological control agent, the triploid grass carp (*Ctenopharyngodon idella*) (TGC) is used to consume hydrilla and other aquatic vegetation. When used in confined areas, and in adequate stocking rates, the TGC can suppress a population nearly to extinction. However, to prevent establishment of a wild population, the CDFG Code requires that only sterile fish be stocked. (TGC roe is put through a high-pressure treatment that gives each egg a triploid chromosome complement and makes the fish sterile). Nonetheless, the CDFG is concerned that the sterility might not be absolute, so they have tight restrictions on TGC use. According to the CDFG Code, the TGC cannot be deployed in any open water bodies that empty into natural waters of the state (CDFG Code, Sections 6440-6460). Therefore, all use of the TGC must be in areas that are contained with gates and screens, which severely restricts TGC use. Despite this limitation, the use of the TGC can be very effective in ponds and canals where the inlets and outlets can be screened to contain the fish.

While the IID continues to employ the TGC for control of hydrilla and other aquatic vegetation in the canals (delivery system), the fish cannot be placed in the drains or farmer's side canals because water levels undergo large and rapid changes. Therefore, in 2004 when hydrilla was again detected in the Wildcat Drain (hydrilla was found here in 2002 and 2003) officials from CDFA, Imperial County Department of Agriculture and IID surveyed and mapped the entire drain. A total of 5.1 miles of the drain was divided into 15 units, based on topography. Hydrilla was seen in Units 2 through 13. IID personnel removed as much of the hydrilla as possible following the mapping.

A follow-up survey in October 2005 revealed the continued presence of hydrilla in the Wildcat Drain. Plants were also seen in another drain, the Wisteria, located southwest of the Wildcat Drain. The Wisteria Drain flows into the Greeson Drain, which in turn, makes its way to the New River and the Salton Sea.

Hand removal activities were resumed in November 2006, with IID crews continuing to survey in 2011. Numbers of plants are continuing to drop.

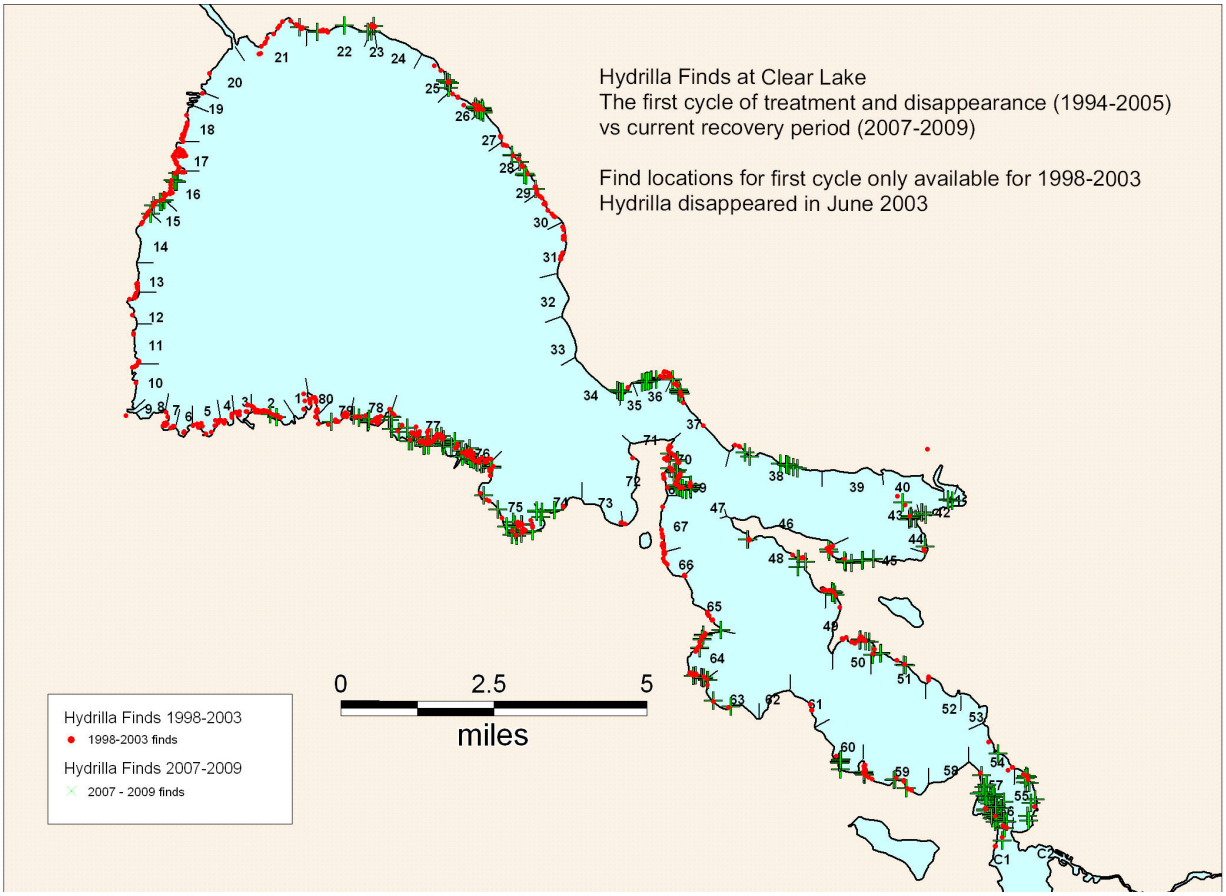
LAKE COUNTY *(Leads: Patrick Akers and Russ Huber)*

Hydrilla disappeared for the first time from Clear Lake on June 23, 2003, but plants returned in 2007. After plants disappeared in early 2003, treatments continued in 2003, 2004 and 2005. Surveys also continued without finding a single plant. The three seasons without plants met the criterion to end treatments, and no herbicides were applied in 2006. That was the first year since the beginning of the Clear Lake Project in 1994 that no herbicides were applied. No plants appeared in 2006, but they came back in 2007. With the return of the plants, treatments resumed. The plants made a very strong showing in 2008, but in 2009 the number of plant finds declined noticeably, as did the vigor of the plants. The number and vigor of plants continued to decline dramatically in 2010 and 2011.

Program managers did not assume that the detection of no plants in Clear Lake in 2003 through 2006 meant that the lake was free of hydrilla. CDFA surveys are thorough, but no survey system can hope to detect a single small plant amongst the mass of aquatic weeds in a 43,000-acre lake. In addition, treatments with fluridone slow-release pellets continued through 2005. The purpose of this herbicide is to kill hydrilla plants as they emerge from underground tubers. If the herbicide performs as intended, it kills plants when they are small and very difficult to detect. Fluridone remains in the bottom sediments for an extended period, so it can mask a remnant infestation. Program biologists suspected that there were still tubers in Clear Lake that could continue to sprout. They increased the number of boat crews from two in 2006 to three in 2007 to intensify the survey at a time when the hydrilla might be recovering from earlier treatments. The number of crews was increased to four in 2008.

The current resurgence of plants clearly comes from tubers that were able to survive the three-year no-plant follow-up treatment after the first disappearance of the plants. A review of the history of plant finds around the lake through the entire project show that plants that appeared in 2007-2009 largely appeared where plants had been during the first elimination of the plants during 1994 through 2003 (Plate 6). Further, the 2007-09 plants appeared in many parts of the lake all at once. That is, the finds did not concentrate in one or a few locations. This was unlike the pattern of the original infestation, which was concentrated on the western shore of the lake (Plate 7). If the plants had been re-introduced to Clear Lake, it would likely have been at one or a few locations and not in widespread places all at the same time.

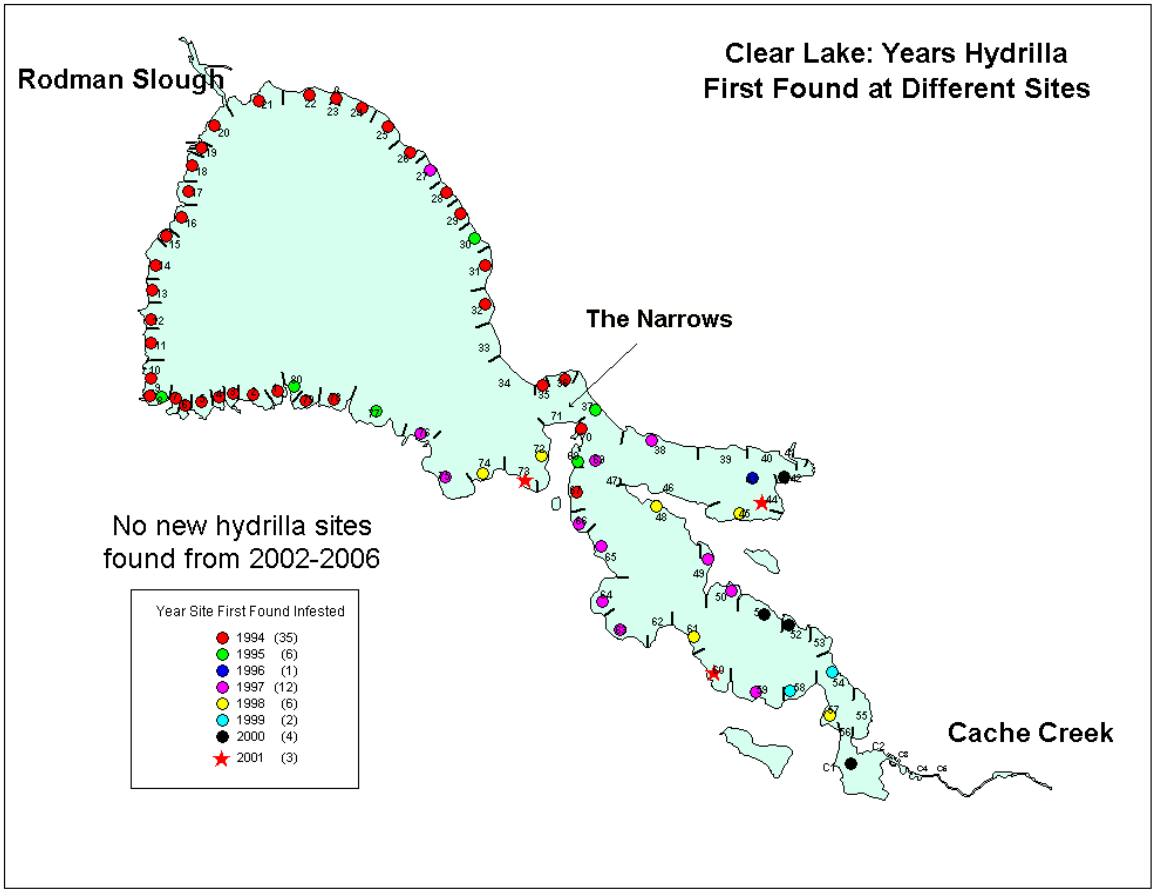
Plate 6: Plant find locations from 2007-2009 compared to finds in 1996-2003



The Clear Lake Project is a cooperative effort of the CDFA, the Lake County Department of Agriculture and the Lake County Department of Public Works. Clear Lake is the largest freshwater, natural lake completely within California's borders[21]. It is almost 22 miles long and eight miles wide, has a surface area of approximately 43,000 acres and has about 100 miles of shoreline. Clear Lake is located roughly 90 miles north of San Francisco. The lake is relatively shallow, with an average depth of approximately 26 feet. Because it is shallow and has winds most afternoons, Clear Lake's waters move and mix significantly even near the bottom so it does not strongly develop the temperature-based layering (thermocline, stratification) that is typical of most lakes, not even in late summer. Water temperatures range from mid to high 30's degrees Celsius (86+ degrees Farenheit) in the summer from 5 to 10 degrees Celsius (40 to 50 degrees Farenheit) in the winter. Temperatures are ideal for hydrilla germination and growth from April until mid-October, especially the monoecious form that is in Clear Lake.

[21] Clear Lake is a popular fishing and water sports recreational lake. Clear Lake has often been described as the "Bass Capital of the West." The Lake is host to a number of bass tournaments throughout the year. There are also catfish, crappie, hitch and bluegill in the lake. There is also carp bow hunting.

Plate 7. Map of Clear Lake in Lake County Showing Location of Hydrilla Program Management Units and the Year Hydrilla First Detected in Each Unit.



Hydrilla was first found in Clear Lake on August 1, 1994 during a routine detection survey by personnel from the CDFA and the Lake County Department of Agriculture (Plates 7, 8). The CDFA and Lake County biologists responded rapidly and applied copper herbicide to some infested areas within two weeks of the first detection. In addition, the CDFA, with the cooperation of the Lake County Agricultural Commissioner, put Lake County under quarantine[22]. The CDFA and Lake County biologists conducted the initial delimiting survey in 1994 and found that 175 to 200 surface acres along the shoreline of the upper arm of Clear Lake were infested (Plates 7, 8). Infestation levels varied from a few scattered plants to dense populations covering many acres. In addition, in both 1994 and 1995 thousands of hydrilla fragments were visible at some of the boat ramps at the western end of the lake. The CDFA convened a Scientific Advisory Panel in 1994 (Stocker, R.K. and L.W.J. Anderson *et. al.* 1994) which recommended a survey, treatment and public education program.

[22] Because of the heavy recreational use of the lake, and the high risk that contaminated recreational equipment, clothing, or vehicles could spread hydrilla plant fragments, tubers, or turions around the Lake, or out of the Lake to nearby ponds, lakes, and streams (particularly Cache Creek), the CDFA and Lake County restricted movement of watercraft, motors, trailers, fishing gear, and other vehicles and equipment until they were inspected and cleaned of aquatic vegetation at the boat docks and ramps. These restrictions are still in place.

Plate 8: Hydrilla in Clear Lake, 1994, in the area of Big Valley, before treatments started.

Clear Lake Project personnel divided the lake's shoreline into 85 (originally 80) management units in order to better organize eradication efforts (Plate 7). These management units were based upon landmarks for ease of navigation; they are not equal in length or area. The management units also varied in width but usually extended about 500 to 600 feet from shore toward the center of the lake where the water is 15 to 20 feet deep. In 2003, all of the management units were surveyed and mapped using global positioning system/global information system technology to increase accuracy of herbicide treatments and to better coordinate aquatic vegetation management activities with the Lake County Integrated Aquatic Vegetation Management Program[23].

Survey of Clear Lake

Surveying for hydrilla in Clear Lake is a challenge. Surveys cover from the shoreline out to between 600 to 800 feet from the shore, so the area to be surveyed in one circuit of the lake's 100+ miles of shoreline is about 7,300 acres (about 11 square miles). In addition, hydrilla is actually scarce in Clear Lake now. It takes a great deal of work to find the plants. For instance, the crews found 76 plants in 2009 but that represents a tiny part of a 43,000-acre lake. Square

[23] The Clear Lake Integrated Aquatic Vegetation Management Program is a permit system to allow the public and Lake County to conduct weed control operations in Clear Lake. The program is operated by the Lake County Department of Public Works.

miles of Clear Lake's area are also heavily covered in submerged weeds, which further interfere with surveys. Finding each plant took an estimated 95 to 105 person-hours of actual search time on the water in 2009.

The Project attempts to survey every management unit every three to four weeks during hydrilla's growing season. Surveys always represented at least 40 percent of the Clear Lake Project's activities, and that percentage continued to increase as management units reached the three-year criterion for ending treatments during 2002 to 2006. Presently survey represents about 85 percent of the crew's time, or around 8,000 person-hours per season of actual time on the water (not including prep and travel time).

Change in Survey Protocol

The Technical Review Panel of 2009 (see below) recommended that the Clear Lake Project try to make its survey methods more systematic. They suggested exploring possibilities such as recording the boat tracks, analyzing search coverage, and/or setting up survey grids to direct each boat's search, all based on an on-board GIS. Unfortunately, the CDFA IT Division refused to allow the purchase of the GPS-enabled ruggedized field computers that would be necessary to carry out such work in the environment of an airboat. In an attempt to make the surveys at least a little more systematic, Project personnel re-drew the boundaries of the survey areas for 2011 and beyond (Plates 9, 10).

The new survey areas are all close to being equal in area. They are provided to the crews on a consumer-grade boating GPS, so they can track their progress. The old survey areas (= "management units") were never really drawn at all. They had somewhat vague boundaries along the shore that were based on not-necessarily-permanent landmarks, outer boundaries of "around" 600-800 feet, and surveys were not guided by GPS. The management units varied widely in length and in area, from about 35 acres to 409 acres, according to one attempt to draw the units (Plate 9). They totaled 8,460 acres by that same drawing. The new survey areas are all very close to 78 acres. They were drawn using the following rules: survey from shore (Zero Rumsey) out a minimum of 100 feet and out to maximum of 1200 feet from shore or to a depth of 20 feet (Zero Rumsey), whichever comes first. This contour was plotted all around the lake excluding the outlet area where it enters Anderson Marsh, and then divided into 80 survey units, each intended to be equal in area. The new survey areas range from 77.4 to 78.9 acres, except for one, which was the last to be drawn at the end of drawing the 79 previous ones. There ended up being only 72 acres left to put into it. The total survey area within the lake is now 6,229 acres.

Plate 9: Comparison of old "management units" with new "survey areas"

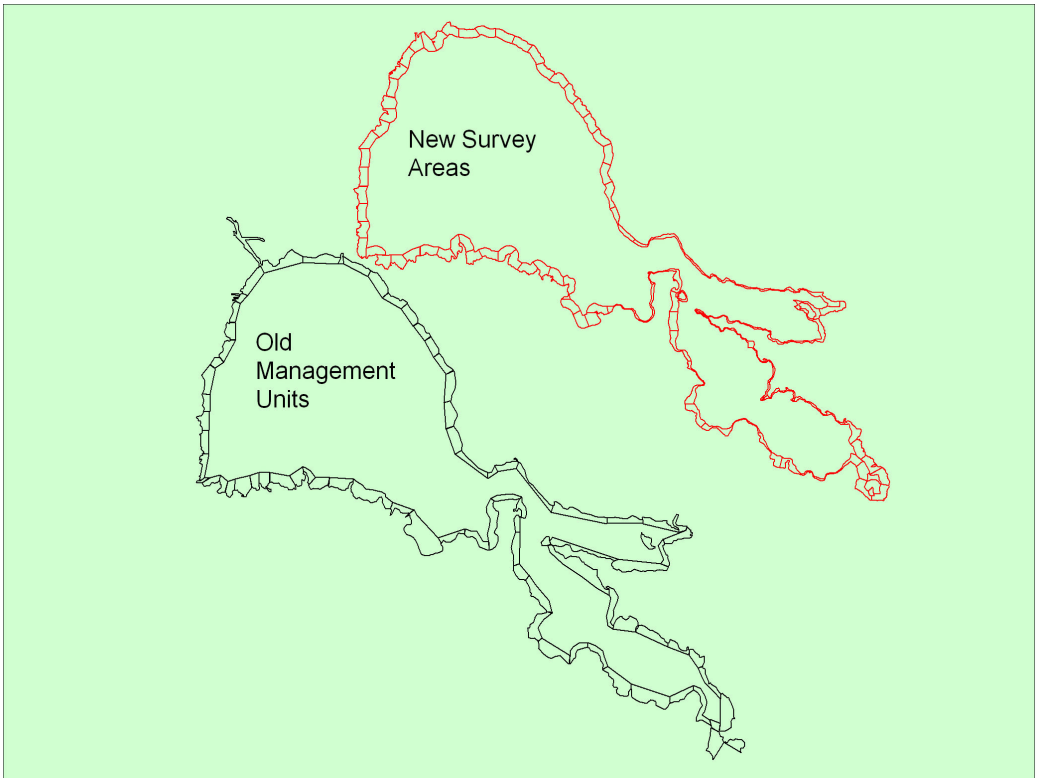
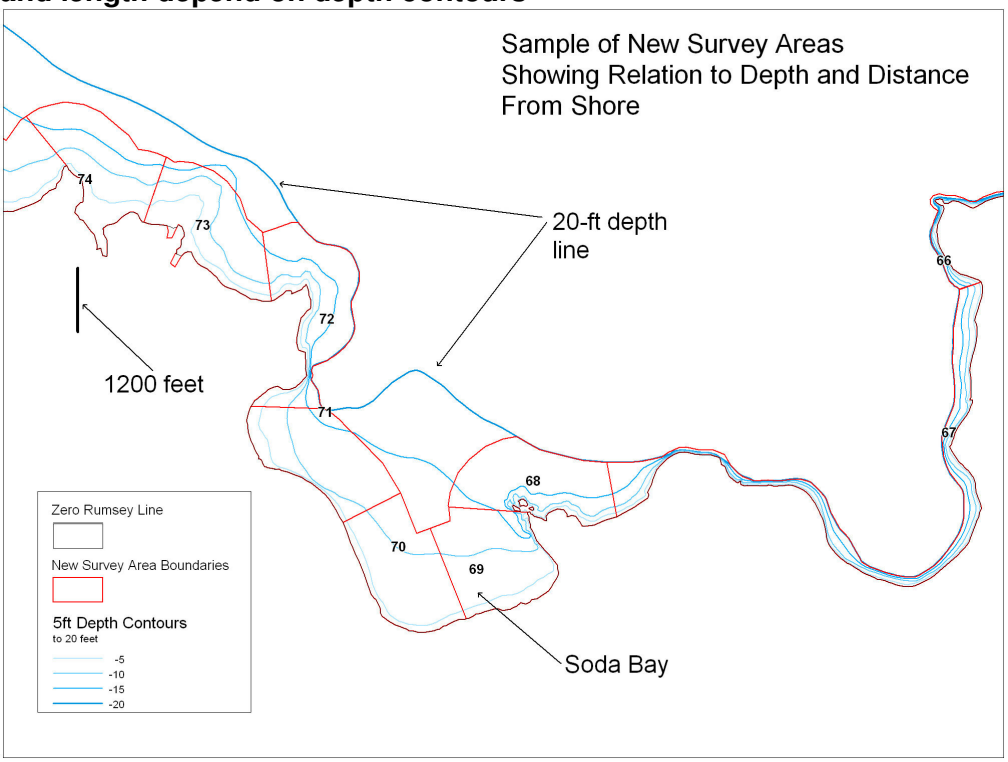


Plate 10: Close-up of a few of the new equal-area survey areas, showing how their width and length depend on depth contours



The new survey areas are short and broad where the water depth falls off very slowly, as in the western basin of the lake, and they are long and skinny where depth falls off quickly (Plate 10). But, they all have close to the same area, so it is more likely that the same intensity of survey effort will be put into each area than with the old areas. The boats each have a consumer-grade GPS with the survey areas marked in them, and the crews can track their progress so they can see whether they are achieving even coverage.

Results

In 2005, project crews conducted 549 surveys of the management units for an average of 6.4 surveys per unit. In 2006, the crews surveyed the management units on average once every four weeks, conducting 495 surveys for an average of 5.9 surveys per unit. In 2007, even though hydrilla returned and treatments resumed, the crews surveyed 719 management units for an average of 8.5 visits to each unit. In 2008, the crews accomplished 744 surveys for an average of 8.75 visits to each unit, or about once every 3.4 weeks. In 2009, the crews accomplished 750 surveys for an average of 8.82 visits to each unit, or once every 2.9 weeks. In 2010, the Project leads decided to focus on spending some extra time during each survey bout in each management unit. In previous years, the crews tried to complete roughly three management units each day. In 2010, the goal was to survey roughly two units each day but put more time in each. This also decreased time moving between units. In 2010, the crews accomplished 566 surveys for an average of 6.9 visits to each management unit or about once every 3.4 weeks.

In 2011, the crews performed 510 surveys of survey areas for an average of 6.0 surveys for each area. As the survey season ran from May 10 to November 9, this led to survey areas being surveyed on average once every 4.4 weeks. A couple of factors contributed to the decline in survey intensity in 2011. First, a Governor's hiring freeze on seasonal employees meant that the crew was down three members (= one boat crew) until about mid-August. Second, an effort was made this season to locate tuber beds by collecting and searching sediment cores. This effort diverted another three to four crew members for at least three weeks.

No hydrilla plants were detected in 2004, 2005 or 2006, but they reappeared in 2007 (Table 4). Previously, the last plant found in the lake had been on June 23, 2003. In 2007, about 72 "spots" of hydrilla were found (Plate 11). In 2008, another 196 plant locations appeared. Most were single plants but many were large, vigorous clumps up to several yards across and topping out at the water's surface, especially during September and October. In 2009, counts were down with about 76 plant locations and the plants were, in general, much less vigorous than in 2008. Only a couple plants reached the surface and none were larger than a yard or two in diameter. Most finds were just a few weak stems. In 2010 the decline was even more marked. The crews found only 12 hydrilla plants and most were very sickly. Only five finds were outside established treatment areas, which meant only 20 acres were newly brought under treatment that year.

In 2011 only 6 plants were found, all small and most sickly. Only two finds were outside current treatment areas, leading to only 9.6 new acres being brought under treatment. By comparison, the number of new acres brought under treatment in previous years was 350, 249, 120, and 20 acres in 2007 through 2010, respectively. The first plant in 2011 was found on August 10 (July 9, June 17, June 9, and June 15 in 2007 through 2010, respectively) in Unit 50 (old scheme), on the north shore of the southern arm. The last finds were on November 7 (November 15, December 9, November 12, and August 19 in 2007 through 2010), one in Unit 51, and one in

Unit 71 on the south shore of the Narrows. The first survey in 2011 was on May 10 and the last on November 9. The water temperature at the time of the first survey was 16.7 degrees Celsius (62 degrees Farenheit) and was 10.6 degrees Celsius (51 degrees Farenheit) at the last survey.

Once again the plant finds this year were scattered around the lake (Plates 11a and b, 12), as was also indicated by the plants appearing in five management units (Table 4). That was a decrease from the 7 management units in 2010.

Other aquatic plant species detected in Clear Lake in 2011 included coontail, curlyleaf pondweed, American pondweed (*P. nodosus*), Illinois pondweed (*P. illinoensis*), egeria, common elodea, Eurasian watermilfoil (*Myriophyllum spicatum*), sago pondweed (*Stuckenia filiformis*), smartweed (*Polygonum* species), coontail, water primrose, spatterdock (*Nuphar luteum*) and spiny and southern naiad.

Plate 11a. Hydrilla Finds in Clear Lake, 2007 - 2011: Western section of the lake.

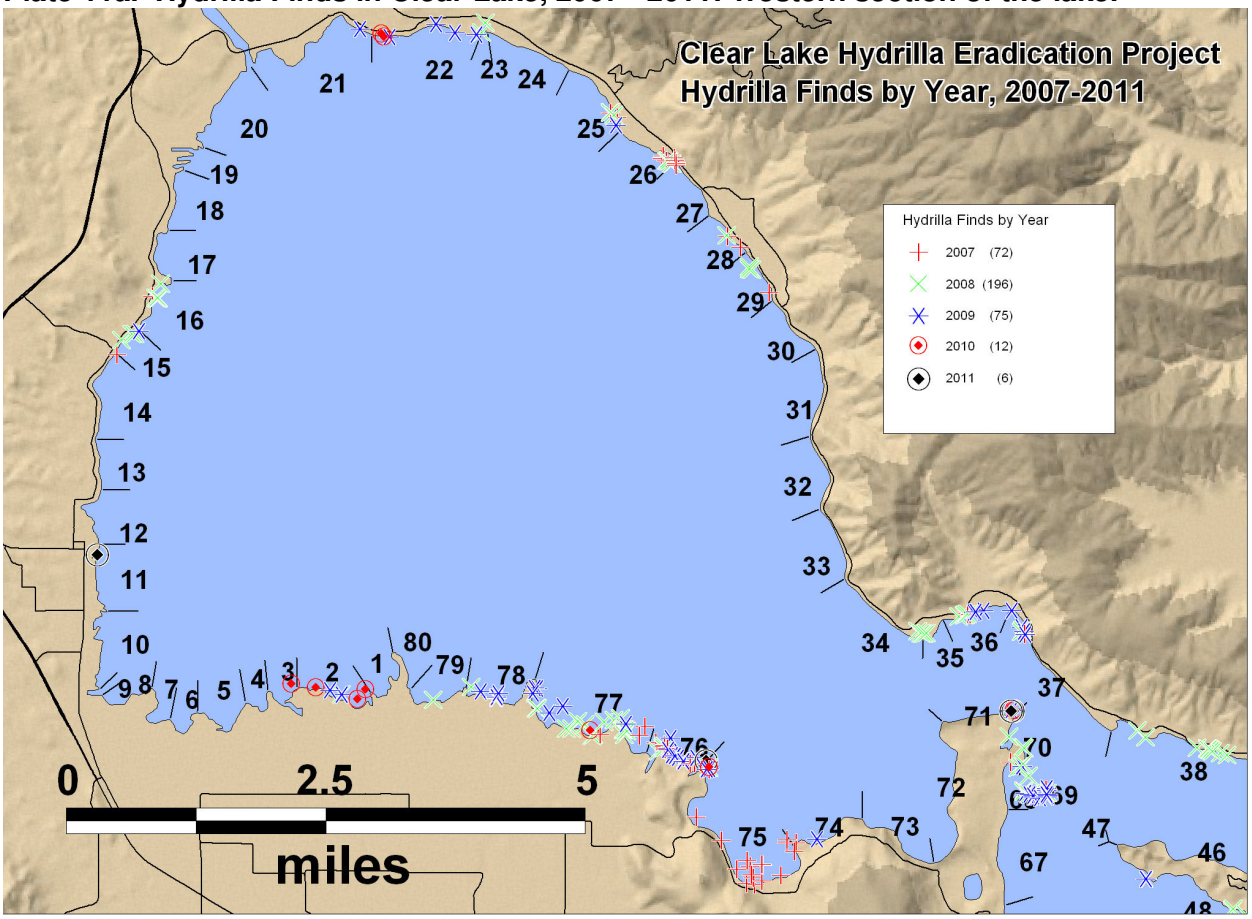


Plate 11b. Hydrilla Finds in Clear Lake, 2007 - 2011: Eastern section of lake.

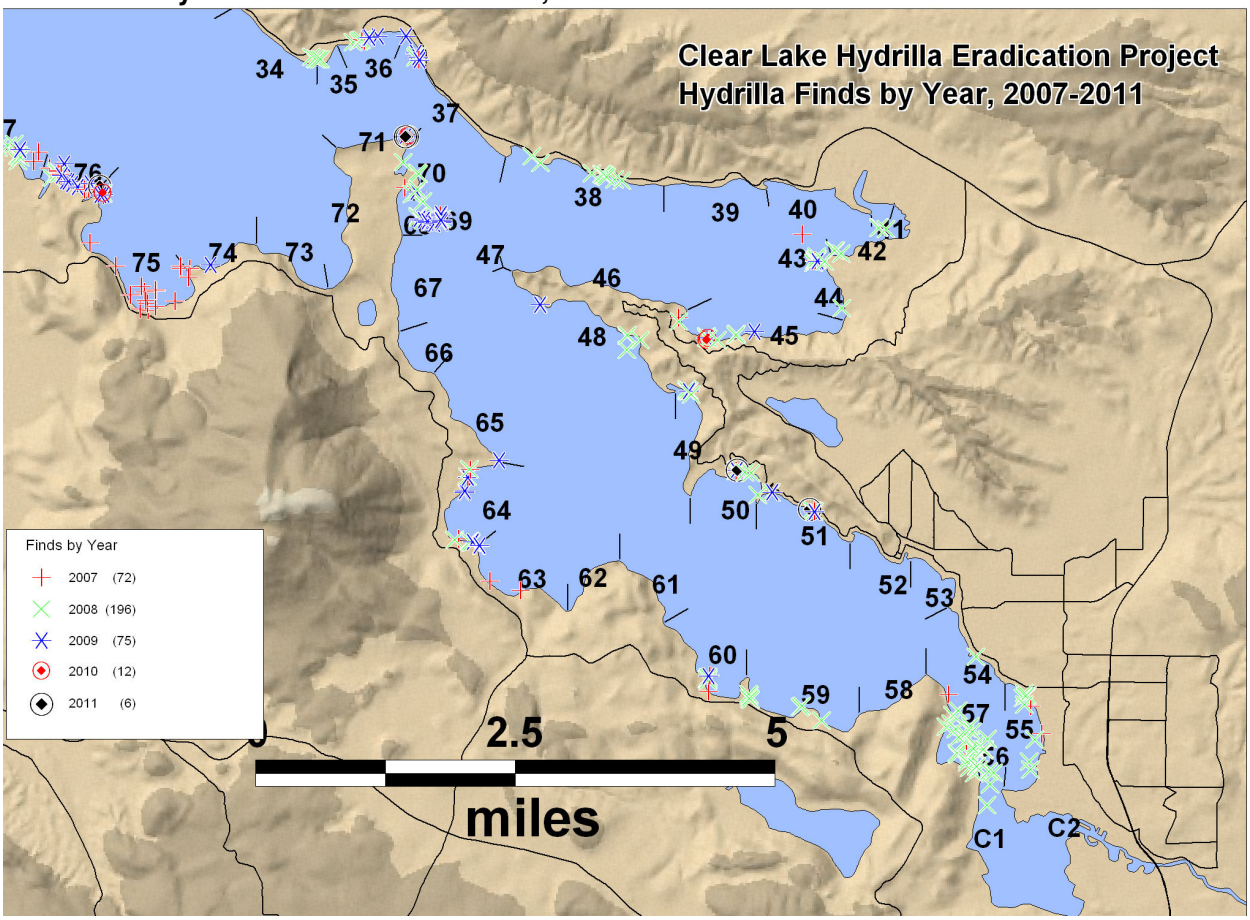


Plate 9. Hydrilla finds in 2011, whole lake

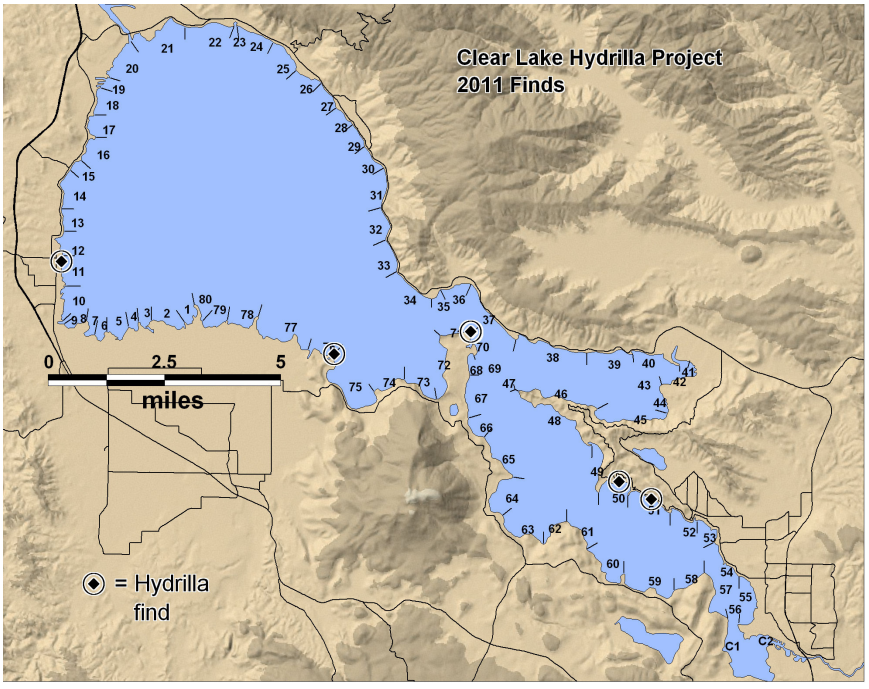


Table 4. Level of Hydrilla Infestation in Clear Lake, Lake County by Number of Infested Management Units* and Number of Finds, 2000 to 2011

	2000	2001	2002	2003	2004 – 2006	2007	2008	2009	2010	2011
Number of Management Units with "Finds"	31	21	6	1	0	24	34	24	7	**5**
Number of Hydrilla "Finds"	67	41	12	1	0	72	196	76	12	**6**

*The management units were originally defined with reference to natural landmarks for ease of location, survey, and treatment. Management units are not identical in size or shape.

Clear Lake crews survey the deeper center sections of the lake in mid to late summer every year. This period was chosen because any hydrilla plants growing in the deeper sections of the lake would have reached the water surface by this time and would be fairly easy to detect. In 2009, project crews made three center section surveys. No hydrilla has ever been detected in deep-water sections of the lake.

In addition to surveys, the Clear Lake hydrilla crew also does boat and trailer inspections for hydrilla before and after major fishing and boating events. In 2008 they conducted 180 boat and trailer inspections. No hydrilla was found.

Treatments of Clear Lake

Herbicide use in Clear Lake had dropped during 2002 through 2006, but that trend reversed itself beginning in 2007 (Table 5).

The Project used 285 pounds of elemental copper this year. This was down from previous years because there are fewer finds and fewer finds outside established treatment areas. Each new find receives a single initial treatment with copper at 1 ppm. The treatment is very effective at burning back any hydrilla present and it greatly reduces the amount of biomass that might otherwise tie up fluridone. Some copper was used this year to locally re-treat some areas where hydrilla was re-growing even within treatment areas. Fluridone is used for the remainder of all treatments.

Table 5. Aquatic Herbicide Used by the CDFA in Clear Lake, Lake County 2000 - 2010

Copper, pounds, as active ingredient

2000	2001	2002	2003	2004 – 2006	2007	2008	2009	2010	2011
1,960	1,112	282	12	0	4352	5292	2206	492	**285**

Fluridone, pounds, as active ingredient

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2,689	2,839	2,370	1,824	867	219	8.2	570	912	1,140	1,457	**1,464**

The Clear Lake Project's use of fluridone had also decreased until 2006 (Table 5) as management units reached the previous three-year criterion for the end of treatments. That trend also reversed itself in 2007. In 2005, project crews treated 137 acres with fluridone slow-release pellets and none in 2006 (except for a five-acre area to maintain access to a survey area). In 2007, the Project established 248 acres of treatment areas, all of which will require

treatment with fluridone for about five years. During the 2008 season, the 196 finds required creating 62 new treatment areas covering an additional 325 acres. With adjustments and merging of treatment areas before the start of the season, 2009 started with about 599 acres under treatment. During 2009, the 76 finds required bringing another 120 acres under treatment. For the start of the 2010 season, about 719 acres required treatment. Treating that area and the 20 acres that were added this year required the 1457 pounds listed in Table 5. In 2011, less than 10 acres were added and those only late in the season after fluridone treatments had ended, so the 1464 pounds of fluridone used in 2011 is only slightly higher than 2010.

Clear Lake is a weedy lake and the Lake County Department of Public Works has an ongoing program for the management of general aquatic weeds. They contract with private applicators to control nuisance weeds in high-use areas, and they issue permits for private groups to control weeds in the lake. These permits require the permittee to identify the location of all proposed treatments, the method of treatment and any aquatic vegetation present. The CDFA lead person at Clear Lake approves these permits before treatment can commence. In 2011, there were 111 permits for treatments.

Surveys Outside of the Quarantine Zone

With the intensive treatments, survey on the lake itself, fewer crew, and the tuber survey this season, surveys of other water bodies in the area have dropped off. In 2011 no water bodies other than Clear Lake were surveyed.

Public Information and Awareness

Public information and awareness are essential components of the Clear Lake Project. Since public access to the lake is not restricted and there are hundreds of access points, fishermen, guides, outfitters, fishing tournament organizers, boaters and other users of Clear Lake, the public needs to know how to prevent the spread of hydrilla within the lake or from Clear Lake to other lakes and streams. Clear Lake Project personnel distributed approximately 800 informational pamphlets to businesses and government agencies around Clear Lake.

In 2011, Clear Lake Hydrilla Eradication Project personnel made several presentations about the project. The project was highlighted in a presentation at the Western Aquatic Plant Management Society Conference in March. Patrick Akers gave a presentation to the California Lake Management Society, which had its annual meeting in Lakeport in October.

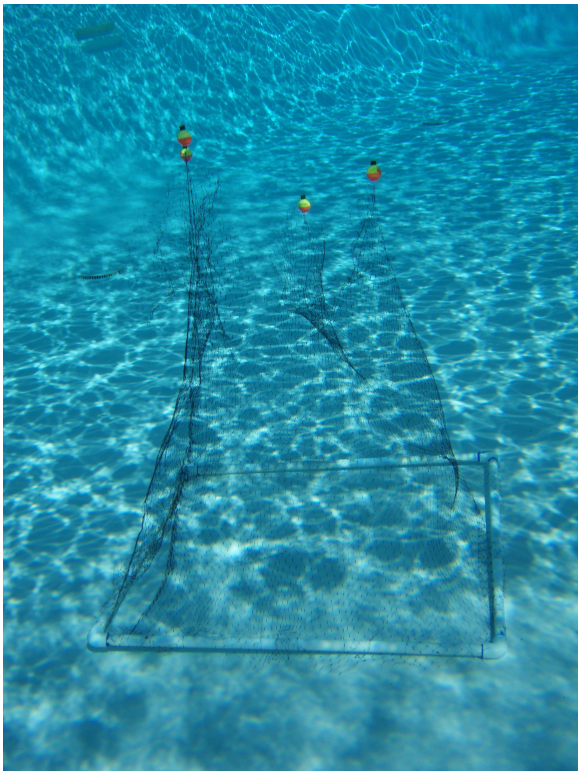
New Initiatives 2010-2011, based on the Technical Review Panel Recommendations

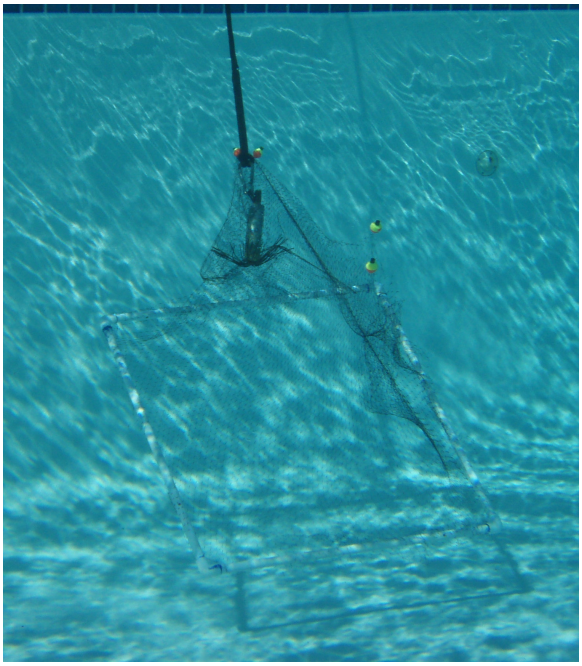
In October 2009, the Program convened a Technical Review Panel of four outside experts to review the Clear Lake Project and recommend improvements. The group spent a day and a half discussing the project. They suggested a number of refinements for both survey and treatment, but supported the overall goal of eradication and the general approach. Their report is available on the CDFA's Hydrilla Program web page at: http://www.cdfa.ca.gov/phpps/ipc/hydrilla/hydrilla_hp.htm.

One initiative prompted by the TRP has already been discussed: the re-drawing of the survey areas to make them equal in area, and to provide at least some guidance by GPS to provide more uniform survey coverage.

Another suggestion was to attempt to quantify the likelihood of finding plants using our sampling methods. In an attempt to begin addressing this question, Project personnel developed a surrogate "artificial hydrilla" hooking target (Plate 13). The target is a simple PVC frame 30 inches square, with about 1 meter (40 inches) of bird netting suspended above it by a few fishing floats. The hydrilla hooks catch in the bird netting quite efficiently, lifting the target off the bottom and into the boat.

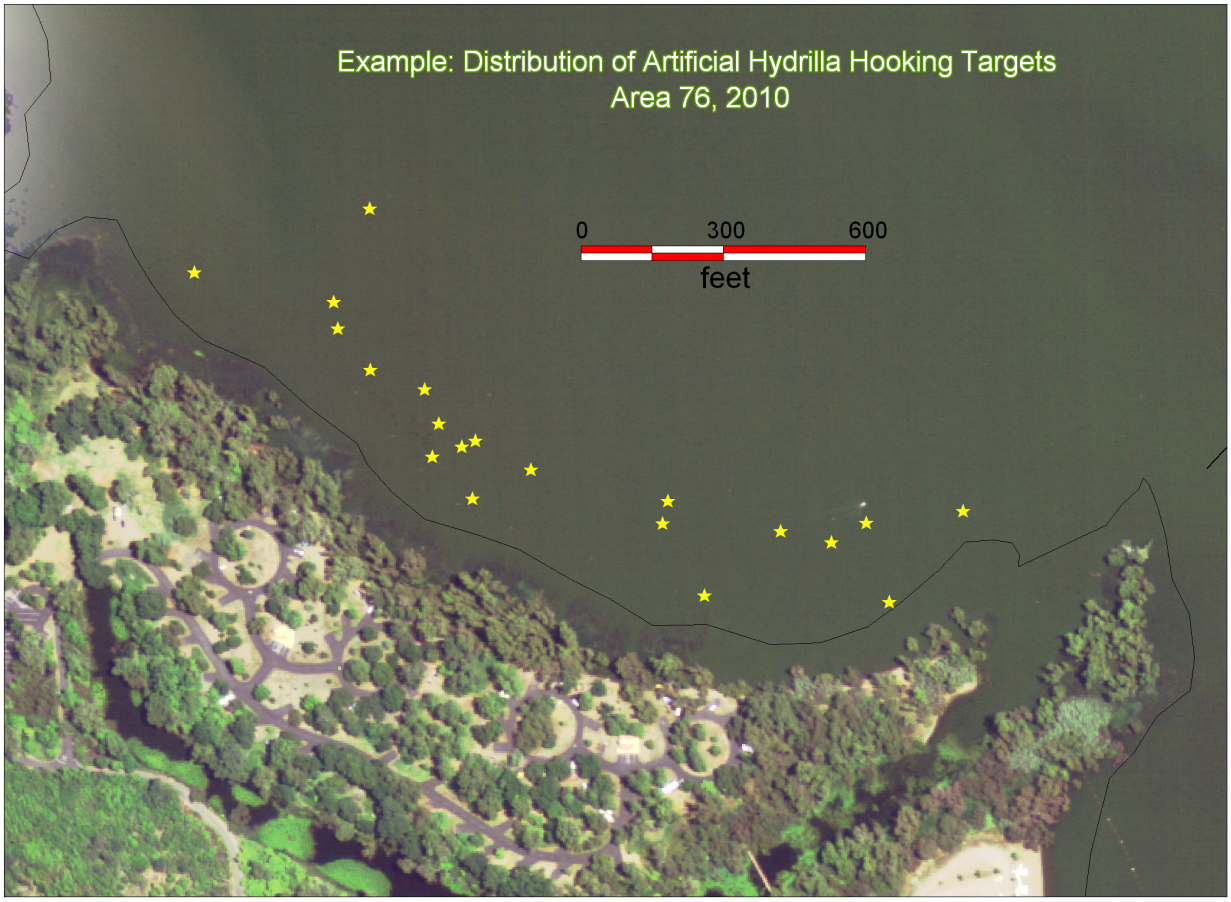
Plate 13: Demonstration of the "artificial hydrilla target. Left: target sitting on bottom. Right: target being lifted by hydrilla hook.





In 2010, Project personnel put out five replicates of (usually) 20 targets each in typical management unit areas (Plate 14). Then a survey crew carried out its normal survey activities in the area. A survey of an area is normally about three to four hours, the amount that can be done in a morning or afternoon. Over the five replicates, the crews hooked 13 of 96 targets, or 13.5%. On a per-replicate basis, the crews hooked an average of 14±4.8% (standard error of the mean) of the targets in each replicate.

Plate 14: Sample of distribution of targets within management unit, for one replicate of target hooking exercise



This result allows estimates of how certain we can be about finding a single plant in an area. This is important because, for eradication, we have to be reasonably certain we can find every plant. In other words, if there's a single plant left in the lake, we want to know the probability we will find it with a certain level of effort. If there is a single plant in an area, the probability of finding it is:

$$P_n = 1 - q^n, \text{ where}$$

P_n = the probability of hooking a target if it is the only target in the survey area, after n surveys,
n = the number of surveys,
q = 1 – p, where p = the probability of hooking the single target with a single bout of survey.

Using p = 0.135, there is about a 95% chance of hooking the single plant at between 20 and 21 surveys. With seven surveys per year, this is about three years of survey. For a single year of survey, there's about a 58% chance of hooking a lone plant if there are six surveys, and about a 64% chance if there are seven surveys.

Project personnel intend to continue pursuing this initiative, but did not have time in 2011 after working on the tuber survey.

A third suggestion by the TRP was to try to monitor the decline of tuber abundance in the lake, to provide another indicator, other than plant finds, that could show whether eradication was approaching. The idea was to make an initial broad sweep of the most likely areas where tubers might be found, in order to locate tuber beds (discrete locations with high densities of tubers, usually in areas with vigorous plants). If such beds could be located, they could be sampled year after year to determine if tuber densities were declining through time.

Plate 15: The sampling head for the dredge-based sediment core sampler. The head is the aluminum tube on the right. Just to the left of the tube, being held by the crew person, is the square plate that limits the depth the core head can sample. To the left of that, the suction tube leading to the dredge leads off the sampler at a right angle. The crew person in the sunlight holds the sampler up by its handle, which can be adjusted in length for different water depths.

Finding a sediment sampling method that would work in Clear Lake took some effort. We tried a standard open-ended static-vacuum core sampler (eg, Madsen 2007), but the sediments in Clear Lake proved to often be sandy or gravelly and the samples were usually lost. Madsen (2007) noted his sampler often did not work well in sandy sediments. We then worked on

modifying a standard venturi-type, small hydraulic gold dredge to take core samples. After a variety of modifications, we created a sampler that could create approximately 4-inch by 12-inch core samples (Plate 15). We washed the samples through 3/16-inch screen and visually searched the material retained by the screen for tubers. The core sampler commonly brought up tubers of sago pondweed, fragile snail shells, seed pods of cocklebur, damselfly nymphs, and even small fish upon occasion, almost all undamaged. Previous work in other eradication projects used gold dredges, and had no problem collecting tens of thousands of tubers. Therefore the method should have collected any hydrilla tubers without seriously damaging them. The core sampler and screens were mounted on a pontoon boat to provide a work platform (Plates 15, 16).

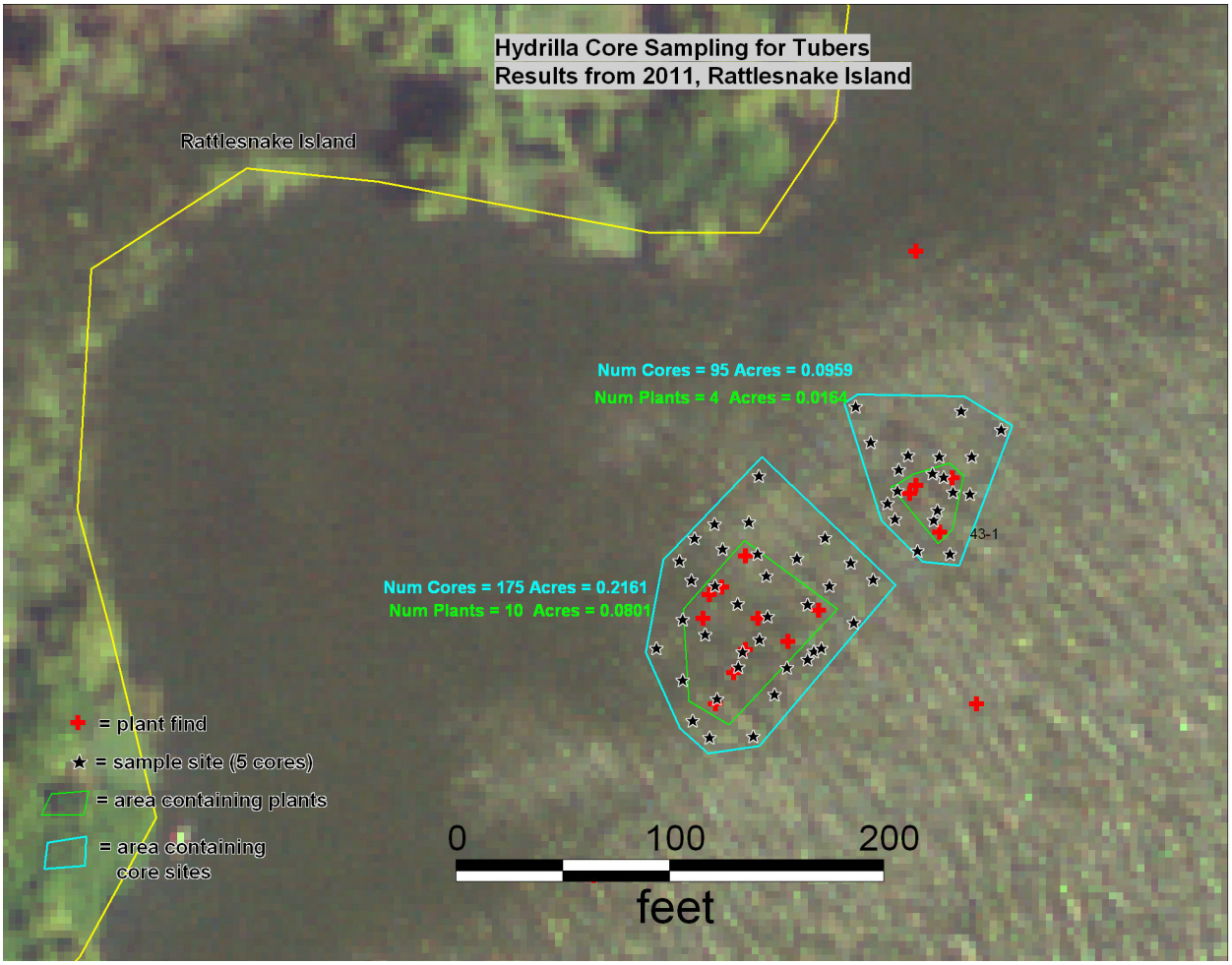
Plate 16: The sampling pontoon boat, showing the lines running from four corners of the platform to the anchors (marked by orange buoys).

The location of candidate areas for tuber beds and the control of the work platform took some consideration, too. Hydrilla is actually very rare and widely dispersed in Clear Lake, which creates a problem for finding likely tuber beds. To illustrate, during 2007-2010 crews found about 355 plants or small spots with hydrilla in Clear Lake. That sounds like a lot of plants but they are scattered across a 43,000-acre, and the crews had to spend about 32,000 man-hours actual time on the water to find them. All plant locations since 2007 have been marked using GPS, so it was straightforward to visualize those spots that had had the highest concentrations of plant finds. We chose three locations around the lake which had the densest concentrations and most robust plants, as indicated by both the GPS maps and by interviews with the survey crews. The locations were just outside the Clear Lake State Park boat ramp, around Anderson Island, and just east of Rattlesnake Island. No hydrilla plants were found growing in the sampled areas during the 2011 season.

In order to fix the location of the work boat in the lake while taking core samples, we placed 180-pound anchors at the four corners of a rough quadrangle surrounding or within one of the candidate high-density plant sites. The anchors were spaced 50-150 feet apart, and a rope ran from each one to a separate corner of the pontoon boat. To remain on a core sampling site, the ropes were pulled snug from each corner to its anchor (Plate 16). At such a core sampling site, five core samples were taken along one of the long sides of the pontoon boat, at intervals of approximately three to four feet. The pontoon boat was moved from one core sampling site to the next by adjusting the lengths of the ropes to the anchors. The boat could then progressively cover the area.

Individual core sample sites were scattered on top of and around plant locations. GPS locations of the plants and the boat had accuracies of 20 to 30 feet, so more emphasis was placed on covering the general area with a number of sampling sites rather than attempting to stay very close to the putative plant location. All sampling sites were recorded with a data-recording Trimble GPS (GeoXT), and latitudes/longitudes were also recorded on the data sheets. An example of the distribution of plants and sampling sites is given in Plate 17. This area was next to Rattlesnake Island, which had the highest numbers and density of plants, many of which were large, topped out, and very healthy when found.

Plate 17: An example of one of the areas searched for tubers, showing plant distributions and sampling locations.



We found no verifiable hydrilla tubers in the entire survey, while inspecting 875 core samples from 175 sampling sites, taken from within an area totaling approximately 1.16 acres. The candidate high-density historical hydrilla locations represented 30 plant sightings contained within a total area of approximately 0.37 acres.

We did find five possible suspect "tubers". Four were badly decomposed and the fifth did not sprout when it was placed in an open jar of purified water in a sunny location. A viable tuber should have sprouted. In addition, the suspects actually looked more like aborted leaf buds from a tree or other plant, rather than hydrilla tubers.

With a sampling intensity of more than 750 samples per acre, we calculated we should have had about a 50% chance of hitting a tuber bed six feet in diameter, and an 87% chance of hitting a bed eight feet across. If there had been even 50 to 60 square feet of tuber beds in the sampled areas (in a total of about 50,560 square feet), we should have hit them.

As the Project had spent at least three full weeks in sampling, not including the time developing the methods, we concluded a tuber depletion study did not warrant the effort. On the other hand, the fact that such intensive sampling did not turn up any tubers, even though it was done in the locations that should have had the highest likelihood of having tuber beds, indicates that tubers probably are becoming very rare in the lake.

The TRP also made suggestions with regard to treatments. Based on their suggestions, the Project is working with the manufacturer of the Sonar herbicide (SePro) to produce a different formulation that will allow a more even dispersion of the herbicide on the bottom, which should reduce skips that allow plants to escape the herbicide.

New Dredging Initiative and Planned Reduction of Area Treated with Herbicide

The Hydrilla Program usually uses a range of methods in a project to eradicate hydrilla. It is unusual for a Project to depend so wholly on herbicides as has been the case in the Clear Lake Project. However, Clear Lake is also the largest, most difficult project the Program has ever faced, and herbicides provide efficient control of large areas. Although it is labor-intensive, the most common and useful of the alternate control methods in other projects has been small-scale dredging, to directly remove the tubers from the sediments. Dredging provides one of the few methods that is at all effective in directly attacking the tuber bank and seems like one method that should be suitable for Clear Lake, especially for attacking the last few "straggler" plants.

Project personnel have wanted to try dredging in Clear Lake for several years, and the TRP also recommended pursuing the strategy. Unfortunately, dredging is itself almost more highly regulated than herbicides, especially in Clear Lake where there are mercury problems. Even though the area that would be dredged for any one plant would be small (10x10 to 15x15 feet) and probably 200 sites would be a very high guess as to the number of plants that would be dredged, it still requires several permits from several different agencies. However, even though there were concerns, the Clear Lake community seemed supportive of the approach in general.

In the fall of 2010, the Hydrilla Program entered into a $45,000 contract with Lake County to support one of their Biologists half-time in the Water Resources Department. Her task was to put the permits in place that would allow dredging. By the fall of 2011, the permits were in hand. The Program has submitted a contract that will provide for up to $150,000 for small-scale

dredging services over the next two years. This contract is out to bid, so the Program hopes to have it in place by the time plants appear that would be targeted for dredging.

In anticipation of moving to dredging as the main method to remove straggler plants, Project personnel plan to drop herbicide treatments on several treatment areas. These areas for the most part have all had at least four full seasons of herbicide treatment and have passed at least four full seasons without having any plants. Other criteria for choosing candidate areas were number of plant finds within the treatment area, water depth, location on the west (upwind) shore, proximity to other treatment areas with recent finds, and distance to the outlet, among others. The Project has identified about 90 acres that will come out of herbicide treatment in 2012, the first reduction in treatment area since 2007.

NEVADA COUNTY *(Lead: Jonathan Heintz)*

Overview of Projects

Hydrilla was found in a pond in a waste transfer station in July 2004 in Nevada County. In 2005, probably as a result of heightened awareness, two more infestations were found in the County. One infestation was found at the County Fairgrounds in late February 2005, and a second was found in late December in a small irrigation pond about six miles south of Grass Valley. For clarity, the infestations will be treated separately.

Waste Transfer Station Fire Control Pond

Many details concerning the infestation and initiation of the eradication project were presented in the 2004 report and only a summary is provided here.

On July 21, 2004, a representative of an aquatic plant management company found hydrilla in a fire control pond at the Nevada County Transfer Facility near Grass Valley. The CDFA and the Nevada County Department of Agriculture then started the Nevada County Hydrilla Project.

Project biologists mapped the pond (Plate 18) within two weeks. Several hydrilla mats were clearly visible in the northeastern third of the pond, including one that was fairly large. The pond is 0.6 acres in area, averages 18 feet deep and has a rubber liner. It provides water for fire emergencies and to cool a wood waste chipping operation. The chipping operation requires substantial amounts of water several times a month. The Transfer Facility site itself is a 'no-runoff' site and is surrounded by a drainage canal and several ponds to capture runoff. Two surveys for threatened and endangered species determined that treating the infested pond would not pose a threat. The frogs in the infested pond proved to be non-native bullfrogs.

The Office of Administrative Law added Nevada County to the listed state hydrilla eradication areas on August 5. On August 23, the Secretary of Agriculture signed the Proclamation of an Eradication Project.

In early August 2004, CDFA divers free-dived the pond at the northeast end where the hydrilla mats were most visible. Divers reported several inches of sediment at this end of the pond and recovered several tubers. Dr. Lars Anderson of the USDA-Agricultural Research Service also did a pre-treatment survey of the density of the hydrilla infestation finding an average of 2.3 ± 0.7 kilograms of hydrilla (dry weight) per square meter (Anderson, Lars W.J., 2004, Unpublished

data, USDA-ARS Exotic and Invasive Weed Research Unit). The survey also showed that most of the water column was filled with hydrilla, even where it was not clearly visible at the surface.

Survey and Treatment of the Fire Control Pond

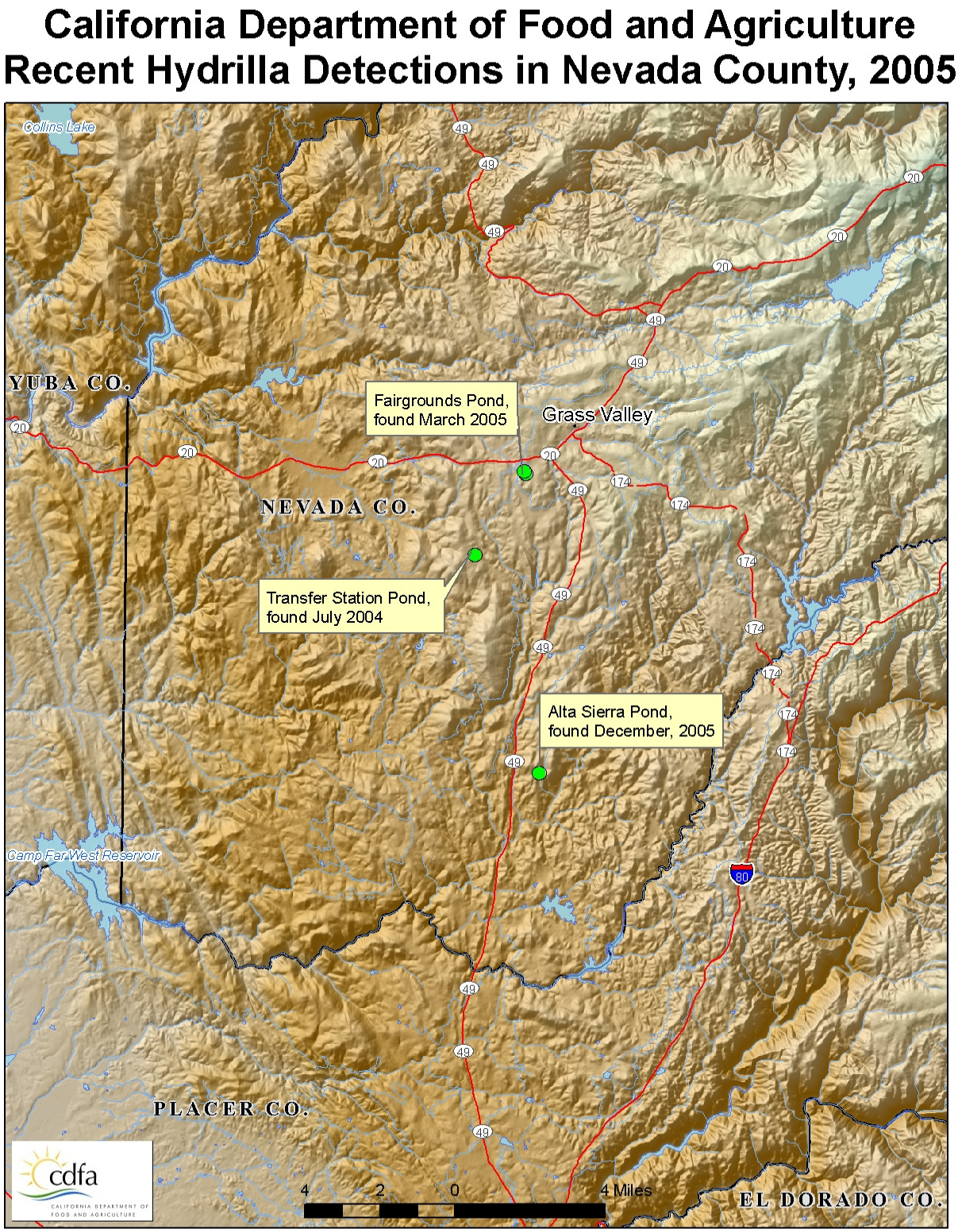
The Project biologist surveyed the pond once, in June, 2011. No hydrilla was found. This represents the sixth year without plants (Table 6). The pond was treated once in July with fluridone to reach a concentration of 90 ppb (1.5 pounds of active ingredient). Because the pond is isolated and has little flow, a single treatment is sufficient. Water sampling has shown that the fluridone remains at effective levels through the winter.

Nevada County Fairgrounds Pond

On February 22, 2005, a county biologist on a mosquito survey saw plants that he suspected might be hydrilla in the main pond at the County Fairgrounds. He reported to the County Agricultural Commissioner's Office and John Mills, the Deputy Commissioner, sent a sample to the CDFA Botany Lab, which confirmed the plant as hydrilla. On February 24, CDFA biologists made the first assessment of the pond. On March 23 and 25, they screened the outlet of the pond and carefully surveyed the pond and environs. Raking and visual surveys indicated that the pond bottom was nearly 70 percent covered with hydrilla but later soil core sampling, taking a four-inch diameter core at 29 locations, recovered no tubers and only one fragment of hydrilla. Surveys of the ponds and streams in the area found no other hydrilla locations.

The major function of the pond is as the irrigation reservoir for the fairgrounds, but it is also a popular local fishing spot, locally known as Lions Lake because the Lions Club holds an annual fishing derby there. GPS measurements showed that the area of the pond is 2.75 acres, and boat transects showed that the average depth is about 5.5 feet. Most of its water comes from the Nevada Irrigation District flume, which runs through the Fairgrounds near the pond, but during rainstorms the pond can receive considerable runoff. The pond was formed by a dam or berm and is not directly in the bed of the local stream system, which leads to Squirrel Creek and the Yuba River. During dry weather, little or no water leaves the pond, but during storms significant amounts can overflow into the local stream. Reference sources indicated that there was an endangered plant in the area, and by June, after working with Department of Fish and Game experts and the CDFA's environmental compliance officer, project personnel found two populations of the Scadden Flat checkermallow (*Sidalcea stipularis)*. One population lies uphill of the pond area and away from any influence from it, but the other population lies about half a mile downstream from the pond. The plants do not reside directly in the stream but do grow in

Plate 18. Map of Ponds currently known to be infested in Nevada County



the riparian area nearby. Because of the presence of the checkermallow and the use of the pond water for irrigation, project personnel limit the application rate of fluridone in the pond to 20 ppb at any time. In past practice, this level has proved to not be toxic, even to sensitive species of plants, and it still controls the hydrilla.

Survey and Treatment of the Fairgrounds Pond

The Project biologist surveyed the pond three times in 2011 at monthly intervals, in June, July, and August. No hydrilla was found. This represents the fifth year without plants (Table 6). The pond was treated each time with fluridone at 20 ppb.

Valkenburg Lane Pond

On December 21, 2005, an employee of the Nevada County Irrigation District, who had attended a training session on hydrilla, was checking a section of the Nevada County Irrigation canal for another purpose when he noted suspicious plants in a small irrigation/recreational pond just downhill from the canal. He informed the Nevada County Agricultural Commissioner's Office and Brian Steger from the office took a sample and sent it to the CDFA Botany Laboratory. The lab verified the plant as hydrilla, probably dioecious, on December 23. The pond is within the town limits of Alta Sierra, off Lime Kiln Road, about six miles south of Grass Valley. It is about 0.1 acres in area and 5 to 10 feet deep. The pond is formed by a small berm and does not have any significant connection to the local stream system. Its situation also limits local runoff into the pond and any potential overflow.

A group of biologists from the Commissioner's Office and the CDFA Hydrilla Program visited the pond before the end of the year and found it approximately 95 percent covered with hydrilla. On January 20, 2006, a crew from the Hydrilla Program surveyed all the ponds between the Valkenburg Pond and Wolf Creek and also surveyed the irrigation canal for several hundred yards both upstream and downstream of the pond. They found no plants. The crew set up cage screens on the outflow pipe.

Surveys and Treatments of Valkenburg Pond

The treatments of 2006 and 2007 brought the hydrilla populations down to where no plants were visible in the pond by early 2008. The Project biologist surveyed the pond three times in 2011 at monthly intervals, in June, July, and August. No hydrilla was found. Discounting one suspicious sighting in 2010, this represents the fifth year without plants (Table 6). The pond was treated each time with fluridone at 30 ppb.

Table 6: hydrilla finds in Nevada County ponds by year

			Year			
Pond	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Transfer	N	N	N	N	N	N
Fairgrounds	Y (3 plants)	N	N	N	N	N
Valkenburg	Y (15% cover)	N	N	N	1?*	N

* = suspicious plant spotted on visual survey but could not be recovered to confirm

SHASTA COUNTY *(Lead: Ed Finley, now Jonathan Heintz, Patrick Akers)*

2011 saw a major change in the Shasta Eradication Project. For the last eight years or so Ed Finley took care of the hydrilla and spongeplant eradication projects around Redding. This year, however, the CDFA ended all General Fund resources for the weed programs in the Department, effectively eliminating them. Most of Ed's support came from the weed programs. He had been planning retirement during the last couple of years and did so on June 30. However, with the cuts his vacant position in Redding was not filled but eliminated. For the foreseeable future biologists from Sacramento will attend the projects, with the help of seasonal crews from Clear Lake or Fresno. Fortunately, the Shasta projects are well advanced in their progress and with luck should need just a few thorough surveys each year.

The Shasta County Hydrilla Eradication Project (Shasta Project) is a cooperative effort between the CDFA and the Shasta County Department of Agriculture. The Shasta Project began in 1985 after the dioecious form of hydrilla was detected in seven ponds located next to the Sacramento River. Due to the close proximity of the river and the potential threat to California water ways, the Governor of California issued a "Proclamation of Emergency" to empower eradication efforts. Surveyors in 1986 detected hydrilla in four additional ponds. The CDFA convened a Scientific Advisory Panel in 1986, which recommended a survey, treatment and public education program (Stocker, R.K. and L.W.J. Anderson *et. al.* 1986). Based on these recommendations, Shasta Project crews chemically treated and filled in with soil 4 of the 11 ponds. Shasta Project biologists also treated the remaining seven ponds with herbicides for several years. By 2000, surveys showed that no hydrilla plants were detected in the 11 ponds and the CDFA considers hydrilla to be eradicated at these locations.

However, in 1994, a new infestation was detected in two interconnected ponds in River Park in Anderson, about eight miles south of Redding, and in 1996 hydrilla was detected in a pond system at the Riverview Golf Course in Redding (Plate 19). These infestations appear to be unrelated to the previous ones. The Shasta Project initiated a treatment program of aquatic herbicides and manual removal.

Survey and Treatment in the Anderson River Park Ponds

The Shasta Project crew detected no hydrilla in the two Anderson River Park Ponds from 1999 to 2004 but in 2005, hydrilla returned to one of the ponds. The ponds were surveyed and treated with fluridone in 1999, 2000 and 2001, and were surveyed but not treated, in 2002, 2003 and 2004, as per the eradication protocol. In addition to surveys from shore and canoe in 2002 and 2004, the CDFA contracted a crew of divers from the Shasta County Sheriff's group to survey the large pond. No survey found any plants. In 2004, the ponds were surveyed 10 times between May 17 and October 22. Six weeks prior to the last survey date the Project crew used triclopyr to treat water primrose that was encircling the large pond, to improve visibility and access. The last survey was very intense, and employed a crew in a canoe and a crew of divers. The crew in the canoe surveyed the entire pond by visual inspection and by repeatedly dragging the grappling hook. The divers focused on previously infested areas of the pond, where hydrilla was last detected in 1999. No survey detected any hydrilla.

Following the 2004 surveys, the Shasta County Department of Agriculture and the Hydrilla Eradication Program declared the infestation as eradicated in early 2005. Even though the infestation was declared eradicated, CDFA crews generally continue to occasionally visit

previously infested ponds, with decreasing intensity as time passes without finding plants. Unfortunately, in the last week of July 2005, three plants were found in the pond, again demonstrating hydrilla's capacity for surprises. The plants were dredged and the whole pond was treated three times with fluridone, each time to achieve a concentration of 30 ppb.

The re-appearance of plants in 2005 re-initiated the complete eradication cycle. The hydrilla crew surveyed the ponds 17 times in 2006, and plants continued to emerge. The first survey was on May 31 and the last was on November 15. The first finds were five plants on May 31. The crew found two more plants in June, 11 plants in July, 12 in the first two weeks of August, and over 100 plants on August 22. The last find, a single plant, was on September 8. In total, approximately 130 plants appeared in 2006.

The crews treated the infested pond in 2006 with hand digging, dredging and herbicides. Between June 2 and August 11, the crews dug and dredged a total of 26 plants. The Program delayed fluridone treatments in 2006 to give the plants an opportunity to appear because fluridone lasts several months and will mask infestations. The first treatment occurred on August 25, just after the plants made their major flush. Four treatments were made at two-week intervals with fluridone slow release pellets. The first treatment was at 50 ppb, and the remaining three were each at 30 ppb, giving a total rate of 140 ppb and using 25.9 pounds of active ingredient. On August 23, prior to the first fluridone treatment, the crew treated the part of the pond that had plants with 2.6 pounds active ingredient of copper ethylenediamine complex (Komeen), at 1 ppm. This treatment removes the top growth of all aquatic vegetation, which allows more fluridone to remain and attack newly emerging hydrilla.

No hydrilla appeared in the Anderson Ponds during 2007 through 2010, and none appeared in 2011. The crews surveyed the ponds 13 times in 2007, nine times in 2008, three times in 2009, twice in 2010, and two times in 2011. The surveys this year were fairly intense, spending a full day each time surveying the ponds. The first survey in 2011 was on July 14 and the last survey was on August 25. Other aquatic plants noted were egeria, coontail, water primrose, parrotsfeather, and curlyleaf pondweed.

Because hydrilla made a strong appearance in 2006, treatments started earlier in the years since. In 2011, the crew treated the hydrilla with Sonar SRP on July 15 and August 26 at 50 ppb of fluridone each time. The treatments used a total of 512 pounds of Sonar SRP, representing 25.6 pounds of fluridone. No copper was used this year. Crews also used some triclopyr and diquat to treat obstructing vegetation. The main target was water primrose.

Plate 19. Map of Infestation at Riverview Golf Course, Redding.

Survey of Riverview Golf Course Ponds

The Riverview Golf Course infestation consists of four interconnected ponds (Plate 19). The pond farthest upstream is approximately 30 acres in size and is adjacent to but outside the golf course. Project personnel refer to it as "Rother's Pond." It is fed by a small canal from the Sacramento River. The next three ponds are on the golf course, and, heading downstream, are approximately six, two and one acres in area. Water returns to the Sacramento River by a small stream from the one-acre pond. The one-acre pond and return stream often go partially or completely dry in the late summer. When Shasta Project crews first surveyed these ponds in 1996, they found the 30-acre pond to be infested in the lower 15 acres, where the infestation ranged from scattered single plants to small clumps. The six-acre pond was moderately to heavily infested, and the two small ponds were heavily infested.

The crew found 12 plants in 2005 in Rother's Pond and three in 2006, but there were no plants in 2007, 2008, 2009 or 2010 (Table 7). There were 11 surveys of Rother's Pond in 2009. In 2010, the crew inspected Rother's Pond 10 times.

The crew surveyed the ponds twice in 2011. The surveys this year were fairly intense, spending a full day each time surveying the ponds. The first survey in 2011 was on July 12 when the

water temperature was 18.9 degrees C (66 degrees F) and the last survey was on August 23 when the water temperature was 22.2 degrees C (72 degrees F). Other aquatic plants noted were egeria, coontail, water primrose, parrotsfeather, and curlyleaf pondweed.

No plants have been found in the lower three ponds since 2002.

Other water plants noted during the surveys were elodea, water primrose and cattails.

Table 7. Number of Hydrilla Plants and Tubers Found and Removed from Redding Golf Course Ponds, Shasta County 2000 - 2011

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007-2010	2011
Rother's Pond	Plants	1	9	18*	1	0	12	3	0	0
	Tubers	0	0	0	0	0	0	0	0	0
Riverview Golf Course Ponds 1, 2, 3	Plants	32*	31	10	0	0	0	0	0	0
	Tubers	0	0	75**	0	0	0	0	0	0

*Estimated from narrative descriptions.
**Dredging operation in 2002 in main infested area; no dredging done in other years.

Treatment of Riverview Golf Course Ponds

The treatment strategy for the Riverview ponds was different in 2006 from other years. Rather than beginning treatments early at the beginning of June, they were delayed until late in July. The delay was meant to allow the plants to grow large enough during the early part of the season to let them be found readily. In previous years, the crew treated only the lower, 15-acre originally-infested area. Beginning in 2006, treatments were made to the entire 30-acre pond, but no treatments are made directly to the smaller downstream ponds. The lower three ponds have not had any hydrilla in several years, and, in addition, water sampling shows that fluridone spreads readily to them from Rother's Pond (see 2006 report).

After hydrilla revealed itself in 2006, treatments to Rother's Pond began earlier in the years since. In 2011, the crew made two applications to Rother's Pond of fluridone slow release pellets. Both applications were at 50 ppb, to achieve a total concentration of 100 ppb[24]. Applications occurred on July 13 and August 24. A total of 1052 pounds of Sonar SRP were used, representing 52.6 pounds of fluridone. No copper herbicides were used this year.

Starting in late July and for most of the treatment season, the Riverview Golf Course pumped irrigation water from the Sacramento River in order to avoid using fluridone treated water from Rother's Pond[25].

Survey Inside and Outside the Quarantine Zone[26]

[24] Rother's Pond is large enough to qualify for a higher total seasonal application rate (150 ppb) than the smaller ponds (90 ppb), as per the Sonar® SRP label.
[25] In 1996, the golf course superintendent was concerned that fluridone treated irrigation water might injure the turf or ornamentals on the course. For this reason, Rother's Pond was not treated with fluridone in 1996 in order to avoid any possibility of phytotoxicity. The golf club developed an alternate water source in 1997, and fluridone has been applied to the pond since 1997.
[26] Hydrilla infested counties are "Eradication areas" by California Code of Regulations, Section 3962. "Quarantine zones" are reduced areas within "Eradication areas" and are the specific water bodies in the county where there are restrictions as to water access or use, as per California Code of Regulations, Section 3410.

Because of budget constraints, the seasonal crew was eliminated at the Redding office in 2009. No general detection surveys were done. In the recent past, 200 to 300 ponds and stream sites were checked each year.

TULARE COUNTY *(Lead: Florence Maly)*

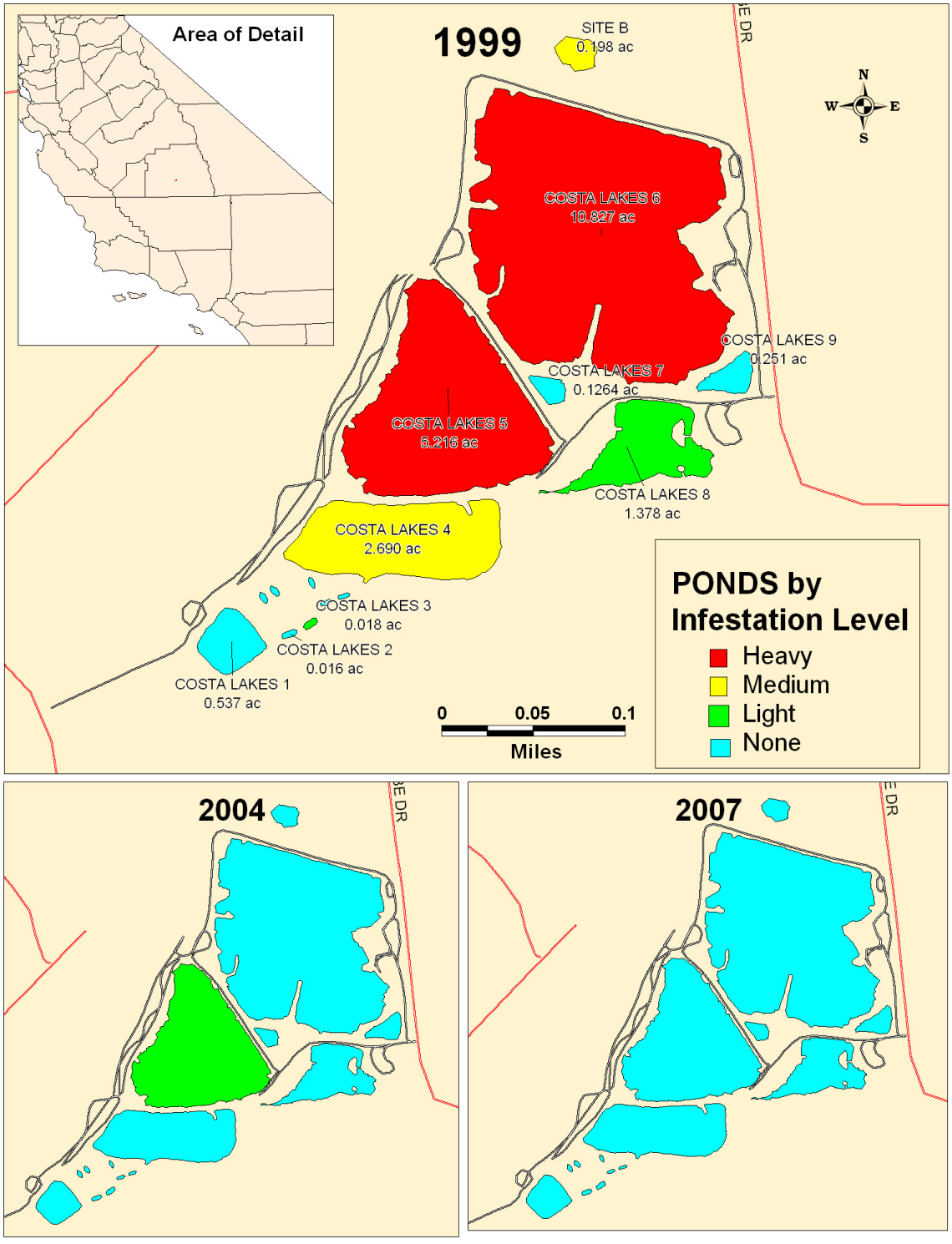
There have been two separate infestations of hydrilla in Tulare County. In 1993, a biologist for the Tulare County Department of Agriculture detected monoecious hydrilla in three small ponds that belonged to an ornamental wholesale nursery near Visalia. The CDFA and Tulare County biologists, with the cooperation of the owner, emptied the ponds to dry out the hydrosoil, and then fumigated with metam-sodium. The ponds were never refilled with water and remain dry to this day. The CDFA crews continued to survey these ponds for several years, but no hydrilla was ever found. The CDFA considers the hydrilla in these ponds to be eradicated.

On October 7, 1996, a second infestation appeared in a fishing resort southwest of Springville and east of Porterville. The Tulare County Hydrilla Eradication Project (Tulare Project), which is a cooperative effort between the CDFA and the Tulare County Department of Agriculture, began soon thereafter. This resort is adjacent to the Tule River and is approximately two miles upstream from Lake Success[27]. The hydrilla is of the dioecious form.

Delimitation surveys by project crews determined there were five infested ponds on the resort and one infested pond on an adjacent downstream property. The infested ponds ranged in size from 0.02 acres to 10.8 acres with a total surface area of 20 acres (Plate 20). The infestations in the ponds ranged from very dense to just a few scattered plants. Four other non-infested ponds were also on the resort. Additional ponds have been created since the initial hydrilla detection. Most of these are relatively small (less than 0.1 acre) and the owners use them for fish breeding. There are now a total of 15 ponds.

[27] Lake Success is a 2,450-acre reservoir managed by the USACE and is used primarily for flood control and agricultural purposes, although it is also popular for recreation.

Plate 20. Map Showing Change in Hydrilla Infestation at the Springville Ponds from the Year of First Detection, 1996, to Current Year, 2011



Survey and Treatment of the Springville Ponds

Project crews surveyed all 15 ponds on the resort property and the one infested pond off the property between four to eight times in 2006, five to six times in 2007, three to five times in 2008, four to five times in 2009, three to four times in 2010, and three to five times in 2011. In 2011, the first survey was April 12, when the water temperature was about 17.2 degrees Celsius (63 degrees Farenheit). The last survey was on December 13, when the water temperature was about 6.7 degrees Celsius (44 degrees Farenheit). Originally, in 1996, there were five infested ponds; by 2004, the only pond that had any hydrilla was number five, where 10 mats were found (Plate 12, Table 8). In 2005, nine surveys in that pond detected no hydrilla, and neither did eight surveys in 2006, six in 2007, five in 2008 and 2009, four in 2010, or five in 2011. Because of high turbidity and algal blooms in the ponds, the water visibility is often poor. Crew members have developed a technique of cruising the pond while sitting on a kayak with a survey hook tied to one leg. Using this method, they can repeatedly cover the pond, stop quickly when they feel any resistance, and carefully tug on the obstruction. Because of their technique and the soft bottom of the ponds, they can often bring up a plant with its root crown intact. Other aquatic vegetation detected in these ponds included elodea, curly leaf and small leaf pondweeds, chara, azolla, water primrose, duckweed, naiads, nitella, cattails and algae.

Table 8. Number of Rooted Hydrilla Plants and Tubers Found and Removed from the Springville Ponds, Tulare County 2000 – 2011

YEAR	2000	2001	2002	2003	2004	2005-10	2011
Mats	0	0	0	0	10*	0	**0**
Plants	9**	37***	0	0	0	0	**0**
Tubers	1,749***	243***	0	0	0	0	**0**

*Pond 5 only.
**Ponds 5 and 6.
***Pond 6 only.

Since the project began, the eradication treatments have included hand removal of plants, copper and fluridone herbicides and small-scale dredging of tubers. In 2008, Pond 5 was treated twice with Sonar SRP for a total concentration of 70 ppb. Since 2011 was the seventh year with no plants, no herbicide was applied this year.

YUBA COUNTY *(Lead: Jonathan Heintz)*

Yuba County has had three distinct hydrilla infestations: Lake Ellis, Shakey's Pond and Oregon House. The first two infestations were considered eradicated. The first hydrilla infestation in California was in Lake Ellis, a 31-acre ornamental lake in the center of Marysville. Dioecious hydrilla was found there in 1976. In 1979, Program personnel drew down the lake, removed the hydrosoil and treated the infested areas with metam-sodium (Vapam). Six plants re-appeared in 1980 in one small location. The biologists then treated the entire lake with endothall and copper ethylenediamine complex, with special attention paid to the infested location. By 1981, the lake was free of hydrilla and eradication was declared in 1984. The second infestation in Yuba County was discovered in 1990 in Shakey's Pond. It may have become infested as a result of hand carrying infested material to it from Lake Ellis in the 1970's, or as a contaminant in a planting of bass from Florida. Hand removal and aquatic herbicide treatments reduced the number of plants in the pond until only one plant was found in 1996,

when the pond received three treatments of fluridone. No plants were found in the pond after 1996, and this infestation was also considered eradicated after 2002. That status continued until 2007, when a follow-up inspection found hydrilla in the pond. More details will follow the discussion of the Oregon House infestation.

Oregon House: The On-Going Eradication Project

On August 7, 1997, a third infestation of hydrilla appeared in Yuba County near Oregon House (Plate 21), about halfway between Marysville and Grass Valley, north of Highway 20. A visitor to a local winery suspected that hydrilla was in one of the ponds on the grounds and reported it to the Yuba County Department of Agriculture. Yuba County biologists investigated, found hydrilla and sent a sample to the CDFA Plant Pest Diagnostics Lab for confirmation. Scientists at the United States Department of Agriculture, Agricultural Research Service (USDA-ARS) Exotic and Invasive Weed Unit confirmed it to be the monoecious type.

The Oregon House Hydrilla Eradication Project (Oregon House Project) started after this first detection. The Project is a cooperative effort between the CDFA and the Yuba County Department of Agriculture. Biologists conducted delimitation surveys at the winery and found a total of five infested ponds (ranging from 0.15 to 3.0 acres in size and nine to 13 feet deep) and an infested ornamental fountain[28] (Plate 21). The winery uses two of the ponds, Ditch Pond and Tank Pond, to irrigate the vineyard. Project crews also conducted delimitation surveys within a three-mile quarantine zone and detected additional infestations on three private properties: the Spiers 1, 2, and 3 Ponds (3.8, 0.5, 0.4 acres) and the Clouse and Ronen Ponds (1.9 and 0.1 acres) (Plate 21). The two smaller Spiers Ponds were used for rearing catfish. Another 40 ponds were surveyed and found not to be infested.

In 2000, project survey crews on routine surveys detected three additional infested ponds. These were Reservoir 23 (0.25 surface acres), Davis (0.37 acres) and Citron (0.22 acres) Ponds (Plate 21). Reservoir 23 is also used for irrigation at the winery. In 2003, surveys detected a single hydrilla plant in Spiers Pond number 5. Project staff had surveyed this pond multiple times per year since the beginning of the project. A plant fragment probably floated down to it from Spiers Pond number 1, via a small creek. In 2007, the Project biologist discovered a new pond (named Cornejo) in the area that had been dug recently. It proved to be infested.

Although hydrilla was first found in a pond, they are all are downstream of and fed by an infested canal (see below). Final eradication of the hydrilla in the ponds is not possible as long as the canal remains infested and can provide plant fragments to re-infest them. Therefore, the strategy has been to keep the populations in the ponds suppressed and under surveillance, but to not push all out for eradication, until the infestation in the canal has been destroyed.

2011 Surveys of Ponds within the Quarantine Zone

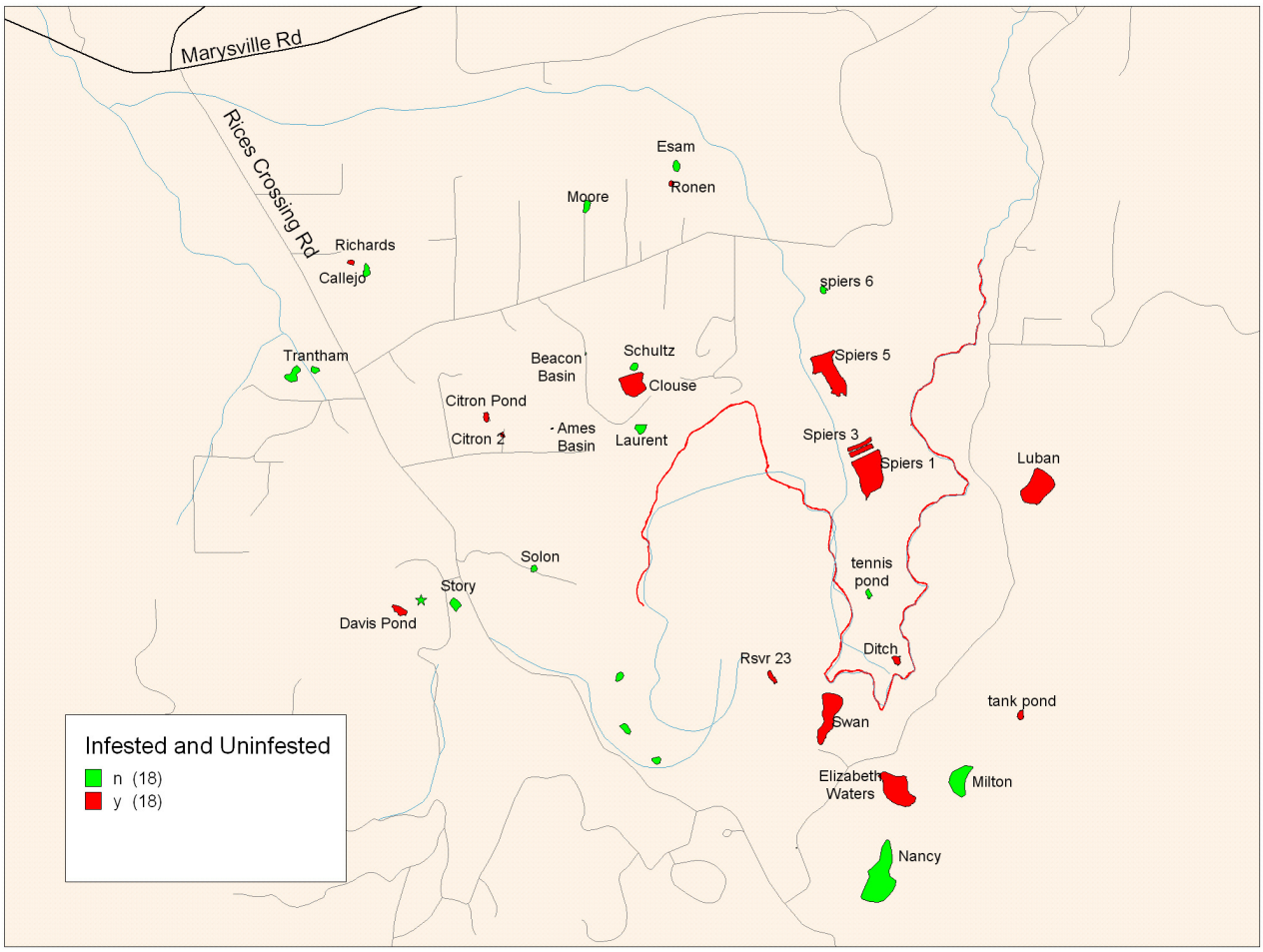
Project staff visited most ponds three or four times in 2011, focusing on ponds that have had hydrilla in recent years. Visits were made at monthly intervals in June, July, August and September.

Of the three ponds used for irrigation Ditch and Reservoir 23 had no hydrilla this year. Hydrilla

[28] The infested water lilies in the ornamental fountain were removed, the hydrilla plants and tubers destroyed, and the water lilies repotted and returned.

was found in Tank Pond in August. Other aquatic vegetation noted during the surveys included coontail, egeria, Eurasian watermilfoil, and two forms of algae, nitella (Nitella species) and chara (Chara species).

Plate 21. Hydrilla Infested Ponds near Oregon House, and Hydrilla Infested Portion of Yuba County Water District Canal



Of the 11 ponds not used for irrigation, no hydrilla was detected in any of them in 2011 as opposed to one (Luban pond) in 2010 (Table 9). Each pond has its own hydrilla history. In 2006, Citron Pond was heavily infested by mid season, and produced plants in each of the following year. However, the pond was lined in 2010 and produced no plants either that year or in 2011. Clouse Pond, which had over 50 plants in 2006, has been free of hydrilla for the last five years. Davis Pond has been clear after producing a few plants in 2006. Two ponds, Elizabeth and Swan, had not produced any plants for at least six years (Table 9) as of 2007. Intensive surveys in 2008 turned up a single plant in Swan but found none in Elizabeth. No plants have been found in either pond since 2008, including 2011. The four Spiers ponds have been free of hydrilla for the last four years, as well as small Ronen pond. One big recent surprise was in 2007 in Luban Pond. It had been free of hydrilla for three years, but in 2007 at least one-third of the pond was very heavily covered by plants. Since the pond is isolated, the

crew has been trying experimental treatments, occasionally using copper and fluridone if the population became too persistent. In 2009 less than 50 plants were sighted during the growing season, in 2010 only a handful of plants were found, and no plants were found in 2011.

Table 9. Presence (+) or Absence (-) of Hydrilla Plants or Tubers in the Yuba Ponds Near Oregon House, Yuba County 2000 – 2010

Hydrilla Detections (Plants or Tubers) in the Yuba County Ponds

			YEAR											
Pond Type	**Pond Name**	**Pond Size (Acres)**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Irrigation	Ditch	0.2	+	+	+	+	+	+	+	-	+	+	-	-
	Reservoir 23	0.3	+	+	+	+	-	-	+	-	-	+	-	-
	Tank	0.2	+	+	+	+	+	+	-	-	-	-	-	+
Non-Irrigation	Citron	0.2	+	+	+	+	-	+	+ extremely heavy	+ many	+ many, small	+ many, small	- (lined)	-
	Clouse	1.9	-	-	+	+	-	+	+	-	-	-	-	-
	Cornejo									+ new	+	-	-	-
	Davis	0.4	+	-	-	-	-	-	+	-	-	-	-	-
	Elizabeth	3.1	+	-	-	-	-	-	-	-	-	-	-	-
	Luban	3.0	+	-	+	+	-	-	-	+ very heavy	+	+	+	-
	Ronen	0.1	-	dry	dry	+	-	+	+	-	-	-	-	-
	Spiers 1	3.8	+	+	+	+	-	+	+	-	-	-	-	-
	Spiers 2	0.5	-	+	dry	dry	+	-	?*	-	-	-	-	-
	Spiers 3	0.4	-	dry	dry	dry	-	-	?*	-	-	-	-	-
	Spiers 5	3.5	-	-	-	+	-	+	+	-	-	-	-	-
	Swan	2.7	-	-	-	-	-	-	-	-	+	-	-	-

*? = suspicious-looking plants but could not be hooked for confirmation.

Treatment of Ponds within the Quarantine Zone

Water bodies are treated according to the conditions observed in the ponds and management goals. The three irrigation ponds (Reservoir 23, Tank, and Ditch) are only treated with copper, to avoid damage to irrigated plants. Copper is applied only when hydrilla is visible. Tank pond was the only one with plants in 2011, and it was treated once with copper at 1 ppm in late August. None of the other ponds were treated this year. Luban was not treated because it is one of the few places left in California that has had significant densities of hydrilla within the last few years, and there is interest in trying some new herbicides in it that are candidates for being registered in California. Most of the other ponds were not treated because they have not produced any hydrilla for four to five years. Also, with the progress in lining the canal, we are interested to moving towards dredging in the ponds to pick of any straggler plants and associated tubers, and move the ponds to full eradication.

Table 10. Treatments to Water Bodies in the Oregon House Eradication Project, Yuba County, 2011

Water Body	Date Treated	Product	Active Ingredient	Target Concen-tration in Water	Concen-tration Unit	Notes
Citron		na	na			Pond lined 2010
Luban						No treatment
Spiers 1-5						No treatment
Elizabeth						No treatment
Res 23						No treatment
Tank						No treatment
Ditch	August	Komeen	Copper	1	ppm	No treatment
Swan						No treatment
Cornejo						No treatment
Davis						No treatment
Ronen						No treatment
Clouse						No treatment
Shakeys	7/1/08	Sonar SRP	Fluridone	30	ppb	

Several ponds have received special treatments in recent years. The big change in 2010 was in Citron Pond. Project biologists, working with the land owner, decided to line the pond. The Project biologist devoted a large portion of his time that season to lining the pond with a heavy synthetic rubber bottom liner. The liner completely seals the bottom of the pond. No plants were found in the pond in 2011, though Project staff plan to watch it carefully for the next few years. It is possible some hydrilla might emerge at the water's edge or if a tear develops in the liner. However, this action should put an end to the major persistent site of infestation in Oregon House, other than the canal itself.

The Yuba County Water District Canal

While surveying Oregon House in 1997 after finding hydrilla in a winery pond, the Project biologists found that the lowest 3.1 miles of an 18-mile irrigation canal were infested with hydrilla (Plate 21), in the area where it passes through the winery. In addition, two other small basins, which are used to transfer water from the canal, were also found to be infested (Ames (0.01 acres), and Beacon (0.02 acres)). The Yuba County Water District (YCWD) owns the canal and runs water in it between April and October. The canal is the source of hydrilla for all the ponds, thus eradication of the hydrilla in the canal is a requisite for eradication of the hydrilla in the ponds.

From 1997 to 1999, Project biologists tried several treatment methods in the canal, with mixed results. A method to meter copper herbicide into the flowing water proved promising in 2000 and has been used ever since. The method uses electric pumps at three stations, one mile apart along the canal, to apply the herbicide to the water for four hours. The rate of application decreases from station to station to maintain a one-ppm concentration of copper along the canal. Visual observations in 2000 indicated that this method was relatively effective in

controlling the hydrilla top growth. In 2006, the Project Biologist improved the delivery system for the copper herbicide so that the treatment duration could be increased from four hours to 12. Also, in 2000, project biologists started raking[29] and digging tubers in the canal, which has proved effective, though labor intensive and time consuming. In 2001, an acetic acid treatment was tried with promising results (Spencer, D. and G. Ksander, 2001), although the conditions required for treatment are so exacting that the method is not very practicable.

Survey and Treatment of the Yuba Water District Canal

Project biologists have noted a decrease in the number of plants and tubers removed from the canal in the past several years, indicating a continuing decrease in the tuber bank. The crews removed 2,696 tubers and plants in 2005 and 1,175 in 2006, but they found only 170 in 2007, approximately 100 in 2008, and only about 20 plants in 2009. Many of the heavily infested sections of the canal were lined with concrete in 2008 and 2009 (see below), which helped contribute to the few plants found in 2009. All plants were dug out in 2009, so no copper treatments were made that year.

Visits to the canal suffered through the middle part of 2010 because of the effort put into lining Citron pond, so the canal went six to eight weeks without a visit. Visits began September and continued monthly through November, turning up about 20 plants again in 2010. All plants were dug out, with an effort made to find the tubers. In 2011, the canal was surveyed every few weeks from June through September. About 20 plants were again found this year, and were dug as in 2010. The concrete lining of the canal also made significant progress this year (below).

The two transfer basins for the canal also have a history of hydrilla. Plants were detected in Ames in 2003. The irrigation district dug out this basin with a backhoe in 2004 and no plants were found that year. Two plants were found and removed in 2005, but none were found in 2006 and 2007. A few plants appeared in 2008 and 2009, and all were dredged out to remove any tubers. A few plants appeared again in 2010. In 2011 two or three square yards of the basin were found covered with plants and the biologist took care while removing them to not send fragments of hydrilla downstream. The project biologist and the canal company are still considering the best method to line the basin.

The Beacon holding basin is concrete-lined and was cleaned of all sediment and hydrilla by project biologists in January of 2002. No hydrilla has been detected there since.

In addition to hydrilla, project biologists found several other aquatic plants in the canal, including elodea, American pondweed, sago pondweed and cattails. In places, the population levels are quite high, making survey difficult and interfering with treatments. The plants also develop a heavy cover of algae, which complicates survey and treatment.

Lining of the Yuba County Water District Canal

In April 2007, Program staff developed a $100,000 contract to line the most heavily infested section of the canal with concrete, in an attempt to put an end to this infestation. The contract was awarded on March 27, 2008, and provided for lining approximately 3,500 feet of the canal.

[29] The rake method is simply to use a garden rake to sift the sediment in the canal bottom and sides to remove any hydrilla plants, tubers, roots, and root crowns. Screens are placed downstream of the raking operation to catch any floating hydrilla fragments.

Work began on March 31 and finished April 9. The contractor used a custom-designed bucket on a four-wheel-drive backhoe to remove sediment from the canal and contour its profile, then sprayed three to four inches of concrete on the cleaned surface (see 2008 report for photographs). The work was challenging because of access issues, but was very well done.

The canal lining accomplished by the CDFA encouraged the Yuba County Agricultural Commissioner, Louie Mendoza, and his staff to work with the Yuba and Sutter Counties Weed Management Areas (WMA) and the canal company to continue the effort and try to line all of the most heavily infested parts of the canal, a total of about 9000 feet. They organized an effort to line another 1500 feet in April of 2009, with the help of a $20,000 contribution from the Hydrilla Program.

Since then the Agricultural Commissioner's Office and the WMA have continued organizing funds, including contributions from the Hydrilla Program. In 2011 all the different logistic and contract complications were overcome and the group lined 3,665 feet this year. With this effort, all but about 540 feet of the upper infested section of the canal will have been lined, and all the most heavily infested sections have been covered.

Three years after lining the canal in 2008, some stretches of the lined section are developing deposits of soil and organic matter. A few hydrilla plants were noted growing in the deposits, but they were easily removed. Project personnel are working on cleaning the sediments from the lined section.

Shakey's Pond, Survey and Treatment

Dr. Anderson reminded Program staff in late August, 2007, that Shakey's Pond had been infested, although the infestation had been declared eradicated about 2002. When the Oregon House Biologist went to survey the pond, he found small clumps of hydrilla scattered among very dense stands of other aquatic weeds such as egeria. Treatments began in about a week.

The heavy plant biomass originally in the pond would have interfered with the hydrilla taking up fluridone. Accordingly, Project biologists used copper to quickly take down the mass of plants. However, killing too much biomass at one time can cause oxygen depletion and lead to a fish kill. To minimize that possibility, the Biologist treated one-third of the pond at a time. No fish mortality was noted. The copper treatments occurred on September 4, 14 and 21, to reach a concentration of 1 ppm of copper in each treated area. The copper treatments cleaned up the pond very thoroughly, and the biologist applied two treatments of fluridone at 45 ppb during October 2007. Those treatments established the fluridone in the sediments to wait for new plants emerging in 2008.

Water samples taken early in the 2009 treatment season revealed that the pond holds fluridone concentrations well. One treatment of fluridone at 45 ppb was applied in June, 2010, and water tests in spring of 2011 showed there were still effective levels in the pond. No fluridone was added to the pond this year. The pond was surveyed twice in 2010 in June and November and three times in 2011 in July, August, and September. No plants were found either year. The last plants appeared 2009, when three plants were found. They were small and sickly and were removed with tubers attached.

SURVEY ONLY PROJECTS

The Sacramento-San Joaquin River Delta Survey

Each year since the mid-1980s, CDFA personnel have conducted a survey of the Sacramento-San Joaquin River Delta and the lower reaches of the tributary rivers for hydrilla[30]. The annual survey is conducted in September when hydrilla plants would have reached the surface and formed dense mats. The crews also note the presence of other aquatic weeds.

Survey of the Sacramento/San Joaquin River Delta

Staff from the Fresno and Sacramento offices conducted the 2011 Delta Survey during the first three weeks of September. Surveys of larger waterways, such as Old River, Middle River, major canals and many of the major sloughs, were conducted from motorboats. The marinas, launch ramps, and some of the smaller channels and sloughs were surveyed by canoe, kayak or airboats. Smaller watercraft allowed the crews to get closer to shore and boat slips, resulting in a more thorough survey. No hydrilla was found.

The following waterways were surveyed:
Old River southeast of River's End Marina to rock dam, Fabian and Bell Canal, Grantline Canal, Old River from Frank's Tract to Grant Line/Fabian Bell Canals, Widows Island, Quin's Island, North Canal, Middle River from Connection Slough to Victoria /North Canals, North Canal, North Victoria Canal, Woodward Canal, Indian Slough, Orwood Cut, Railroad Cut, Smith Canal, Calaveras River to I-5, Empire Cut, Turner Cut, Fourteenmile Slough, Latham Slough, part of Connection Slough, Deep Water Channel from Disappointment Slough to end at Port of Stockton, part of the Deep Water Channel to Mandeville Cut, Sand Mountain Slough to Emerald Pointe Marina, Hog I Cut, Old River/Holland Cut between Holland Riverside Marina and Sand Mound Slough, Holland Cut, part of Columbia Cut, Ward Cut, Tinsley Island, Bear Creek, Pixley Slough, Disappointment Slough, Honker Cut, Bishop Cut, White's Slough, Potato Slough, South Mokelumne River between Tower Park Marina and Mokelumne City, North Mokelumne River, and Georgiana Slough.

Marinas and launch ramps:
King Island Resort, Honker Cut Marina, Herman & Helen's Marina, Tower Park, Westgate Landing, Oxbow Marina, B & W Resort, Perry's Boat Harbor, Owl Harbor, Bruno's Island Resort*, Rainbow/River's Edge, Delta Bay Club Resort, Spindrift Marina, Easy C's Marina, Happy Harbor, Lighthouse Resort, Willow Berm Marina, Riverboat Marina, Korth's Pirate Lair Marina, Sam's Marina, Sunset Harbor, Vieira's Resort, Cliff House, Duck Island RV Park, Brannon Island State Park boat ramps, swim beach, and fishing pier, Seven Mile Slough, berthing area, Mossdale Crossing ramp, and Dos Reis County Park.

Aquatic Plants Seen:
Algae, American pondweed, azolla, cabomba, coontail, curly leaf pondweed, duckweed, egeria, water hyacinth, watermilfoil, parrotfeather, water pennywort, water primrose, sago pondweed, small leaf pondweed, South American spongeplant, cattails, tules.

[30]The Delta carries 47 percent of all the runoff water in the state. It provides water for residential, industrial, and agricultural uses in both the north and south state areas. The Delta supports approximately 120 fish species, approximately 750 plant and animal species, and is the largest wetland habitat in the western United States (CALFED Bay-Delta Program 2001). The annual survey of the Delta was partially initiated in response to recommendations made by the Scientific Advisory Panel convened in 1988 to consider the hydrilla infestation in Calaveras County (Stocker, R.K. and L.W.J. Anderson *et. al.* 1988).

SOUTH AMERICAN SPONGEPLANT (*leads Patrick Akers, Ed Finley and Florence Maly*)

The CDFA occasionally gives the Hydrilla Program responsibility for other newly introduced, invasive aquatic weeds. One recent example is giant salvinia, which has been eradicated from within the state. Similarly, beginning in about 2004, the Hydrilla Program began work on South American spongeplant (*Limnobium laevigatum*). This species behaves much like water hyacinth or giant salvinia except it reproduces heavily from seed, as well as producing new plants by budding. Until 2007 the effort was quite small. Spongeplant was limited to one small pond in the Redding area where it responded well to treatment. Over the last four seasons, however, new, separate infestations started appearing in waterways and spreading in several parts of the Central Valley, particularly the San Joaquin Valley. The increasing problems warrant including the plant in this report.

Spongeplant could very well present a threat to California much like water hyacinth. However, it seems to spread much more easily in canals and other water infrastructure than hyacinth, so it may become a more widespread and persistent problem. Nonetheless, hydrilla is the Program's priority, and the increasing number of infested sites is straining the Program's ability to address the new pest.

South American spongeplant presents something of a paradox as far as eradication is concerned. On the one hand, in any one location, even small crews can make significant progress and reduce populations to very low levels, even over long stretches of water. If an infestation is caught early, before the plants set many seeds, often plants never come back after an area is thoroughly cleaned. On the other hand, the plant seems to be leapfrogging about, appearing in locations that have apparently minor connections. Its small, abundant seedlings seem to move much more easily than water hyacinth. Also, once a location has been heavily infested and the plants have set seeds, infestations take a long time to kill out, as the seed bank appears to last at least four years. As a result, sometimes the situation looks very hopeful, other times it looks fairly hopeless, and the outlook can change in a few days' time.

Infestations by water system name and detection year:

2007 San Joaquin River
2007 Salt Slough
2008 Cameron Slough/Byrd Slough
2008 San Luis Canal Company/Henry Miller Reclamation District
2008 Central California Irrigation District
2010 North Grasslands Water District
2010 Grasslands Water District
2010 Patterson Irrigation District
2011 San Luis National Wildlife Refuge

San Joaquin River
South American spongeplant was first confirmed in the San Joaquin Valley in August 2007 in the San Joaquin River in Fresno. Program crews initiated delimitation surveys and found plants in patches of various sizes and stages of development, in ponded and slow moving stretches of the river, starting approximately three miles upstream of Highway 41 and stretching downstream to Highway 145, a distance of around 20 miles. Up to 60 miles of river are usually dry below Highway 145. During the 2007 season, CDFA crews identified the upstream limit of the

infestation and hand removed approximately 90 percent of the biomass from there downstream to Highway 99, a distance of about 11 miles. Work continued in 2008, 2009, and 2010, with plant removal continuing down to Highway 145, again removing at least 95 percent of the biomass. In summer of 2009 water flows increased from Friant Dam into the San Joaquin, marking the start of an attempt to restore salmon to the river. The first releases for the restoration project pushed the flow up to a high of 2000 cfs for a brief time. Previously, releases ranged between less than 100 cfs to approximately 350 cfs. The increased flows perhaps pushed spongeplant further downstream, but it also left plants high and dry when the water receded, effectively killing them.

In January 2011 there was a large release of water (over 6000 cfs for a couple of days) which caused major flooding of previously dry areas. The river flow did not decrease to a safe level for survey activities until August. We feared finding large numbers of plants, both in the original channels and in newly created channels as well. This was not the case. While the main river channel had changed in some places, there were no new large ponded areas. Further, there were no large mats of plants. In the river channel proper, plant numbers were so low they could be counted individually. The crew removed approximately 3900 plants from the channel. Five isolated ponds accounted for approximately 15,000 plants. Numbers above about 100 are visual estimates, but the crew members are now highly experienced with different densities of plants. No plants were found downstream of Hwy. 99 to Modoc Ave. This was the farthest downstream point we could survey because in early November the water release from Friant Dam was greatly reduced and the river went dry somewhere west of Modoc Ave. The crew checked the river bed from San Mateo Ave. up to the Chowchilla Bypass, where the water was in small pools; no spongeplant was seen.

Kings River area east of Fresno

Spongeplant was discovered in January 2008 in a small canal (Cameron Slough) arising from the Kings River east of Sanger in Fresno County. Delimitation surveys discovered the source pond (about 0.1 acres) and determined that the infestation covered only approximately two miles of Cameron and a short distance of an associated canal, Byrd Slough. The source pond was also cleaned out in February 2008. Since that time, seedlings have been removed shortly after germination, stopping any new seed formation. Very few seedlings are being found as of February 2011. The pond outflow is also screened, which catches most seedlings before they can enter the canal. In the canal, six weeks of intensive hand removal in winter 2008 reduced the biomass by 90 percent, and by 98 percent by the end of the year. Eradication efforts continued through 2009 and 2010. Very few plants were detected in the last survey of 2010. Spongeplant was never found in the Kings River itself.

Hydrilla Program personnel pumped mud out of the bottom of the source pond in October, 2011. The pumping probably removed thousands of seeds and seedlings. Its effectiveness was demonstrated by the decrease in the appearance of seedlings. After the pumping less than 100 seedlings were removed before the end of the year. Prior to the pumping we were removing about 500 seedlings every 3 weeks.

In Cameron Slough itself, high water flows kept crews out until November. Several “hot spots” were located and cleaned out. Plant numbers totaled 1000 at most.

San Luis Canal Company/Henry Miller Reclamation District

An infestation covering a few hundred feet was discovered in a small end canal in June 2008. By the end of July this infestation was eradicated, with no return of plants. In 2010 additional infestations were found in other canals and drains in the system. Further delimitation survey is

required to find the extent of the infestation. An infestation found in Salt Slough in 2007 may have come from the SLCC/HMRD system, which is upstream of the Slough.

Extensive survey and mapping of the district occurred in 2011. A few relatively small infestations were found. The district did not allow the Program crew to remove the plants, for fear of liability. However, the district did increase their spraying and dredging activities and were able to reduce these infestations.

Central California Irrigation District and related waterways
In November 2008, CDFA was notified of yet another infestation, this time in northwestern Fresno and southwestern Merced Counties between Mendota and Dos Palos, in canals and drains of the Central California Irrigation District (CCID). This large water system extends over three counties (Fresno, Merced and Stanislaus) and its Main Canal runs for approximately 76 miles between Mendota Pool and Crows Landing. Many scattered plants and limited spot infestations were eliminated in a number of these canals, usually within two to three months of the find. Major portions of Main Canal have been dredged by the CCID, removing plants and, hopefully, seeds.

Infestation levels in 2011 were less than 30 percent of that seen in 2010. The Irrigation district dredged more canals and drains, and sprayed plants were the CDFA crews could not hand remove them.

The CCID canals are the likely source of infestations discovered in 2010 in the Grasslands Water District and the North Grasslands Wildlife Area canals. With these discoveries, spongeplant has now been found well north of Los Banos.

Patterson Irrigation District
In October 2010 a small infestation was discovered in the central canal of the Patterson Irrigation District system. PID personnel reported that they eliminated all the plants by the end of 2010. A quick survey of the infested area in March 2012 did not find any plants.

San Luis National Wildlife Refuge
This infestation was discovered in July 2011. Two canals and a large marsh were heavily infested. By year's end, all plants had been removed by the CDFA crew and Refuge personnel. Plants were too numerous to count but the estimates are that several tons of biomass were removed.

Grasslands Water District:
The Irrigation District attempted to bring this infestation under control on their own, but the spongeplant grew so fast that their spray program could not keep up with it. The Hydrilla crew removed square yards of plants to bring the infestation to a point where the district could manage it.

Cebro Drain:
The drain is a farmer's small side channel located adjacent to the CCID Main Canal. The owner committed to spraying every two weeks and the Program crew placed some booms to keep plants out of the Main Canal. However, at year's end there were still many small plants. The crew will have to look at hand removal this spring.

Sacramento Delta

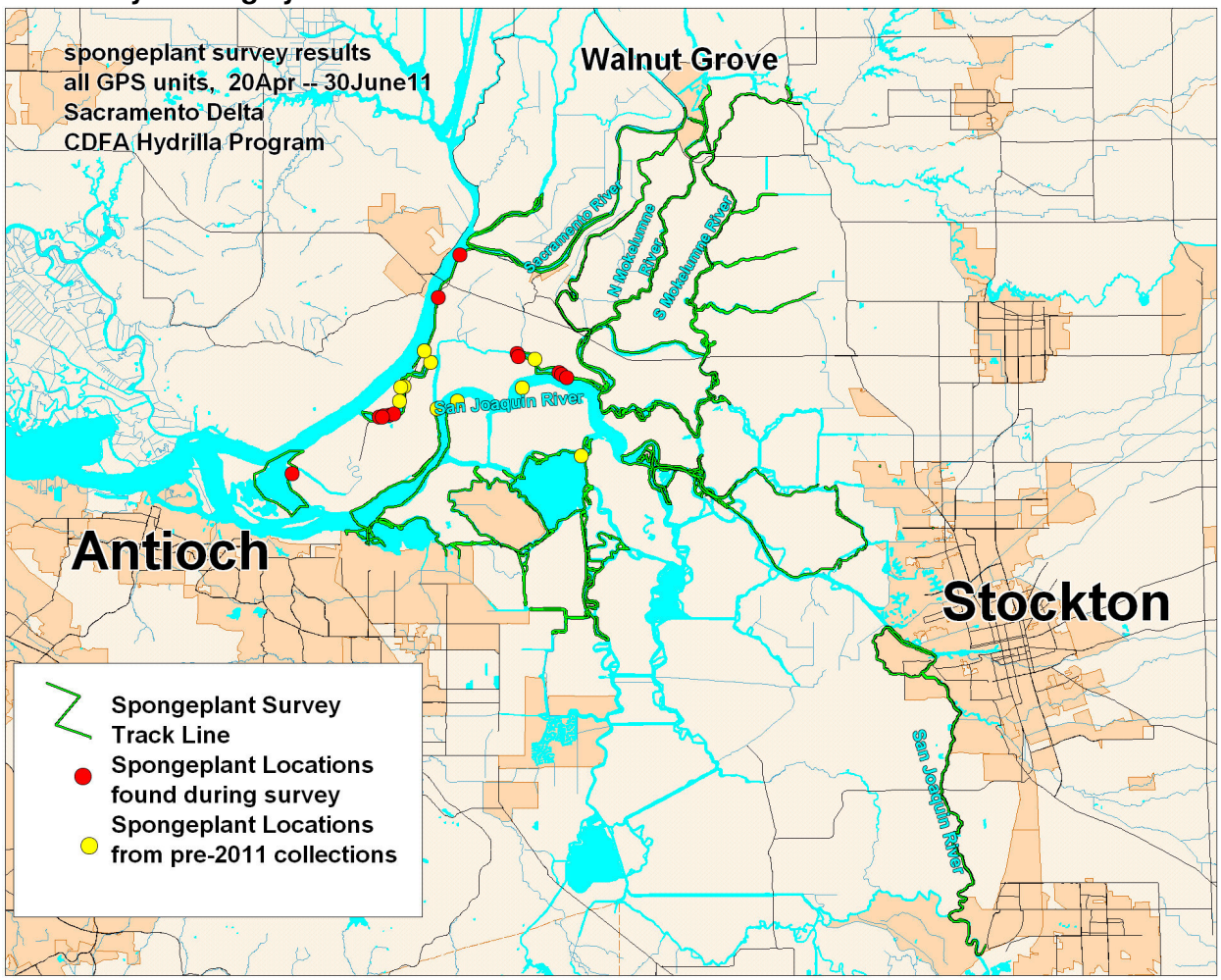
In late December 2007, a patch of spongeplant was reported along the east edge of Decker Island, on the Sacramento River near Rio Vista. That patch appeared to disappear when a major winter storm hit a few days after the report. However, in 2009 spongeplant re-appeared in that location. Since then, staff members from the Hydrilla Program and the Department of Boating and Waterways have found spongeplant spreading slowly to the east and south. Unfortunately, no crews are available nearby that can focus on attacking it.

In 2011, the CDFA Emergency Fund provided the Hydrilla Program about $50,000 to work on spongeplant in the Delta and extend surveys for it. In late April through early June, Program crews spent several weeks there, surveying for the plant and carrying out some preliminary removals to see if such work was feasible.

Previous reports of spongeplant had placed it near and around Brannan Island, stretching from Decker Island to the east end of Seven-Mile Slough. However, no systematic survey had taken place. The CDFA undertook to survey the extent of the infestation in 2011. The strategy was to start in the area where spongeplant had been spotted and radiate out away from there along all the connected waterways, working toward the north, east, and south (Plate 22). The crew also checked along the San Joaquin River as it enters the Delta, on the theory that plants from farther upstream near Fresno or in the Westside canals could have made it down, particularly with the recent higher flows. These surveys were carried out in airboats and other craft (surface drive) that could get close to and into the tule and emergent plant mats, allowing a thorough search for the spongeplant.

The survey showed that the infestation remains limited essentially to the area where it was already known (Plate 22). There were a couple of new infested locations found upstream along the Sacramento above where it had been known before, but even these spots were relatively nearby. Neither was there any sign of the spongeplant coming down the San Joaquin. Accordingly, the infestation still seems to be relatively small and isolated.

Plate 22: Results from survey for spongeplant in the Delta, showing waterways searched, historical finds (before 2011), and finds during survey. Note that the finds made during the survey are largely in the same area as the historical finds.



The crews also attacked several spongeplant mats along Decker Island. This work was prompted by the fact that the heavy infestation there had been devastated during the winter of 2010-11, probably by the high flows and cold temperatures of that winter. There were only three locations found that had many plants, and the largest mat was probably only 50 by 100 feet. Populations appeared to have been decreased by at least 90 percent, and we wished to take advantage of this opportunity. By late May, the crew had removed nearly everything that could be found, leaving only a few broken, widely scattered plants. The removal apparently had some effect, because it was very difficult to find any plants during a visit to the island in late January 2012.

SUMMARY AND CONCLUSIONS

In 2011 the CDFA Hydrilla Eradication Program continued the momentum towards achieving eradication in the two largest and most challenging projects, Clear Lake and Oregon House. In Clear Lake, only 6 plants were found this season, a 97 percent reduction from the challenging

season of 2008. Even better, only two of the plants were outside established treatment areas, so only 10 acres were newly brought under treatment this year. This is also a 97 percent reduction from the 325 acres that were brought under treatment in 2008. The results this year continue and improve on the trend started in 2009, increasing the probability that the pattern is real and not just a random fluctuation. With the leveling off in treatment areas, there is reason to hope that the project will remain within the budget available to the Hydrilla Program. With lining of another 3700 feet of the Oregon House canal in 2011, that infestation should also begin a clear trend towards complete eradication.

The Eastman / Chowchilla infestation has been formally declared eradicated and three of the other infestations are approaching eradication. No plants were detected for the last seven years in Calaveras County in Bear Creek and the stock ponds near Mokelumne Hill, or in the Tulare County fishing ponds. No plants have been found for five years in Shasta County, and those two infestations are moving to the survey-only phase. Two of the Nevada County ponds have also been clear of plants for at least five years and may move off treatment. Only two infested drains remain in Imperial County.

While all the eradication projects made progress this year, the effort to survey for new hydrilla introductions has suffered some in the past four years, especially north of the Delta. This is due to the demands of Clear Lake, which led to the loss of the seasonal crew in Redding and the Clear Lake crew focusing all its efforts on the lake, with no time for detection surveys. In the Delta and San Joaquin, survey continues at a good pace, much of it in conjunction with work on spongeplant. CDFA and county biologists continue to survey the critical Sacramento / San Joaquin River Delta. Once again, CDFA survey crews detected no hydrilla plants in the Delta in 2011.

The CDFA Hydrilla Eradication Program has been a cooperative effort since the first discovery of hydrilla in Lake Ellis in Marysville in 1976. The Governor, Legislature and the CDFA recognized the threat hydrilla posed for the State of California and quickly instituted the legal framework needed to eradicate this noxious weed. With the support of many cooperators, the CDFA Hydrilla Eradication Program has been successfully conducting survey, eradication and public education efforts ever since.

In conclusion, the CDFA's Hydrilla Eradication Program is helping to protect California's waterways by keeping them free of an especially invasive, noxious, aquatic weed. Continued diligence in survey and public outreach, and rapid response to any new detection, are keys to the success of this effort. The CDFA Hydrilla Eradication Program would like to thank its supporters and cooperators for aiding in its success.

COOPERATORS

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