



California Society for Ecological Restoration Quarterly Newsletter Summer Volume 26, Issue 2

# Collaboration, Implementation, and Practice: *Highlights from SERCAL 2016 in Tahoe*

by Allegra Bukojemsky, Wildlands

As a first time newsletter compiler I had big thoughts as to possible articles and themes, then I attended our conference and was again reminded of why I truly value and enjoy SERCAL — for the focus on implementation and practice, and especially how our members openly share and discuss so much of the nitty gritty. While it is wonderful to see pretty pictures of successful projects, the challenges, pitfalls, experiments, and related research are often what inform us most. In our work we are often faced with challenges and unknowns, some of which are of vitally important for the restoration community to address sooner rather than later. While I opted to attend a field trip instead of the panel discussion on *Phytophthora*, this and the *Fusarium* dieback was the topic of many casual discussions during the conference. And of course, there is the constant discussion about technology. Just keeping up can sometimes be tricky, but the quickly evolving applications are exciting. With presentations touching on the possibilities of automated image analysis with GIS, the use of drones, and more, I thought a summary would be useful. Thank you to our authors, conference presenters, and attendees for continuing the to share your knowledge. *Enjoy!*



What a backdrop for SERCAL 2016! Close to 200 people attended this year's conference, enjoying two days of presentations and plenty of time for interesting discussions with long-time and potential colleagues. *Photo courtesy Cindy Thompson.*

*This issue was compiled by Region 4 Director, Allegra Bukojemsky.*

*Ecesis* is published quarterly by the California Society for Ecological Restoration, a nonprofit corporation, as a service to its members. Newsletter contributions of all types are welcome and may be submitted to any of the regional directors (see page 14).

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left Monterey County restoration site inadvertently planted with *P. tentaculata*-infected plants. Further investigation revealed other *Phytophthora* species and root knot nematode. Photo courtesy Kathy Kosta, CA Department of Food and Agriculture.

right Outplanted sticky monkey flower (*Diplacus aurantiacus*) infected with *Phytophthora tentaculata* in a restoration planting in Alameda Co. After the pathogen was diagnosed, the infected plant and others were cut at the ground line and soil solarized to sanitize the area. Photo courtesy Tedmund Swiecki, Phytosphere Research.

# Nursery Plants as a Pathway for Plant Pathogen Invasion

*Precautions are needed to protect our restoration investments*

by Susan J. Frankel<sup>1</sup>, Kathy Kosta<sup>2</sup>, and Karen Suslow<sup>3</sup>

Over the past several years, numerous species of the pathogen *Phytophthora* (pronounced Fie-TOF-ther-uh) — notorious agricultural, horticultural, and forest plant pathogens — have been detected in California native plant nurseries and restoration sites. For example, the sudden oak death pathogen (*P. ramorum*), introduced to California on ornamental nursery stock, has killed millions of tanoak (*Notholithocarpus densiflorus*) and coast live oak (*Quercus agrifolia*) along the California coast over the past two decades. *P. infestans*, cause of the Irish potato famine, continues to hinder potato and tomato production.

Of particular concern is *Phytophthora tentaculata* — a species that had never been found in the US prior to 2012 — which has been detected in eight California native plant nurseries and on outplanted nursery stock in four restoration areas. To date, *P. tentaculata* has been identified on several species of California native plants, with sticky monkey flower (*Diplacus aurantiacus*) observed as the most susceptible (Table 1). *P. tentaculata*'s complete host range is not yet completely known.

*continued next page*

**Table 1.** *Phytophthora tentaculata* has been isolated from approximately a dozen California native plant species in native plant nurseries or restoration areas.

- Artemisia douglasiana* (Asteraceae) — California mugwort
- Artemisia dracuncululus* (Asteraceae) — Tarragon
- Artemisia californica* (Asteraceae) — California sagebrush
- Artemisia palmeri* (Asteraceae) — San Diego sagewort
- Ceanothus cuneatus* (Rhamnaceae) — Buckbrush
- Diplacus aurantiacus* (= *Mimulus aurantiacus*) (Phrymaceae) — Sticky monkey flower; orange bush monkey flower
- Diplacus* x hybrids (Phrymaceae) — Colors “apricot”, “burgundy/white”, “red brick/gold”, “light peach”, “light pink”
- Frangula californica* (= *Rhamnus californica*) (Rhamnaceae) — Coffeeberry
- Heteromeles arbutifolia* (Rosaceae) — Toyon
- Monardella villosa* (Lamiaceae) — Coyote mint
- Salvia* sp. (Lamiaceae) — Sage

<sup>1</sup>USDA Forest Service, Pacific Southwest Research Station; <sup>2</sup>California Department of Food and Agriculture; <sup>3</sup>National Ornamentals Research Site at Dominican University

# Nursery Plants as a Pathway for Plant Pathogen Invasion

continued

With the broad range of plants susceptible to *Phytophthora* and other plant pathogens, there is the potential in restoration activities to inadvertently introduce *Phytophthora*-infected nursery stock into sensitive habitats, setting up a direct pathway for pathogen introduction and spread, and destroying the ecological values that restoration is trying to enhance. However, not all *Phytophthora* species cause plant diseases — some are adapted to live in water and pose low risk to plants (i.e., *P. gonapodyides*). Determining the risk of particular *Phytophthora* species is difficult, so there is much uncertainty as to the threat from *P. tenaculata* and the more than 20 other *Phytophthora* species that have been identified over the past 2 years on plants from California native plant nurseries. *Phytophthoras* are not unique to native plant nurseries; they are also frequently found in ornamental nurseries, agricultural fields, and wildlands.

The impacts of these pathogens in the native environment are uncertain, but the potential ramifications are wide-ranging and may be serious, including widespread plant mortality — as we have seen with *P. ramorum* — and regulatory quarantine measures affecting the entire state. Several water departments and land management agencies have taken a precautionary approach towards detections of infested plants outplanted in their restoration sites or on nursery stock being grown for their use. In 2015-16, managers suspended plantings, cancelled orders, or invested millions of dollars in solarization and other treatments to clean up contaminated sites. But reduced planting is not an ideal long-term solution to *Phytophthora* prevention since many of the benefits of restoration are lost when planting is avoided. Native plant nursery stock can be safely utilized by adopting a systems approach — by looking at the entire restoration process from design, seed collection, nursery propagation, through outplanting — to determine how the pathogens are being introduced to new areas, and then improve sanitation. *Phytophthoras* cannot be totally eliminated but they can be managed so the potential environmental harm is much lower than the real benefits of plantings.

Efforts are underway to prevent pathogen introduction and spread by implementing Best Management Practices (BMPs) for native plant nurseries and restoration projects. There are simple, but effective practices that native plant nurseries and restoration practitioners can implement to minimize the risk of introducing



Sticky monkey flower infected with *Phytophthora tentaculata* found at one of the nurseries that produced plants for the Monterey restoration site. Photo courtesy Kathy Kosta, CA Department of Food and Agriculture.

**With the broad range of plants susceptible to this pathogen, there is the potential in restoration activities to inadvertently introduce infected nursery stock into sensitive habitats.**

infected plants into their habitat restoration projects. Utilizing clean pots and tools for planting is paramount. Elevating plants off the ground and installing footbaths into

sensitive areas, such as propagation zones, are a few examples of BMPs directed at safeguarding product for field planting. Sanitation is the cornerstone of an effective systems approach and must be the focus in each nursery production step.

The *Phytophthoras* in Native Habitats Work Group is bringing all aspects of the problem together to coordinate a comprehensive, unified program of management, monitoring, research, education, and policy to minimize the spread of *Phytophthora* pathogens. For more information see [www.calphytos.org](http://www.calphytos.org). General information on forest *Phytophthora* species may be found at <http://forestphytophthoras.org> and best management practices and other information on *P. ramorum* is at [www.suddenoakdeath.org](http://www.suddenoakdeath.org). The Work Group needs your ideas and observations to prevent unintentional pathogen introductions into high-value habitats. To get involved, contact Janice Alexander, UC Cooperative Extension, Marin County at [jalexander@ucanr.edu](mailto:jalexander@ucanr.edu).



# Solarization

## *A Simple and Low Cost Method for Disinfesting Horticultural Containers*

by Karen Suslow<sup>1</sup> and Kathy Kosta<sup>2</sup>

### Introduction

The reuse of horticultural containers (hereafter collectively referred to as ‘pots’) by nursery growers is a beneficial and sustainable practice but has repeatedly been shown to serve as a mechanism for transfer of plant pathogens within a nursery. More critically, as a consequence, the risk of pathogen transport to natural or landscape plantings also increases. Infestation of habitat restoration sites by the out-planting of secondarily infested plant material has been documented and is a particular focus for preventive control measures. The transfer of water molds (Oomycetes), such as plant pathogenic *Phytophthora* species, is a major concern for restoration projects and should be a critical management control among nursery growers. Our research has established performance and efficacy criteria that demonstrate the risk can easily be avoided by the application of solarization techniques between uses of pots and other horticultural containers.

Solarization of used plant pots is an easily implemented and efficient way to eliminate *Phytophthora* from recycled pots and is considered a Best Management Practice (BMP) to prevent the spread of plant pathogens (such as *P. cactorum*, *P. ramorum* and *P. tentaculata*) within a nursery and to landscape plantings.

### Background

In the summer of 2015, the National Ornamental Research Site at Dominican University of California (NORS-DUC) conducted two outdoor solarization experiments designed to determine the temperature and time requirements at which *P. cactorum* — a commonly found soilborne plant pathogen in the nursery industry — would be killed. Due to quarantine restrictions in the two counties in which the experiments were conducted, *P. cactorum* served as a surrogate for the quarantine pathogen, *P. ramorum*, the cause of Sudden Oak Death. Lab studies at NORS-DUC verified the time and temperature to be the same at which these two pathogens are killed.

Open-environment experiments were conducted in a hot climate and in a cool climate. Under both conditions, the pathogen was killed within the first week in the “clear”, polymer-encased pots (Treatment) versus the Controls with no polymer sheet encasement. The clear polymer sheeting (4 mil thick and slightly opaque in appearance) was purchased off-the-shelf at a local mass merchant store. As an added control, samples of *P. cactorum* — held in the lab at room temperature and maintained in a similar fashion as those in the field — were sampled weekly and remained viable throughout the course of the experiment.

### Methods and Experimental Design Setup

We chose two locations for the pot solarization experiment: one in a hot climate located in Winters, CA, where the ambient peak summer temperatures are typically in the 34–39°C range, and the parallel one in a cool, foggy climate located in Pacifica, CA, where the ambient summer/fall temperatures are typically in the 16–21°C range.

The isolate of *P. cactorum* used in these experiments was provided to us by the California Department of Food and Agriculture (CDFA) Plant Pest Diagnostic Laboratory and was propagated on rhododendron leaves on PARP, a highly selective media (Fig. 1).

The first experiment was conducted over a three-week period, beginning on 25 August 2015, in Winters, CA. Treatments and Controls were randomly arranged on the ground. CDFA Diagnostic Lab processed all samples in the hot climate trial including lab-maintained samples that were kept at room temperature during the course of the experiment. One sachet per week was extracted and the leaf disks plated out. At each weekly interval, viable *P. cactorum* grew from the disks of the lab-maintained sachets.

The second experiment was conducted over a six-week period, beginning 23 September 2015, in Pacifica, CA. Once again, the

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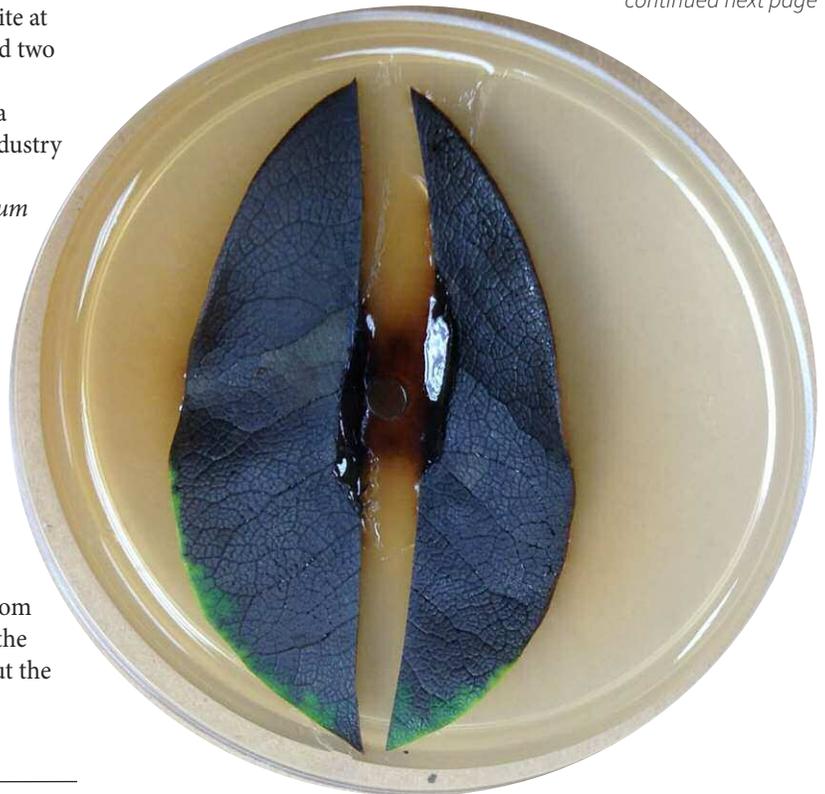


Fig. 1 *P. cactorum*-infected rhododendron leaf.

<sup>1</sup>National Ornamentals Research Site at Dominican University;

<sup>2</sup>California Department of Food and Agriculture



Fig. 2 Disks punched from *P. cactorum*-infected rhododendron leaf.



Fig. 3 Infected leaf disks and soil in sachets being inserted into hollow-core rope.



Fig. 4 Sachets in hollow-core woven rope coiled in the bottom of a 1G pot.



Fig. 5 Hole drilled in 1G pot which enables weekly extraction of sachet.

## Solarization *continued*

Treatments and Controls were randomly arranged on the ground. NORS-DUC processed all samples in the cool climate trial. Retained lab control samples were kept at ambient temperature. One sachet per week was opened and the leaf disks plated out. Each week, across all time-points, *P. cactorum* grew from the disks of the lab-maintained sachets.

Leaf punches were extracted from the infected leaves (Fig. 2) and ten leaf disks were placed in 10ml of potting soil typically used by the Winters or Pacifica grower. The disks were then inserted into a 1" x 3" porous sachet bag (20 micron, Safar Nitex mesh), sealed with tape, and secured with a staple.

For the hot climate trial, in order to facilitate extraction of samples from the pots for each weekly sample, three sachets were inserted into a hollow-core, woven rope (Fig. 3) approximately 10" apart. The rope was then inserted into nested black plastic pots (Fig. 4). Each week, the rope was partially extracted through a small opening in the polymer sheet with minimal release of heat, and the rope excised just below one sachet. The sachet was returned to the lab whereupon the leaf disks were extracted and plated out onto PARP media to determine the pathogen viability. The lab-maintained samples in sachet bags under stable ambient conditions were also plated out each week to confirm continued viability of the pathogen over the course of the experiment.

In the cool climate trial, we inserted two ropes with three sachets each in order to sample weekly over the planned timeline.

The pot sizes selected for this experiment were those that are used extensively in the native plant nursery industry: black 1-gallon (1G) and the narrow D-40 pots. At the Winters location, we also included Tubex tubes, hollow tubes which are used to protect young plants in the native environment/restoration sites from destructive foraging by wildlife. The 1G black pots were nested in 3' high stacks (the number of pots varied in each stack because the used pots are not identical in shape and do not always nest tightly). Three stacks were placed together in the same alignment and secured with polymer gardening tape for the 1G and Tubex tubes. A 2cm diameter hole was drilled in the centrally located pot (Fig. 5) where temperatures had been demonstrated to be the coolest in a pre-trial experiment. Prior to inserting the rope into the drilled hole, the rope was sprayed with water in order to keep the soil sachets moist. (In the

case of the D-40 pots, we secured five stacks each 3' high; hole drilling was required for neither the D-40 pots nor the Tubex tubes.) A temperature data logger (Spectrum Technologies, Inc., WatchDog B-series) was taped in the center pot on the side closest to the ground. The tied, wrapped pots were laid horizontally on the ground on top of a black plastic groundcover (Fig. 6). The Treatment stacks were sprayed with water, wrapped in the polymer sheeting, and securely sealed with strong adhesive clear tape. A small slit was made in the polymer over the drilled hole in order to facilitate removal of samples at weekly intervals. The slit was taped over to ensure complete enclosure. This setup was replicated three times. The Controls were identical to the Treatments; however, the pots were not sealed in polymer sheeting.

## Results

### I. Hot Climate Trials Field Sampling Results (Fig. 7)

Weekly collected field samples from all Treatments (1G, D-40, and Tubex tubes) yielded no *P. cactorum* growth. Additionally, *P. cactorum* was presumptively non-viable during the first week of the experiment in the Controls; however, other fungi and bacteria were isolated from the leaf disks of the Controls during the first two weeks. By week three, no micro-organisms were recovered from the Control samples.

*continued next page*



Fig. 6 Field layout at hot climate site in Winters, CA.

# Solarization *continued*

**1G Pots** — There was a temperature differential of 11°C between the Treatments vs Controls during the hottest interval of the day for 1G pots (1500–1600hrs): 57°C vs 46°C. Ambient shaded temperatures (as recorded by two data loggers located in a shaded area of the field plot, elevated 1 foot off the ground) were approximately 7–10°C cooler than the Control temperatures and 18–21°C cooler than the Treatment temperatures.

**D-40 Pots** — For the narrow D-40 pots, there was a greater magnitude difference between the Treatments and the Controls during the hottest time of the day (1500–1600hrs): 63°C vs 49°C

(14°C difference). Ambient shaded positions were 6–9°C cooler than the Control temperatures and 20–23°C different from the Treatments temperatures.

**Tubex Tubes** — During the first week of the experiment, Treatment Tubex tubes achieved the hottest temperatures (compared to the 1G or D-40 pots), reaching a peak temperature of 68°C; they also showed the greatest difference between the Treatments and the Controls during the hottest time of the day: 68°C vs 47°C.

## II. Cool Climate Trials Field Sampling Results (Fig. 8)

**1G Pots** — No *P. cactorum* was recovered from the Treatments. The pathogen was recovered from all three of the Control sachets in the first week; during the second week, the pathogen was recovered in only one of the three Controls, and continued to be recovered from each weekly sampling throughout the experiment for that particular Control. Another Control yielded other fungal growth (but not *P. cactorum*), on a weekly basis during the course of the experiment. There was a mean temperature difference of 14°C between the Treatments vs Controls during the hottest time of the day for 1G pots (1500–1600hrs): 45°C vs 31°C. Ambient shade temperatures (as recorded by two data loggers located in a shaded area of the field plot, and elevated 3 feet off the ground) were approximately 5°C cooler than the Control temperatures. Ambient shade temperatures were 19°C cooler than the Treatment temperatures.

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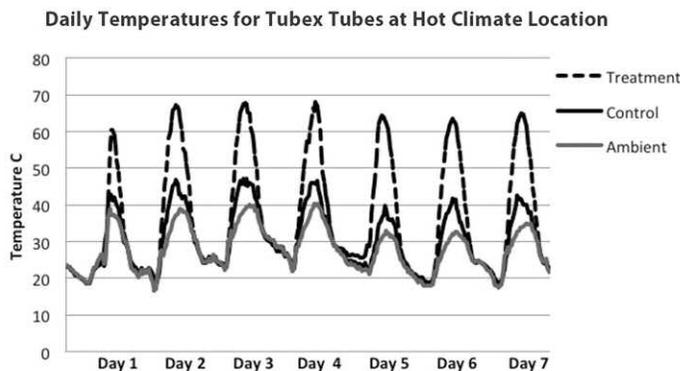
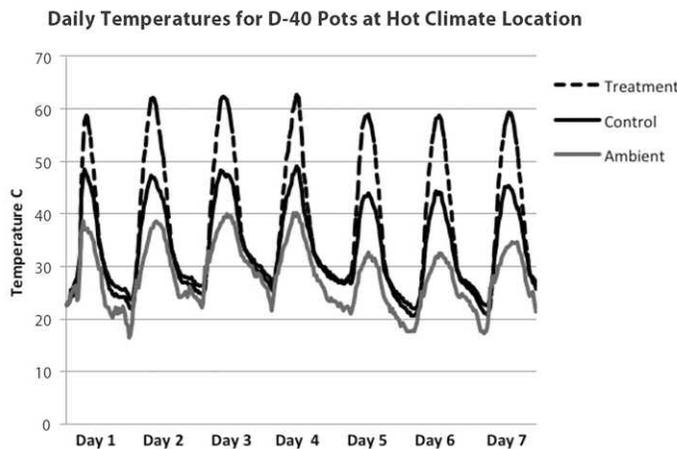
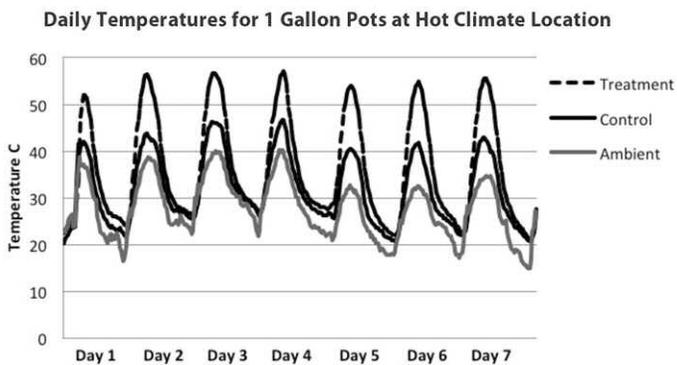


Figure 7 Daily temperatures during first week of experiment in the hot climate.

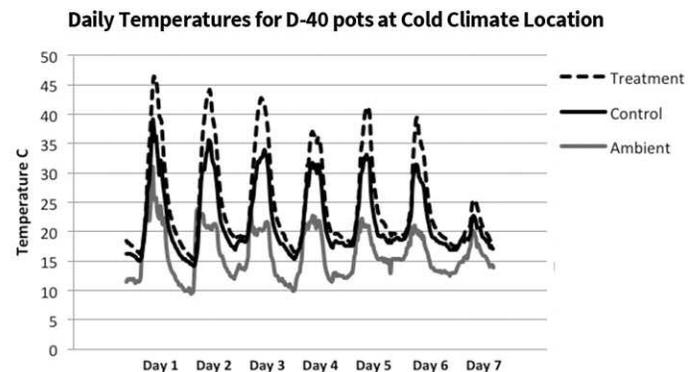
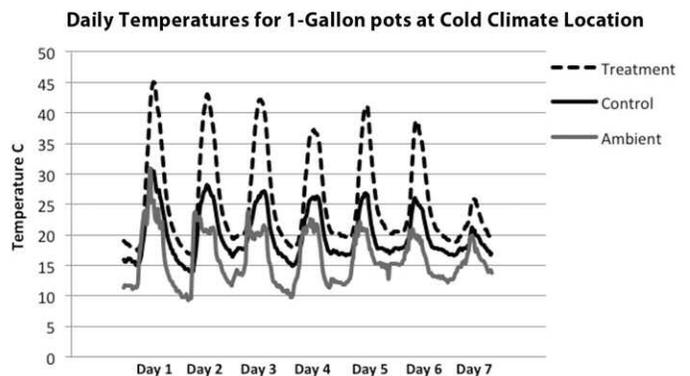


Figure 8 Daily temperatures during first week of experiment in the cold climate.

# Solarization *continued*

D-40 Pots — No *P. cactorum* was recovered from the Treatments. Only one Control yielded *P. cactorum* during the first week's sampling, but thereafter, no *P. cactorum* was found in future weeks' samplings.

For the narrow D-40 pots, there was less of a difference between the Treatments and the Controls during the hottest time of the day (1500–1600hrs): 47°C vs 39°C. Ambient shade was 13°C cooler than the Control temperatures and 14–21°C different from the Treatments temperature. D-40 Controls were a few degrees warmer than the 1G Controls.

## Conclusions

Solarizing horticultural containers is an effective method by which to eliminate high-priority soilborne plant pathogens from used pots. The ubiquitous nursery pathogen, *P. cactorum*, was killed within one week when summer solarization temperatures reached a peak temperature of 57°C in the sealed, clear polymer-wrapped 1G pots, D-40 pots, and Tubex tubes (Treatments) during which the cumulative hours above 50°C was sustained for 25 hours during the first week of the experiment (ambient temperatures ranged from 30–41°C). The pathogen was also killed in the Controls (non-polymer wrapped) within the same week during which the cumulative hours above 40°C was sustained for 30 hours (Table 1).

In lab studies, *P. cactorum* as well as numerous other *Phytophthora* and *Pythium* species, can be killed in 30 minutes at 50°C when exposed to moist heat (Baker and Cook). Reducing the temperature and extending the time has proven to be just as effective at killing *P. ramorum*. In infected rhododendron tissue, in loam soil, *P. ramorum* was not recovered after two days at 40°C nor at 4 days at 35°C (Tooley et al).

In the cool climate trial, the pathogen was killed within the first week of the experiment when the daily temperatures repeatedly reached 40–44°C for four hours within the Treatments. Research has shown that at these cooler temperatures, surviving bacteria may be acting as a preemptive biological control (Haas and DeFago) as was seen in the Controls of the hot and cool climate trials. The cool climate Controls never reached the lethal critical temperature threshold and *P. cactorum* survived in two of the three Controls. Bacteria and other fungi were found in the third Control, but no viable *P. cactorum* was present. Future studies will be investigating this potential biological control effect.

In the hot climate trial, Treatment D-40 pots, due to their long, narrow shape, reached a higher peak solarization temperature by approximately 6°C than did 1G pots; however in the cool climate trials, there was no significant difference between the Treatment groups. In contrast, temperatures in the Control D-40 groups were warmer than the Control 1G group, which may explain the data showing that all three 1G Controls had viable *P. cactorum* and other fungi isolated weekly while the D-40 Control pots only had one occurrence in the first week. Tubex tubes, because they are hollow and bottomless, reached the highest temperatures, frequently reaching 60–68°C daily.

Table 1. Cumulative hours attained during first week of Winters and Pacifica 1G trials.

	40-45°C	46-50°C	≥ 51°C
<b>Winters, CA Ambient temp: 30-41°C</b>			
Treatment	12 hrs	14 hrs	25 hrs
Control	30 hrs	2 hrs	
<b>Pacifica, CA Ambient temp: 19-26°C</b>			
Treatment	18 hrs	0	0
Control	0	0	0

For all pot sizes and in all trials, pots laid horizontally on the ground with black plastic under the pots yielded higher daytime and sustained nighttime temperatures than the ambient temperatures. Although reaching the required temperatures for solarizing is more easily attained in the summer months, in cooler climates and in the later fall months the radiant heat from the soil surface will aid in hastening the solarizing process. Additionally, when solarizing in a cool climate or a warm climate, encasing the containers in clear polymer can provide a heat capture differential of up to a 15–24°C as compared to pots not enclosed in polymer wrapping.

In order to achieve the highest temperatures and the quickest kill of *Phytophthoras*, solarize wet pots in the summertime, sealed in clear polymer, and laid horizontally on the ground with black plastic under the pots. Ideally, it is best to monitor your pot temperatures and correlate those temperature differentials with the ambient air temperature so you can determine when your pots have been sufficiently solarized. Alternatively, conservative time:temperature duration, as reported in this study and adjusted for climatic conditions, is an acceptable control point practice.

Future studies will include the nursery pathogen *P. tentaculata* and more frequent sample recovery periods in the hot climate trial.



We would like to thank Kristina Weber and Dr. Suzanne Rooney-Latham (CDFA), Vernon Huffman, and Drs. Supriya Sharma and Wolfgang Schweigkofler (NORS-DUC) for field and lab assistance with this project. Funding for this project was made possible through the USDA Farm Bill section 10007.

## References

- Baker, K.F. and R.J. Cook (1974). Biological control of plant pathogens. WH Freeman and Co., San Francisco.
- Haas, D. and G. Defago. (2005). Biological control of soil-borne pathogens by fluorescent pseudomonads. *Nature Reviews Microbiology* 3(4):307–319
- Tooley, P.W., M. Browning and D. Berner. (2008) Recovery of *Phytophthora ramorum* following exposure to temperature extremes. *Plant Disease* 92(3):431–437.

# Creativity in Collaboration: SERCAL 2016



*Many thanks to the generous support of our conference sponsors:*

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*Deep appreciation to the dedication of our conference team:*

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*And thanks to everyone who participated in the survey... we are listening.*

## Q13 Please indicate the top three reasons you attended this year:

- 25% Enticing conference theme and technical session topics
- 56% You were a presenter
- 22% Your registration was part of a sponsorship package
- 47% Location, Location, Location!
- 81% Professional development and networking opportunities
- 44% You've had good experiences at SERCAL conferences in the past
- 9% Never been to a SERCAL conference before, but were intrigued and the price was right

## Which aspect(s) of the conference...

Q9 ... were you most pleased with? Q10 ... do you feel could be improved?



# 16 in Tahoe

*Thanks for all the helpful feedback in the post-conference survey\**



“The themes were all really interesting, it was hard to choose.”



“Good to have the leading experts on a particular issue present at the conference.”



“SERCAL is my favorite conference of the year. Love how practical and applicable all of the sessions are.”



“Field trips were fun, informative, and took us to some beautiful places!”



“This was an outstanding conference. The plenary session was very inspiring, the food was great, the band was excellent, and the tech sessions were great. Overall the organization was excellent!”

\* 32 of 188 attendees responded (17%)



① SERCAL President and 2016 Conference Chair, Dave Shaw of Balance Hydrologics, presented the 2016 SERCAL President's Award for Outstanding and Creative Collaboration toward Ecological Restoration to plenary speakers Lisa Wallace, Kath Eagan, and Joanne Roubique of the Truckee River Watershed Council.



② Wednesday evening's hosted poster reception gave everyone a chance to unwind and catch up after the day's 3 rounds of concurrent technical sessions.



③ The Simpletones — SERCAL's official conference band since SERCAL 2000 — made Wednesday evening so delightful that folks stayed long after the evening officially ended. A second appreciation plaque was awarded to bandleader (and former SERCAL President) Michael Hogan for his valuable contributions to the field and the organization.

④ Dave Shaw handed off the President's gavel to Harry Oakes during Day Two's luncheon. Harry announced plans for SERCAL 2017 in Davis.

⑤ The four post-conference fieldtrips — touring a variety of restoration sites around the perimeter of Lake Tahoe — filled up well before the conference, prompting a signup sheet at the conference for any openings.





Clockwise from left An aerial photo of Breuner Marsh (EBRPD) in Richmond, CA. Drone aerial photographs and eCognition remote sensing software were used to map newly established pickleweed in a restored tidal marsh (photo courtesy Questa Engineering). Fixed-wing (photo courtesy Airphrame) and copter-style drones. Screen shot of an application that plans the drone's flight path based on user-defined parameters related to photo capture requirements.

# Drone-Based Remote Sensing Methods for Modeling, Mapping, and Monitoring Vegetation

by Geoff Smick<sup>1</sup> and Sundaran Gillespie<sup>2</sup>

The explosion of commercially available, unmanned aerial vehicles (UAV; i.e., 'drones') in the marketplace provides a novel tool to the restoration ecologist. With both fixed-wing and rotary-style ("copter") drones capable of covering hundreds of acres in a day, there are numerous applications. Drones can produce a number of very useful products that can increase the accuracy and efficiency of traditional field studies to support restoration projects. This article explores the differences in the two primary drone platforms, the various products they can produce, and a variety of applications pertinent to restoration ecology.

## Drone Platforms

Drones come in two flavors, each with advantages and disadvantages:

Fixed-wing aircraft are essentially small airplanes powered by a small electric or gas-powered motor. They require less maintenance than more complex rotary-style drones and are more efficient, thus they can cover more ground per flight. They can also carry heavier payloads, thus they can be paired with more advanced sensors with more capabilities. Fixed-wings do require more space for takeoff and landing, and they cannot hover or fly very slowly which is useful for some applications.

Rotary-style drones are probably more recognizable due to their popularity with enthusiasts. They typically have 4-8 propellers that allow the device to hover and fly slowly while maintaining stability in moderate winds. Disadvantages of this drone type include reduced flight times on a single battery which reduces the amount of ground they can cover, and reduced payload capacity which means they may not be able to carry all the sensors that fixed-wing aircraft can.

For both systems, flights are planned and operated using tablet or smart phone applications that can run on iOS or Android operating systems. The flight area is input using a map interface and the application automatically sets up a flight path for the operator. Multiple flights may be needed to complete the entire flight depending on the size of the area and platform being used. In these cases, the drone returns to its original starting point so the battery can be replaced and then the unit is re-deployed to continue the data capture where it left off.

Both systems also require certain certifications for use. The Federal Aviation Administration requires a Section 333 Exemption from companies or individuals that use drones for commercial use. In addition, drone operators must hold a valid pilot's license. Currently the Section 333 Exemption process takes approximately 4-6 months

WRA, Inc. <sup>1</sup>President; <sup>2</sup>GIS Analyst

*continued next page*

# Drone-Based Remote Sensing Methods *continued*

to obtain. However, the federal government is currently revising the commercial drone operating requirements which should make the process less onerous.

## Drone Products

The two pieces of data most commonly produced by drones are photographs and topographic ground models. While these are not new to our industry, these data sets are indispensable — the drones allow for ultra-high quality images at a very low cost with near instantaneous deployment/data capture.

The primary product that drones produce for restoration purposes are high-resolution, georeferenced, orthorectified mosaic imagery. These are produced by taking hundreds of individual, vertical aerial photos that are mosaicked into a single aerial photo covering tens to hundreds or thousands of acres. Because drones fly at such a low elevation relative to traditional aerial imagery-capturing techniques (i.e., fixed-wing piloted aircraft), they are capable of producing photos with resolution quality of two centimeters per pixel. In comparison, most commercially available aerial photographs are of much lower quality, traditionally a 1–3 foot range.

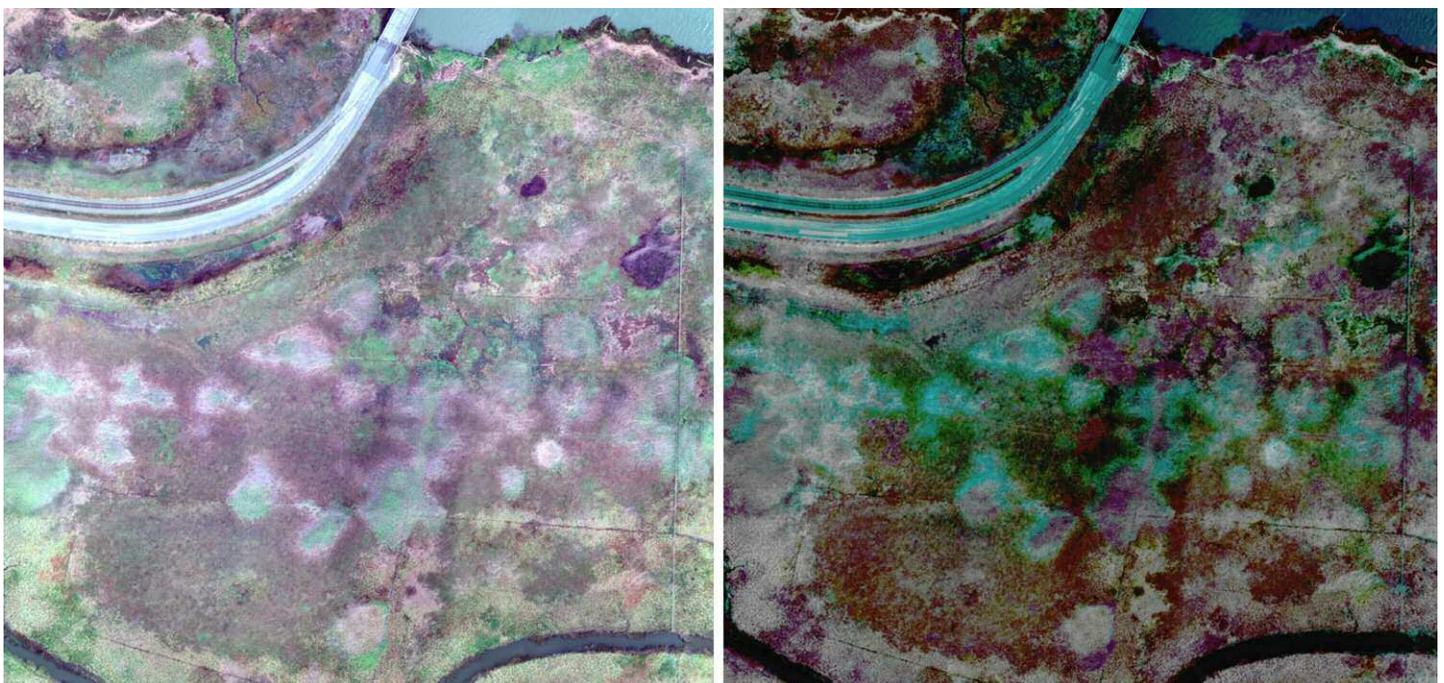
In addition, post-processing can provide a high-resolution digital surface model (DSM) to generate topographic contours. Since the individual photos taken from a drone overlap one another, stereophotogrammetry can be used to reconstruct a 3-D model of the scene. Ground control points are recommended in conjunction with this process to maintain a high level of accuracy since the typical GPS unit on a drone camera sensor has an accuracy of only 2–4 meters.

## Specialized Products

One of the biggest limitations for drones has been payload capacity. However, with advances in technology, smaller sensors are now allowing more specialized equipment to be carried. One of these is a multi-spectral imaging camera. While traditional cameras take panchromatic photographs that represent reflective colors as the human eye perceives them (commonly called three-band imagery: red, green, and blue bandwidths), specialized equipment can obtain multispectral photographs that capture additional wavelengths not perceivable to the human eye (such as infrared or ultraviolet). The most common is four-band (red, green, blue, and near-infrared, or NIR) imaging which allows the production of color infrared photos which are very useful for vegetation studies. Although the technology exists to capture many more bands, the equipment is too heavy for most commercially available drones.

Very recently, tiny LiDAR devices (acronym for Light Detection And Ranging, a surveying technology that measures distance by illuminating a target with a laser light) have hit the consumer market allowing a drone user to procure LiDAR-based elevation data. While expensive, LiDAR is much more accurate and higher resolution than DSMs produced from overlapping aerial photos. In addition, LiDAR can be used to capture both bare earth DSMs (elevations of the ground surface under vegetation) in addition to DSMs of the site that includes vegetation height (which is what is obtained from stereophotogrammetry).

*continued next page*



Two images of the same area showing 3-band (left) and 4-band (right) with near infra-red wavelengths. Certain vegetation types are more easily distinguishable with the additional 4th band that helps tease apart vegetation types that otherwise appear similar to the naked eye. *Photos courtesy GeoWing Mapping Inc.*

# Drone-Based Remote Sensing Methods *continued*

## Applications

### *Mapping Vegetation Communities*

One of the most basic applications for high-resolution drone aerial imagery is mapping vegetation communities. Mapping the extent of various communities — necessary for understanding the baseline conditions of a site or for monitoring the development of habitats following a restoration project — is a common practice for restoration ecologists. While commercially available satellite photos may have sufficient resolution for coarse vegetation classification, the high-resolution photos offered by drones often permit the ecologist to identify vegetation communities to a very detailed level. This is especially true if flights are possible over the site at various times of year, when the phenology of various species may be captured to assist in classification, or if a DSM is used to add topographic data which would include vegetation height data to the vegetation to further differentiate communities. Furthermore, multi-spectral imagery that offer NIR wavelengths can be especially useful in distinguishing between vegetation types.

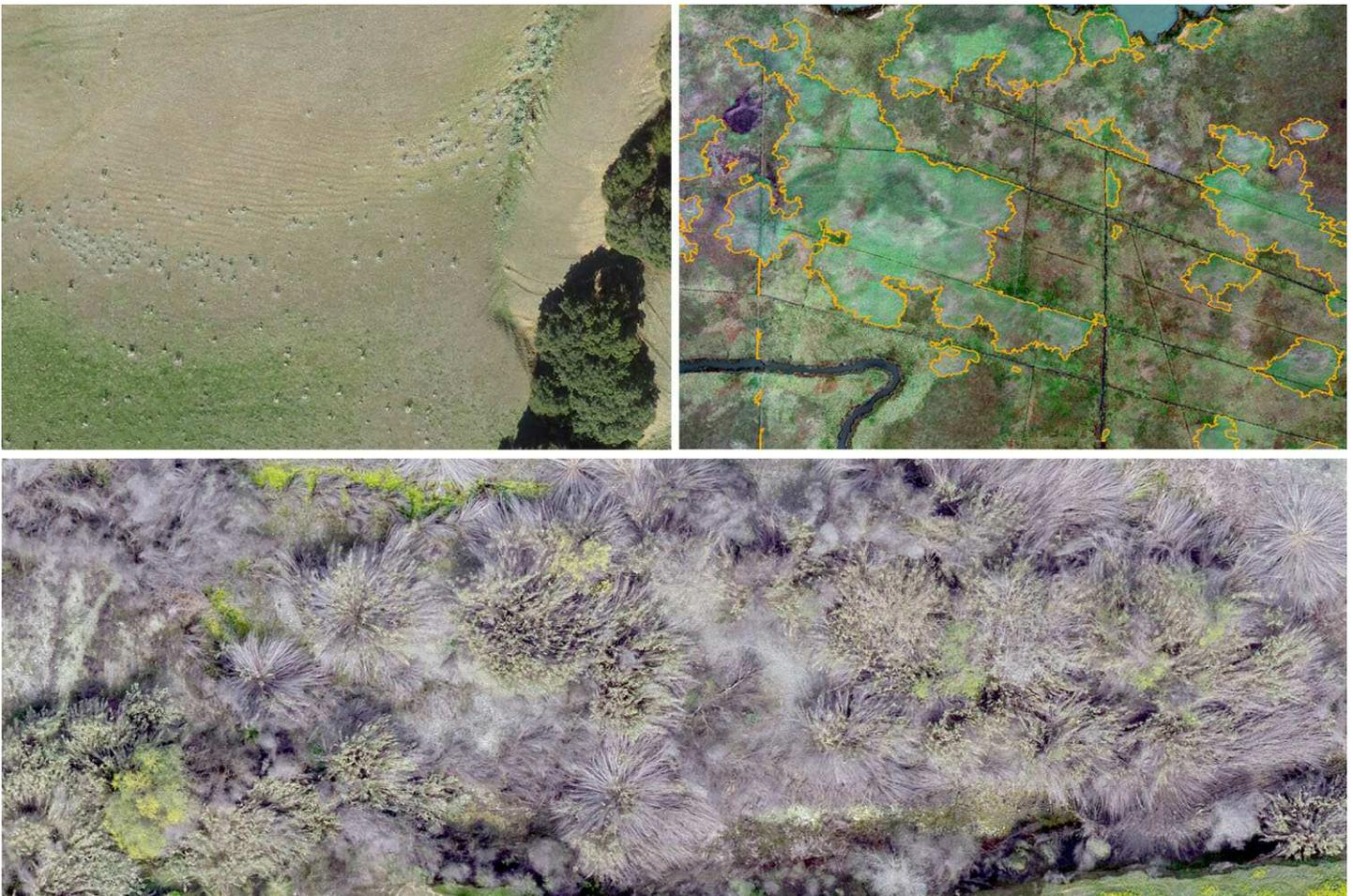
### *Remote Sensing*

Remote sensing software can assist in classifying vegetation types in the aerial photograph. The software divides an image into polygons that contain pixels of a similar color, intensity, and texture. The user creates different categories (e.g., vegetation types), and then selects representative polygons of a specific vegetation community to ‘teach’ the program which category they belong to. Once this has been completed for each of the vegetation types in the image, the program classifies all of the remaining polygons into one of the user-defined vegetation communities. The user reviews the results and errors are reclassified and the recognition process is repeated until the error rate reaches a predetermined (i.e., acceptable) level. Adjacent cells of the same classification are merged and the resulting file is exported into GIS. Once in GIS, the files can be cleaned, acreages can be calculated, and maps can be generated.

### *Weed Mapping/Census*

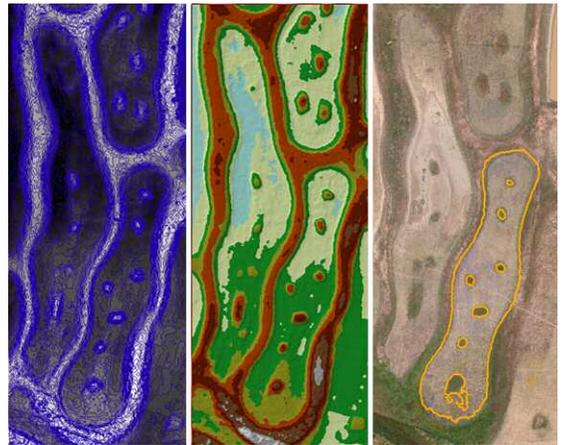
Using a similar process to vegetation community mapping, individual target weed species can also be identified and mapped.

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Clockwise from top left Drone aerial photo of artichoke thistle in a grazed pasture at Ridge Top Ranch Wildlife Conservation Bank in Solano County. *Phragmites* mapped in a brackish tidal marsh along the southern Suisun Bay in Martinez, California. Drone aerial photo of *Arundo* in a stream in Pleasanton, CA. The photo was taken in January prior to leaf set of willows that would shade the *Arundo* once leafed out. Photos courtesy Airphrame.

A vernal pool reference site at the Elsie Gridley Mitigation Bank in Solano County. The right pane shows the drone-captured aerial photo. The center pane shows an elevation heat map based off of a digital surface model (DSM) created from the drone aerial photographs. Low elevations are shown in blue and green while higher elevations are shown in red. The left pane shows topographic contours in ¼-foot intervals that were derived from the DSM. This model will be used to analyze pool depth and compare that to hydroperiod and vegetation communities; the resulting information will then be used to design restored vernal pools with specific parameters based off these reference pools. *Photo courtesy Airphrame.*



## Drone-Based Remote Sensing Methods *continued*

Examples include artichoke thistle, *Arundo*, perennial pepperweed, and *Phragmites*, although others are undoubtedly possible. For these readily identifiable species, the process is as accurate as field surveys for a fraction of the time (e.g. cost), especially for larger survey areas. For some species, such as *Arundo* and pepperweed, timing of the flight may be an important consideration. For *Arundo*, if it is underneath the canopy of deciduous riparian trees, it is beneficial to capture imagery during the winter when the canopy trees are leafless. For a smaller species such as pepperweed, photographing it when in bloom with its distinctive white top is helpful to pick it out from the surrounding species.

### *Mapping Watercourses*

In areas where vegetation coverage is sparse, such as those found in the deserts of the arid west, drone-derived DSMs can be a vital tool for mapping watercourses. Without the presence of vegetation to distort the true surface of the ground, GIS spatial analysis can be performed to identify flowlines and classify them into watercourses based on values from the DSM. By modeling watercourses ahead of time, field-mapping efforts are drastically reduced. This is extremely useful for areas subject to high temperatures or rugged terrain which can pose hazards to field staff. Aside from safety benefits, reduced field time translates into cost-savings for the client, which is always appreciated.

### *Wetland Restoration Planning*

When designing complicated wetland restoration projects, such as vernal pool complexes, it is helpful to have functional reference sites to use as prototypes for the design process. In vernal pools, pool depth is directly related to hydroperiod, which in turn drives plant species establishment and distribution. Minor fluctuations in topography of even a few inches can have a major effect on which plants grow in that area due to the changes in local hydrology. Therefore, having a detailed digital surface model of the pool topography is essential for understanding the distribution of topographic zones within a given pool. By capturing high-resolution imagery during the dry season when the pools are empty, an accurate DSM can be prepared for the area. A follow-up drone flight can be scheduled for the winter when the pools are full to obtain the water levels in the pool complexes. The two DSMs can be compared, while pool volume, depth, outlet elevation, and watershed can all be assessed. Individual pools can be analyzed and

their vegetation communities assessed to determine target elevations and areas of restored pools. This general process has been used in the past but with using either expensive LiDAR data or more time-consuming ground-based data collection methods. With drones, the entire site can be captured at a fraction of the cost.

### *Hydrology Monitoring*

Wetland and stream hydrology is a common criteria used to assess restoration success. This is true for seasonal wetlands and vernal pools, streams, and tidal wetlands. The restored habitats are often compared to reference sites and are supposed to have similar hydrologic function (hydroperiod, depth, flow regime, etc.) as the reference sites. Data collection from drones can be used to assess at least some of these parameters. Geographical extent of ponding, or extent of high tide in tidal systems, is relatively easy to assess using aerial photographs. Similarly, by capturing aerial photos several times over the wet season, hydroperiod can also be determined. If a dry season DEM exists, GIS analysis can overlay a wet season DEM and determine depth of inundation. For large sites with multiple wetlands, drone data may replace many dozens of person-hours of repetitive hydrology monitoring of individual wetlands that may represent only a subset of the entire site. With drone-based aerial photographs, large sites can be flown in a matter of hours providing a complete dataset of extent and depth of ponding for the entire site. This approach can provide a much more robust data set than traditionally available in a fraction of the time.

### **The Takeaway**

While the specific types of products that drones are capable of providing may not be novel tools to the restoration ecologist, the ability to obtain them with drones make them indispensable for modern ecological monitoring and planning. With imminent changes in the legal framework for drone operation, these machines will be available to more operators. Simultaneously, technological advances will permit even more sensors to be reduced in size so they can be affixed to drones to capture even more data. Undoubtedly there are even more applications out there that are pertinent to your needs. We look forward to continuing to explore this exciting realm and hope to hear from others experimenting in this field about their success stories.



Many thanks to these generous members for their support this year!

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**Livestock Grazing and Landscape Diversity in Vernal Pools**

Julia Michaels, Graduate Group in Ecology · Valerie Eviner, Ph.D., University of California, Davis

**Overview and Approach**

Livestock grazing is increasingly being used as a management tool to control exotic species in California's vernal pool ecosystems. It is important to understand the long-term impacts of livestock grazing on patterns of plant diversity and composition. In spring 2015 I conducted an experimental comparison of plant diversity between historically grazed and ungrazed vernal pools.

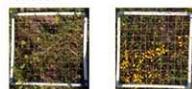
**Methods**

**Study Site:** Rancho Seco is a 1132-acre site in SE Sacramento County owned by the Sacramento Municipal Utility District (SMUD) with over 50 acres of protected vernal pools across several soil types and a wide range of pool characteristics. A fence divides vernal pools that have been grazed continuously for over 45 years and pools that have been fenced off from livestock since the 1970s.

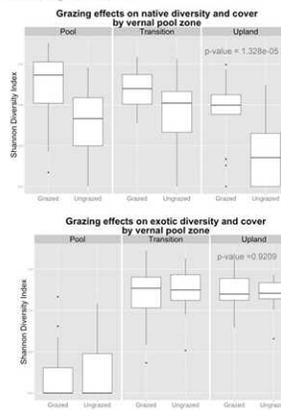
**Comparing Plant Communities:** I paired 15 grazed and 15 ungrazed pools based on soil type, water depth, depth to claypan, and size. I established nine vegetation quadrats per pool, spanning the pool bottom, edges, and upland (30 pools, 270 quadrats total). During peak flowering season, I



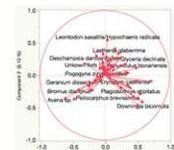
sampled these quadrats for grasses and forbs, and calculated richness, cover and abundance, for both individual species and for native vs. exotic species.



**Preliminary Results**



**Results Summary:**

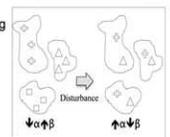


- Grazed pools had significantly higher native diversity and cover than ungrazed pools
- There was no significant difference in exotic diversity and cover between grazed and ungrazed pools

PCA analysis reveals species clustering significantly associated with grazing along PC #1 (p=0.0049)

**Future Research Directions**

I am interested in whether disturbance-mediated changes in diversity may be stronger between pools ( $\beta$  diversity) than within-pools ( $\alpha$  diversity). It is possible that disturbance could increase plant diversity within pools while homogenizing plant communities between pools. I will investigate grazing effects on  $\alpha$  and  $\beta$  diversity across site characteristics, grazing level, and regional climate.



Vernal pools are characterized by high  $\beta$  diversity—adjacent pools may host unique species assemblages

Congratulations to Julia Michaels of UC Davis who presented the winning poster in our Student Poster Competition. Visit [sercal.org](http://sercal.org) to see a larger image of her poster as well as the abstract.



**Acknowledgements**

This research was made possible by grants from the Davis Botanical Society, CNPS Santa Clara Valley Chapter, Northern California Botanists. Special thanks to Emily Bacchini, Sacramento County Utilities District, and Research Assistants: Paola Pomeroy and Jared Borba.

I am seeking field sites with grazed vernal pools for my cross-sectional study. Please contact [jmichaels@ucdavis.edu](mailto:jmichaels@ucdavis.edu) if you are interested.

# SERCAL Board of Directors

## Hello Members!

What a great gathering we had at SERCAL 2016 in Tahoe this May! Conference Chair Dave Shaw crafted such a wonderful Creative and Collaborative mix of sessions, leaders, fieldtrips, and events — and who could not enjoy the gorgeous lakefront setting? Thank you, Dave, and all the volunteer leaders, presenters, sponsors, and conference attendees who added their energies and talents to the three-day event. Much appreciation also goes to Cindy Thompson and Anita Lahey for their able assistance at the SERCAL table, and to Cindy and J.P. Marié for being our official photographers.

SERCAL President Harry Oakes is already working on SERCAL's 2017 conference — May 10–11 at the UC Davis Conference Center — as well as fieldtrips for late this summer and early fall in central, southern and northern California. Be sure to watch [sercal.org](http://sercal.org) and our facebook page for more information as it becomes available.

Besides Ecesis, here's a rough schedule of what's coming to your mailbox through the end of the year; we'll also be sending these docs through email:

- In Jul/Aug, you will receive the elections mailer;
- In Sep/Oct, you will receive your membership renewal;
- In Oct/Nov, you will receive the Call for Abstracts.

If you are interested in sponsoring at Davis, know there will be a limited number of booths available due to space constraints and the fact that we are planning on a strong showing of student posters. The Call for Sponsors will not go out til the first of the year, but if it's better fiscal timing to jump in before the end of 2016, please give me a shout.

The SERCAL Board is continuing to look at updating the organizational bylaws and will likely be presenting recommendations to the membership at or before the 2017 conference.

Thanks so much for all your good energy, enthusiasm, and support this past year! If you would like to become more involved in the forward movement of SERCAL (e.g., ideas for regional events (fieldtrips!) and student outreach opportunities), please contact Harry or your regional board rep, or me at [julie.sercal@gmail.com](mailto:julie.sercal@gmail.com).

All the best,

Julie St John, your Admin Director

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