2014/15 ANNUAL REPORT

JASPER RIDGE

BIOLOGICAL PRESERVE

Stanford | SCHOOL OF HUMANITIES & SCIENCES

STAFF (2014–15)

CHRIS FIELD, PhD '81
Faculty director

PHILIPPE S. COHEN, PhD
Executive director

NONA CHIARIELLO, PhD '81
Staff scientist

CINDY WILBER
Education coordinator

TREVOR HEBERT
Academic technology specialist

CAROLYN TAYLOR
Administrative associate

ERIK ZARAZUA
Temporary administrative associate

CARY TRONSON
Operations manager

JEFF VANCE
Special projects technician

BROOKE FABRICANT
Resident ranger

STEVEN GOMEZ
Maintenance assistant

On the cover: Spined turban gall of the cynipid wasp Antron douglasii *Melika & Abrahamson* (Hymenoptera: Cynipidae) *on the underside of a leaf of Valley oak* (Quercus lobata).

Induced by the wasp, these galls form on the underside of an oak leaf and consist of a single chamber in which a single larva develops. The star-like gall is whitish with shades of pink that become more intense toward the points of the star. The galls are produced during the wasp's unisexual generation, typically August to September, and are mostly solitary but can sometimes form large clusters. The galls are parasitized by at least one species of small wasp.

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FROM THE FACULTY DIRECTOR

CHRIS FIELD, PhD '81

During my time as faculty director, I have been fortunate in being able to pursue JRBP's opportunities and environmental challenges in parallel with work at larger scales. Two focal points of my integration across scales have been climate change and water resources.

For many years, work in the Jasper Ridge Global Change Experiment has detailed the responses to climate change in a grassland, at the same time that I had the opportunity to synthesize climate-change risks and solutions at the scale of countries, continents, and the planet. Similarly, in recent years the Searsville Alternatives Steering Committee, charged with making recommendations about the future of Searsville Dam and Reservoir, overlapped with work coordinating a special issue of *Daedalus* on global water resources, coedited with my colleague Anna Michalak. Being able to integrate my focus on JRBP with work at the global level has helped shape my perspective on what matters and why.

For Jasper Ridge, the big project was completing the report on possible futures for Searsville Dam. The steering committee's report, issued in May, is available online[1]. In brief, the committee identified a first-choice recommendation: create an opening at the base of the dam to provide fish passage and a restored creek channel, while also attenuating high flows. If this option proves infeasible, a second-choice recommendation is to stabilize the sediment in place behind the dam and provide fish passage with a fish ladder or fish-way/rerouted creek. The report explains the criteria and assumptions behind these choices.

There are five take home messages I'd like to emphasize concerning the committee's work and recommendations. The first is that the committee entered the process with a deep commitment to addressing all of the objectives. Although the proposed solutions may not be perfect from some perspectives, they can be broadly effective.

Second, I am confident that the report was based on the right kinds of expertise and the highest level of engagement from the faculty and administrators, together with comprehensive study by consultants. The process for the Searsville Alternatives Steering Committee was a model for an inclusive process across stakeholder groups with potentially contrasting priorities.

Third, implementing any solution for Searsville Dam and Reservoir will be complex and costly, with important considerations that are different from those in every other creek restoration. There is no precedent that is sufficiently similar to the context of Searsville Dam to provide a ready or reliable answer to Searsville's suite of issues regarding environmental protection, water resources, and the communities that live upstream and downstream of the dam. Developing details of a solution will require ongoing interactions and coordination with not only regulatory agencies, but also local communities and other stakeholder groups.

Fourth, much work remains to be done and will lead to new knowledge or new conditions that require adjusting plans. For example, California has been through four years of drought and, very likely, the two warmest years, globally, since the start of the industrial revolution. Over the coming years, we may see changes, some of them dramatic, in populations and ranges of many species. We are already seeing changes consistent with this in, for example, the recent decline of Douglas fir trees. If the 2015–16 El Niño is similar to that in 1997–98, the coming year may be a whiplash in terms of weather, with consequences that are hard to predict.

Fifth, it is exciting to see the next steps getting started. For example, geotechnical surveys in and around Searsville Reservoir are digging deeper into the feasibility of the steering committee's recommendations. In the coming year, that work will consider the sensitivity of the water table in the wetlands to changes in water storage. As early as next summer, work may begin on improving fish passage at the cement crossing. To assure the availability of information to support flexible management as well as to enhance research opportunities associated with restoring Searsville, the Jasper Ridge advisory committee concluded that we need to begin identifying baseline data sets to initiate in parallel with future decision-making on Searsville Dam and Reservoir, along with additional resources to implement that monitoring. Even though the work on restoring Searsville may extend over decades, we want to imagine the finished project and a trail of novel research in its wake.

A key player in the Searsville process—as in all the big questions that have faced JRBP over the past two decades—is Philippe Cohen, who will retire as executive director in a few months. I know I speak for a great many people when I credit and thank Philippe for handling every Jasper Ridge issue and endeavor with passion, determination, and an arsenal of preparation. I can't think of a single outcome that wasn't substantially shaped by his involvement. I hope that come March, Philippe will be exploring new landscapes with fewer cares and much more time than he had during his tenure at JRBP—and with his camera, so we can share in his discoveries.

The issues that face Jasper Ridge are vitally important and inherently fascinating, and their significance deepens the experience of walking familiar trails as they change with the seasons and years. That experience began for me as a teaching assistant in Hal Mooney's course on California ecosystems in 1977. A highlight for me this year was passing on a little of that experience and some of what Hal taught me. The enabler was a graduate seminar that consisted of weekly walks at Jasper Ridge, covering almost every trail. It was incredibly fun, enrollment actually increased over the quarter, and now two more graduate students are carrying out studies at Jasper Ridge.

[1] *http://news.stanford.edu/searsville/Searsville_Steering_Committee_Recommendations_April_2015.pdf*

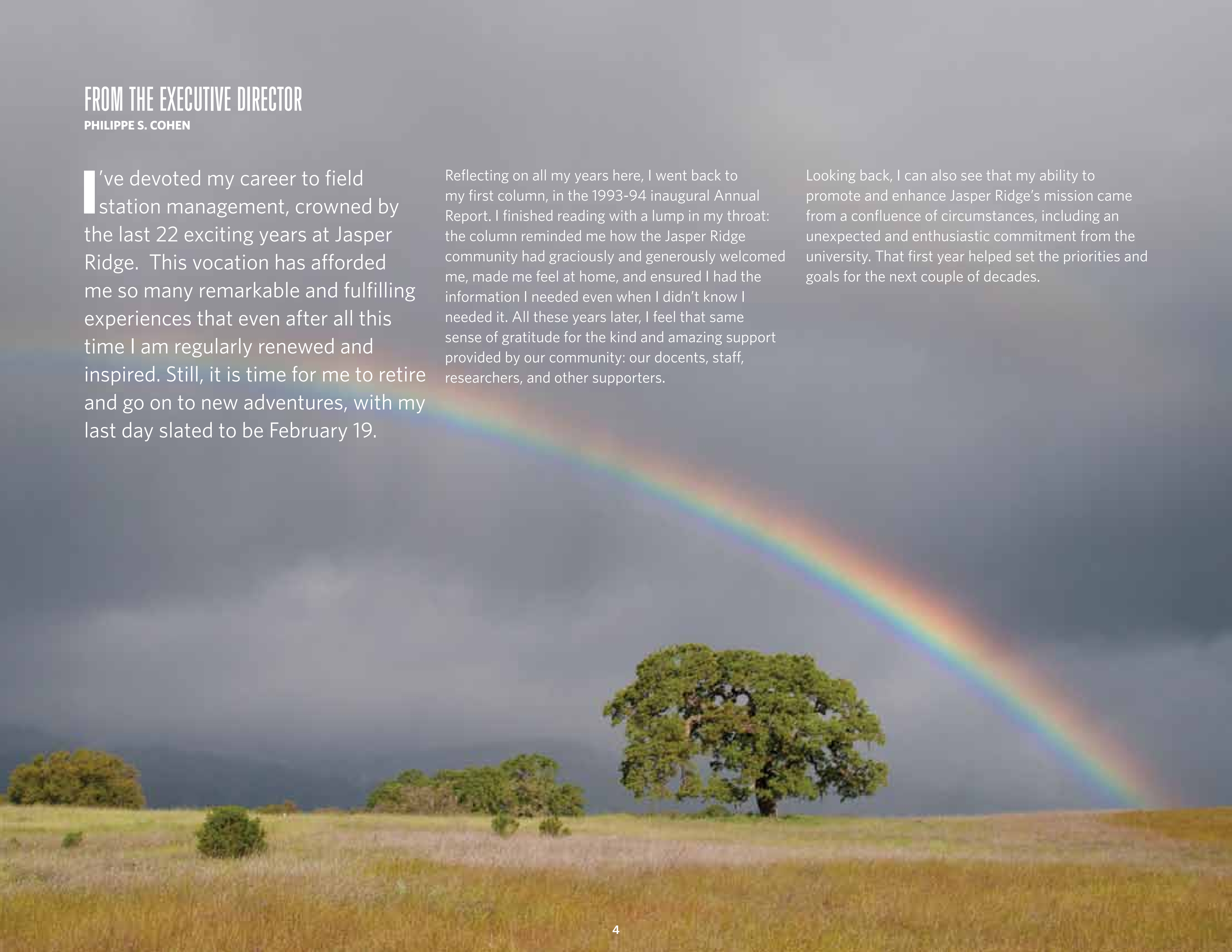
FROM THE EXECUTIVE DIRECTOR

PHILIPPE S. COHEN

I've devoted my career to field station management, crowned by the last 22 exciting years at Jasper Ridge. This vocation has afforded me so many remarkable and fulfilling experiences that even after all this time I am regularly renewed and inspired. Still, it is time for me to retire and go on to new adventures, with my last day slated to be February 19.

Reflecting on all my years here, I went back to my first column, in the 1993-94 inaugural Annual Report. I finished reading with a lump in my throat: the column reminded me how the Jasper Ridge community had graciously and generously welcomed me, made me feel at home, and ensured I had the information I needed even when I didn't know I needed it. All these years later, I feel that same sense of gratitude for the kind and amazing support provided by our community: our docents, staff, researchers, and other supporters.

Looking back, I can also see that my ability to promote and enhance Jasper Ridge's mission came from a confluence of circumstances, including an unexpected and enthusiastic commitment from the university. That first year helped set the priorities and goals for the next couple of decades.



I started my position on November 1, 1993, and by the spring I felt compelled to write to then university president, Gerhard Casper, describing the issues that could compromise the preserve's future as a world-class research and educational site. My timing was fortuitous because the university had just established a discretionary President's Fund designed to make strategic program investments, and President Casper invited me to submit a formal proposal.

The proposal, written with valuable input from faculty and staff (especially Hal Mooney, Paul Ehrlich, Don Kennedy, John Thomas, Monika Bjorkman and Nona Chiariello), identified immediate and long-term needs.

We proposed immediate action to: expand and enhance educational and research use by constructing on-site facilities; secure an increased, predictable and adequate budget; and develop geographic information and data management systems to grow our legacy of research results. Long-term needs focused on producing a hydrological assessment of Searsville Reservoir, and re-zoning adjacent Stanford lands to protect in perpetuity biological connectivity from the preserve to the rest of the Santa Cruz Mountains.

President Casper awarded Jasper Ridge a substantial grant that left me a little intimidated. It was time to walk the talk and begin addressing all these needs, a focus that has guided most of my time here.

Today, the benefits of that initial grant are clear: the sustainable Leslie Sun Shao-ming Sun Field Station supports a growing research and educational community; a more-than-quadrupled operating budget now captures the true cost of managing our lands and programs; and our modern GIS and data management infrastructure significantly enhances research and educational opportunities.

We have also made substantial headway on the long-term goals: the early hydrological study of the Searsville watershed has helped with understanding the important role of sedimentation and in delineating options for the reservoir's future (https://news.stanford.edu/searsville/). And due to good fortune and good timing, habitat "connectivity" to the rest of the Santa Cruz Mountains has progressed through the Stanford Habitat Conservation Plan, spearheaded by Stanford's Land Buildings, and Real Estate and for which Jasper Ridge was one of numerous contributors.

Thankfully, I leave knowing that most of the pieces are in place to ensure the preserve continues to meet its mission, and that Jasper Ridge today is viewed as an integral component of the university's mission.

Jasper Ridge routinely hosts 65–75 research projects and 2,000-2,500 Stanford undergrads in classes and related activities. Each spring, when I stroll from my office to other destinations on the preserve, I can see and hear the focused activity of students and researchers. It brings home to me just how many lives and careers continue to be shaped by the experiences made possible by the preserve. I firmly believe that without that initial grant, things would look very different today.

The challenges and opportunities now facing the preserve are somewhat different in character.

1. Federal support for basic research, especially in the field sciences, may never reach the levels of the past, and it may be increasingly difficult to support long-term research initiatives through National Science Foundation grants. Finding alternate resources to support undergraduate, graduate, and postdoctoral research at the preserve is becoming urgent.

2. A recent National Research Council (NRC) report on biological field stations and marine labs noted that these sites are a hotbed of "convergent" thinking—that is, they create novel opportunities for trans-disciplinary approaches. This has always been a hallmark of the Jasper Ridge experience. Maintaining and enhancing this natural inclination will only grow in importance. One way to further enhance convergent thinking is to develop a visiting scholar/researcher/fellows program. This will provide a recurring way to infuse new dynamism into the trans-disciplinary perspective promoted by Jasper Ridge, one in which the NRC sees great value.

Students during the arts intensive pondering the milled and salvage oak used for siding on the trailer. Even the glass for the windows was salvaged from the preserve.

3. Ever since the preserve's inaugural visiting artist, Ann Carlson, performed her Picture Jasper Ridge tour (see http://vimeo.com/41388304), I have been convinced that there is much about the experience and value of discovery that scientists and artists can learn from each other. It is my hope that in the coming years there will be expanded opportunities for students, faculty and visiting scholars in the arts and humanities to experience Jasper Ridge and engage with the more traditional research and education community.

4. Raising funds to endow the unpaid faculty director position at Jasper Ridge is essential because the faculty director plays such a critical role in shaping programmatic vision and the policies needed to address the complex management challenges that will continue to face the preserve in a changing climate.

It is promising that we have already made progress on each of these fronts. In particular, I would like to highlight #3, as it probably represents my last significant programmatic and management contribution to the preserve. This academic year, artist David Szlasa directed a three-week arts intensive course to build a mobile art studio that will divide its time between Jasper Ridge and campus. We anticipate the studio will be available for Stanford students, faculty, and visiting artists to conduct work at the preserve in the spring and summer quarters, while in autumn and winter quarters the space will reside on campus as a studio and to showcase art created at the preserve. This project is supported by the Ratchye-Frank "Make Art Happen" Fund in Stanford Arts, and developed in collaboration with Stanford Arts Sarah Curran, director of programming and partnerships. Over time, I hope it will help to integrate arts and humanities into the life and mission of the preserve—while raising Jasper Ridge's profile among students and faculty who may not know of its existence and the opportunities the preserve provides.

As environmental challenges grow in scope and complexity, the contributions and role of biological field stations like Jasper Ridge become even more critical. So often I muse that one day, biological field stations will become irrelevant in a new society that views our natural surroundings and heritage as essential to a fulfilling life.

When I came to the preserve, my landscape proclivities were those of an entrenched desert rat. I loved the quiet, open expanses of the western desert and the individualistic presence of plants and animals. Sparseness, lack of people, and abundant space defined my internal sense of beauty. As I have grown to know Jasper Ridge, my world has become more densely populated with a unique community of people, microhabitats, and overlapping organisms.

Crawling through dense chaparral, getting lost in tangled, riparian wetlands, walking through rain-soaked woodlands, and marveling at serpentine colors in spring, my world, internally and externally, has been greatly enriched. I have come to learn more deeply how a "sense of place," particularly at a field station, encourages discovery and intimacy, and provides a unique, powerful, and beautiful means for understanding the world and connecting with other learners like Jasper Ridge's community of docents, researchers, staff, and students.

Jasper Ridge has been my most passionate endeavor, eclipsed only by my love for my wife and son. As my career draws to a close, I resort to poets to better capture my gratitude, sadness, and excitement.

References:

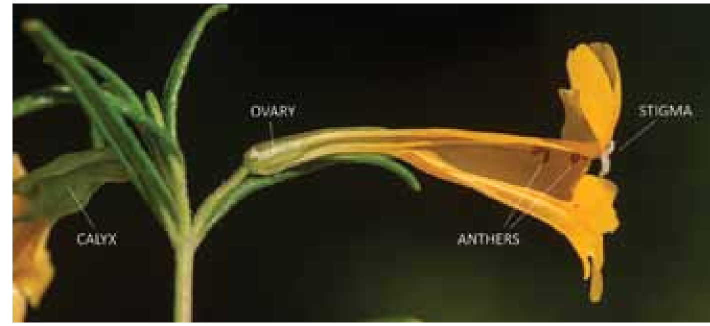
National Research Council, 2014. *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century, Committee on Value and Sustainability of Biological Field Stations and Marine Laboratories, and Nature Reserves in 21st Century Science, Education, and Public Outreach,* The National Academies Press.

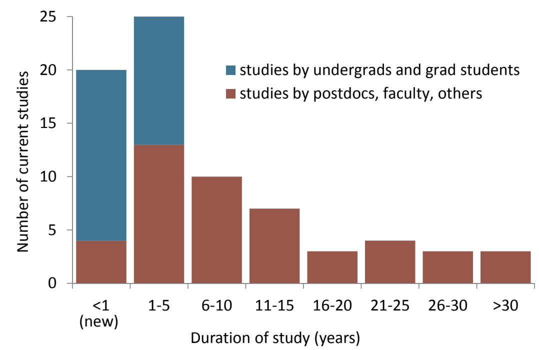
The lines from *Tape for the Turn of the Year*, from my favorite poet, A. R. Ammons, have always captured my feelings for why I have stayed on this career path:

Absorb the margins:
enlarge the range:
give life room:

And from a Mary Oliver poem, *The Messenger*, which I came across this past September (sitting in an outhouse at Rocky Mountain Biological Lab during an Organization of Biological Field Stations annual meeting) these words speak to my upcoming adventures:

Am I no longer young, and still not half-perfect?
Let me keep my mind on what matters, which is my work,
which is mostly standing still and learning to be astonished.
The phoebe, the delphinium. The sheep in the pasture, and the pasture.
Which is mostly rejoicing, since all ingredients are here,
which is gratitude, to be given a mind and a heart
and these body-clothes, a mouth with which to give shouts of joy to the moth
and the wren, to the sleepy dug-up clam, telling them all,
over and over, how it is that we live forever.





Top left: Mindy Perkins studying how bats respond to synthesized bat calls. Top center-right: Franciscan greenstone cores, with white veins of calcite, from an 80 ft borehole near Searsville Reservoir. Upper right: Sticky monkey flower with petals partly removed. Center: Anna's hummingbird hovering in Rivers Ingersoll's study of how hummingbirds support their weight within each wingbeat. Far right: Histogram showing abundance of new studies at JRBP. Bottom: Erin Mordecai and Erin Spear setting up a grassland study of fungal pathogens.

RESEARCH

By its nature, research expands our perception of a "sense of place" toward a sense of connection to other places. At Jasper Ridge, the connection has many threads, from landmark studies that influenced scientific inquiry around the world, to research on global processes such as biological invasions. In 2014–15, another unmistakable connecting thread was the continuing drought.

JRBP's high diversity of ecosystems has provided examples of conditions playing out across the state during this four-year drought, especially in wooded habitats. Several of this year's essays on research illustrate this connection. Greg Asner describes an undertaking by the Carnegie Airborne Observatory (CAO) to quantify drought across JRBP—and all of California's forested area—using techniques that visualize ecosystem stress in a completely new way. Two other essays report long-term studies spanning some of JRBP's wettest and driest years. In the first, Deborah Gordon reviews her lab's 22-year study of the globally invasive Argentine ant, including a comparison of the exceptionally wet 1997–98 El Niño versus the present drought. In the second, Walt Koenig ('72) presents a 26-year timeline of the acorn crop in relation to annual rainfall, a relationship that drives synchronous fluctuations in acorn production across the state.

Climate is also a theme in this year's student essays. Aaron Strong and Tera Johnson share their experience in the Jasper Ridge global change experiment and its influence on their career goals. Kara Yeung ('15) presents results from her honors thesis on the thermal environment of reptiles and amphibians, a study she hopes will be a baseline for future students and wetter years.

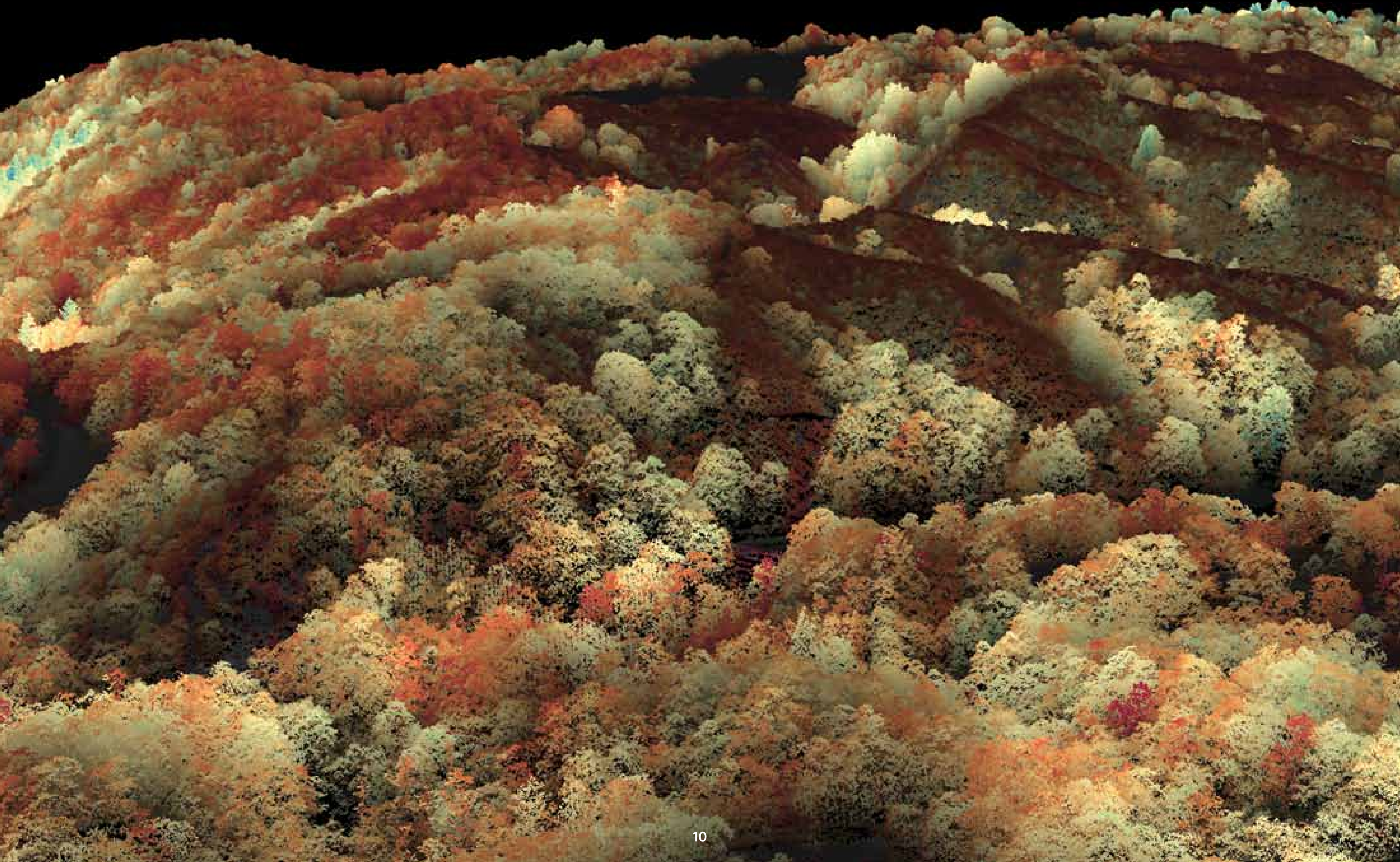
Our closing essay reports on the first ecological study at JRBP by one of our nearest neighbors, the SLAC National Accelerator Laboratory. Courtney Krest and Sam Webb report on using x-ray fluorescence imaging to map heavy metals and other chemical elements in the flower parts of *Mimulus aurantiacus* from plants growing on serpentine versus non-serpentine soils. Their study adds a new dimension to *Mimulus* flowers (pictured at left) as a model system for research and education.

Overall research activity in 2014–15 included 75 projects and 22 publications, consistent with JRBP's most active years. More than a quarter of active projects were new this year, including the studies pictured at left. One is by a new faculty member in biology, Erin Mordecai, who is interested in the effects of indigenous pathogenic fungi on grassland community composition. Her project includes a 0.4 acre site, mostly covered with weed barrier during 2014-15 in preparation for a multifactor experiment examining how competition among grass species varies with the abundance of specific fungal pathogens. The experiment involves an approach new to Jasper Ridge—application of an agricultural fungicide in order to create plots with reduced pathogen load. Those plots will be compared with ambient-pathogen plots and increased-pathogen plots (in which fungal strains from Jasper Ridge have been added).

The Mordecai experiment provides a context for thinking about what kinds of manipulations make sense for Jasper Ridge. JRBP strenuously avoids using biocides. Still, careful application of a biocide for the targeted removal or reduction of an organism may sometimes be the right decision, if it creates a scientifically important opportunity and can be thoroughly managed. With implementation of a spectrum of safeguards, this experiment meets both criteria. At Jasper Ridge, we are fortunate to have the capacity and flexibility to consider every management decision in the context of carefully developed principles and the specifics of each case.

In the bar graph at left showing the "age distribution" of studies, student research makes up the bulk of new projects. A mainstay of student research is a grant program that was established in 1986 by an endowment for this purpose from the A.W. Mellon Foundation to professor Harold Mooney. From the beginning, we used income from the endowment to award an average of two grants per year, while also growing the endowment so it could continue indefinitely. During 2014–15, three awards totaling $10,310 were awarded to undergraduates Ben Bravo and Brendan Palmieri, and to PhD student Grayson Badgley. In all, 59 grants with a combined total of over $150k have been awarded for student research at JRBP.

In 2014-15 JRBP was able to launch a similar grant program to support early phase research by faculty, thanks to an endowment from the David and Lucile Packard Foundation in honor of Donald Kennedy. Inaugural grants of $10k were awarded to Erin Mordecai for her grassland research, and to Greg Asner for CAO research. We expect that two grants will be awarded annually, providing a significant boost to new studies and offshoots of ongoing research. **—NONA CHIARIELLO, PhD '81**



JRBP SUPPORTS AIRBORNE FORESTS-IN-DROUGHT MONITORING OF CALIFORNIA

GREGORY P. ASNER, Carnegie Institution for Science

Recently, climate experts have reported on the severity of the drought in California. Indiana University scientist Scott Robeson summed it up in a 2015 study published in *Geophysical Research Letters*, "The 2012–2014 drought is nearly a 10,000 year event, while the 2012–2015 drought has an almost incalculable return period and is completely without precedent." Stanford Earth scientist Noah Diffenbaugh added that the drought has been exacerbated by global climate change, especially by increasing temperatures.

Despite a growing understanding that periodic mega-drought, along with long-term climate change, may be a new norm in California, we remain ill-equipped to track the effects of climate change on our ecosystems. Will communities of species undergo massive change or more subtle shifts across Californian landscapes? How will climate change interact with disturbance such as fire to alter the composition and functioning of ecosystems? Answers to these questions underpin a wide range of environmental conservation, management and policy decisions, if they can be addressed at the appropriate landscape to regional scales.

In May 2015, the CAO generated 3-dimensional images of the amount of water contained in the foliage of vegetation canopies throughout JRBP. The redder the tones, the lower the water content. This view is looking east across Jasper Ridge, and trail 8 is visible near the center of the landscape as a short dark line. Below trail 8 in the image is Searsville Dam, and above trail 8 is the ridge-top grassland, just below the horizon.

At the Carnegie Airborne Observatory (CAO), we are developing a landscape monitoring program that will aid in assessing how forest and other woodland ecosystems are responding to climate change in California, using approaches we have applied to tropical forests globally. The CAO measures the composition, 3-dimensional structure, physiology and chemical signatures of plants over very large ecosystem scales (http://cao.carnegiescience.edu). The CAO measurements provide a detailed, field-like understanding of individual plant-level properties, while resolving whole-ecosystem processes and feedbacks to disturbances like fire, such as levels of plant stress and mortality, which can be related to fuel load and flammability.

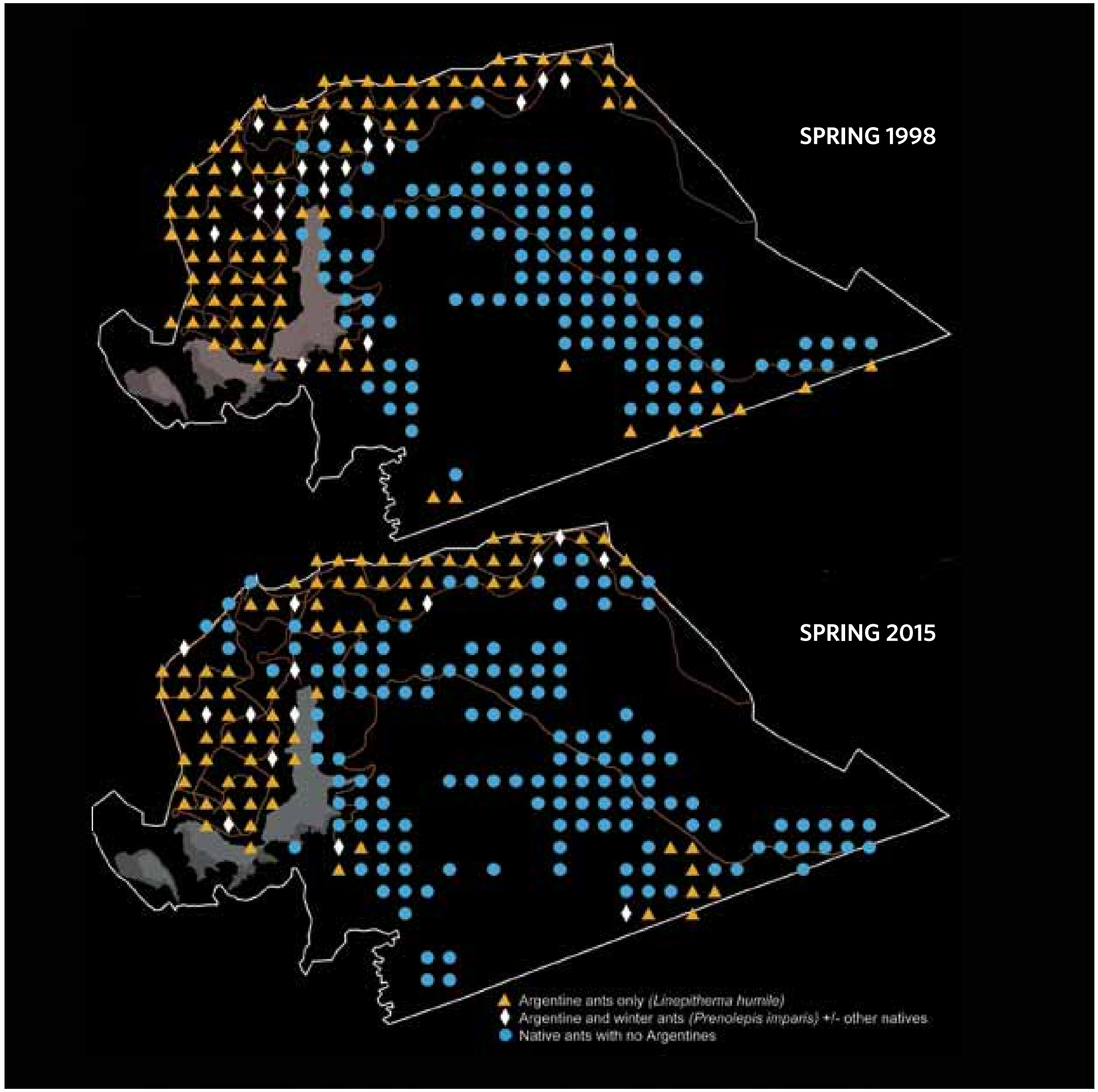
Inside a twin turboprop plane, the CAO houses two types of imaging spectrometers and a dual-laser, waveform light detection and ranging (wLIDAR) scanner. These three instruments are used in combination to map vegetation chemistry, biomass, structure, and stress.

Since 2007, CAO observations have revealed the structure, biomass and canopy chemical composition of woody plants throughout JRBP. With periodic remapping flights of the preserve, my team and I have developed techniques for inferring subtle patterns in the landscape from CAO data. In turn, this understanding has helped us to devise a California state-wide landscape monitoring program. In May 2015, the CAO surveyed JRBP as well as a wide variety of forested landscapes stretching along the Pacific coast, southern California, and the Sierra Nevada. With support, we plan to monitor and report on the effects of the 2012–2015 drought, the anticipated El Niño, and other climate perturbations on our ecosystems. Jasper Ridge continues to serve as a benchmark landscape in the effort to understand how climate change is altering California's ecosystems.

WHAT CAN STOP THE SPREAD OF ARGENTINE ANTS IN JRBP?

DEBORAH M. GORDON, Professor, Dept. of Biology

The invasive Argentine ant originally spread from Argentina around the world in boats carrying sugar, and they are now established wherever there is a Mediterranean climate with wet winters and dry summers. They began to spread up the California coastline about 100 years ago, but became much more abundant over the past 30 years as development has intensified. These are the ants that show up in our homes during wet winters, seeking a dry haven, and at the end of the long dry summer, seeking water. In one study tracking the ants in many households across the Bay Area, we found that not only do the ants come into buildings at the same time, in response to the weather—they also leave at the same time, when conditions improve outside. Another study showed that the Argentine ants are very effective at collective search for resources, which probably accounts for their success in competition with native species.



Since 1993 we have surveyed the ants in JRBP twice a year to measure the spread of the Argentine ant. In each survey, we identify the species of ants found in the vicinity of particular sites. The survey was begun by my first graduate student, Katy Human. It was soon clear that the ants were moving in to JRBP from the edges of the preserve where they thrive on the water available from inside buildings and from irrigated gardens. I thought that within a few years, the Argentine ants would sweep through JRBP, wiping out all the native ants along the way. I was wrong, as the figure at right shows, but Nate Sanders, the next student to take over the survey, showed that even when the Argentine ant does not eliminate native species, it disrupts ant communities by shifting around which species are present. Nicole Heller then continued the survey, and found that rainfall makes a difference: the Argentine ants spread less in dry years. This opened the question of how climate change will affect the spread of Argentine ants. Her work also showed that these ants live in distinct colonies, with many different nests connected by trails, that spread out to cover about 200 m^2 in the summer and contract back to a few large nests in the winter aggregations, and that food is not exchanged between neighboring colonies.

The Argentine ants are most abundant near one edge of JRBP (left). The native ants, especially the winter ants, seem to be pushing back the Argentine ants. Twenty three sites that had Argentine ants in 1998 (orange triangles and white diamonds) had only native ants in spring 2015 (blue circles), whereas only five sites made the opposite switch. 1998 was a wet El Niño year; 2015 was dry. The drought may have helped to contain the Argentine ants (below).

Another study by postdoctoral researcher Krista Ingram demonstrated that colonies are genetically distinct; ants of neighboring colonies do not mix.

The next student to work on the survey, Jessica Shors, was interested in the impact of Argentine ants on native plants and insects, and studied the effects of this species on the native ants that tend the larvae of a butterfly. She developed a simple but effective trap to get Argentine ants out of nursery plants before they are used in restoration projects, to avoid the accidental further spread of the ants into reserves. Then Katherine Fitzgerald began to investigate the role of an apparently innocuous native ant, the winter ant, that, like the Argentine ant, tends aphids to obtain their sugary excretions. An undergraduate class project led to the discovery that the winter ant has a chemical weapon that is deadly for Argentine ants, and the survey data show that the winter ant can hold its own once the Argentine ants are far enough from human development to lose access to the water we provide. Katherine Fitzgerald's models predict that native ants will persist in reserves large enough to contain a central area more than 500 m from human development.

Four years ago the survey became a citizen science project conducted by JRBP and volunteers. The survey that required weeks of work by one graduate student now gets done in one very enjoyable day. Everyone is welcome to join in the survey after a training session showing how to identify ants. The next question is what will happen if the drought ends—will the Argentine ants begin to spread again?

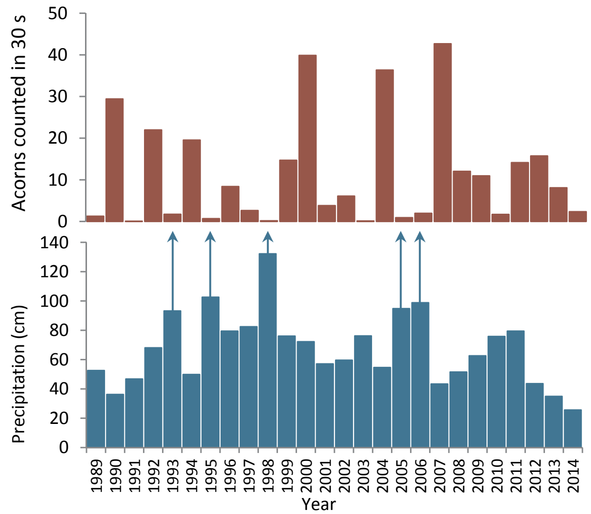
VARIABLE ACORN PRODUCTION BY CALIFORNIA OAKS

WALT KOENIG, '72, Senior Scientist, Cornell University

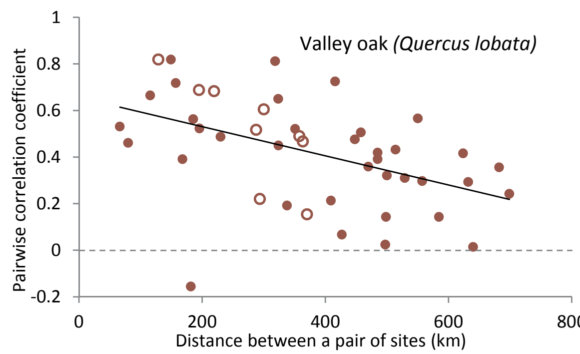
Every autumn, the acorn crop of Jasper Ridge's oaks is awaited by mice, squirrels, deer, and woodpeckers. Some years they are rewarded with a large crop and plenty of food, but in others they wait in vain. The effect of such variable and synchronized seed production—known as masting behavior—on wildlife is considerable. Among acorn woodpeckers, for example—a species I first encountered on the Stanford campus in the late 1960s and have now studied for over 40 years—birds sometimes breed in the fall when the acorn crop is large but abandon their territories when the crop fails.

The most obvious factor affecting the size of the acorn crop is the weather. For valley and blue oaks, two of the most common species at Jasper Ridge, the strongest correlate of acorn production is temperature in April the prior spring, which in turn correlates inversely with rainfall in California. Consequently, in wet years, the valley oak acorn crop tends to be poor. The last big El Niño year, for example, was 1997–1998, which was followed by a strikingly bad acorn crop in fall 1998. Presumably we can look forward to another poor acorn crop in fall 2016 if this winter turns out to be another El Niño year, as currently predicted.

One of the main goals of our work at Jasper Ridge is to understand the mechanism linking weather and acorn production. Acorn surveys we've conducted throughout California over the past 20 years have demonstrated that masting extends much, much farther geographically than previously suspected. Reproductive synchrony of valley and blue oaks, for example, extends across their entire range from



26-year timeline of precipitation and acorn crop at JRBP.



Similarity of acorn crop between all possible pairs of California sites as a function of distance between sites. A value of 1 would indicate that the two sites were in perfect synchrony across years. Open symbols are correlations in which one member is Jasper Ridge; closed symbols do not have Jasper Ridge as a member.

Acorn woodpecker (Melanerpes formicivorus) *on a granary tree just outside the Leslie Shao-ming Sun Field Station.*

Jasper Ridge near the Pacific coast to the Sierra foothills and from Redding in the north to Gorman in the south. What this means is that each fall tens to hundreds of millions of trees are simultaneously deciding to invest resources into acorn production, or not, depending on the year.

How trees accomplish this remarkable feat of spatial synchrony extending across an area the size of California is the main focus of our research at JRBP.

One can never have too many acorns, especially if you're an acorn woodpecker. Understanding why there are often far fewer acorns than the woodpeckers would like in some years promises to provide insight into population fluctuations among species of wildlife dependent on acorns as well as how and why such a striking population-level phenomenon has evolved.

THE CARBON CYCLE AND THE MENTORING CYCLE

AARON STRONG, PhD candidate, Emmett Interdisciplinary Program in Environment and Resources
TERA JOHNSON, BA, Skidmore College

At first, I was nervous about mentoring a student in Stanford's Summer Undergraduate Research in Geoscience and Engineering (SURGE) program. I had many commitments and wasn't sure about taking on another.

But I was excited. I was piloting a new field method in the global change experiment, and eager to help my mentee, Tera Johnson, design and conduct original research. We began by talking and reviewing the literature, and then Tera focused on questions to address. Some of her ideas were too complex, but one just clicked.

My research in spring had shown that adding nitrogen to the soil increases the efflux of carbon dioxide. This was an exciting result, but it was unclear why it occurred. Tera proposed a way to find out—an experiment in which we temporarily increased microbial activity by adding water. The next week I showed her how to use the equipment; she drafted a sampling protocol; and I guided her on the kinds of decisions that come up during field work. Tera's results were interesting—there was no effect of nitrogen on CO_2 efflux, suggesting that the mechanism behind my results was related to spring growing conditions, not the microbial community per se. The following December, Tera presented the results in a poster at the annual meeting of the American Geophysical Union, and I remember her commenting, "Wow, there aren't a lot of undergrads here."

Mentoring Tera taught me a tremendous amount and helped me see the value of my inter-disciplinary PhD program. I felt able to leverage my experiences to advise Tera not just on her project, but also on her stage of life: looking for options after college, trying to find her passion. Ten years ago, I was an undergraduate at a small liberal arts college, looking for a way to get research experience. It was amazing to repeat that process as a mentor. **—AARON STRONG**

Even in the driest of seasons, Jasper Ridge teems with life. Right underneath our feet you'll find soil exhaling carbon dioxide.

The amount of carbon dioxide that diffuses into the atmosphere depends on interacting variables like precipitation, warming, elevated nutrient and carbon dioxide levels. I was particularly interested in precipitation—what happens when dry, thirsty soil suddenly receives an intense, albeit short, pulse of water? Would we notice a difference in soil enhanced with nitrogen? I explored these questions through Stanford's SURGE program under the guidance of my

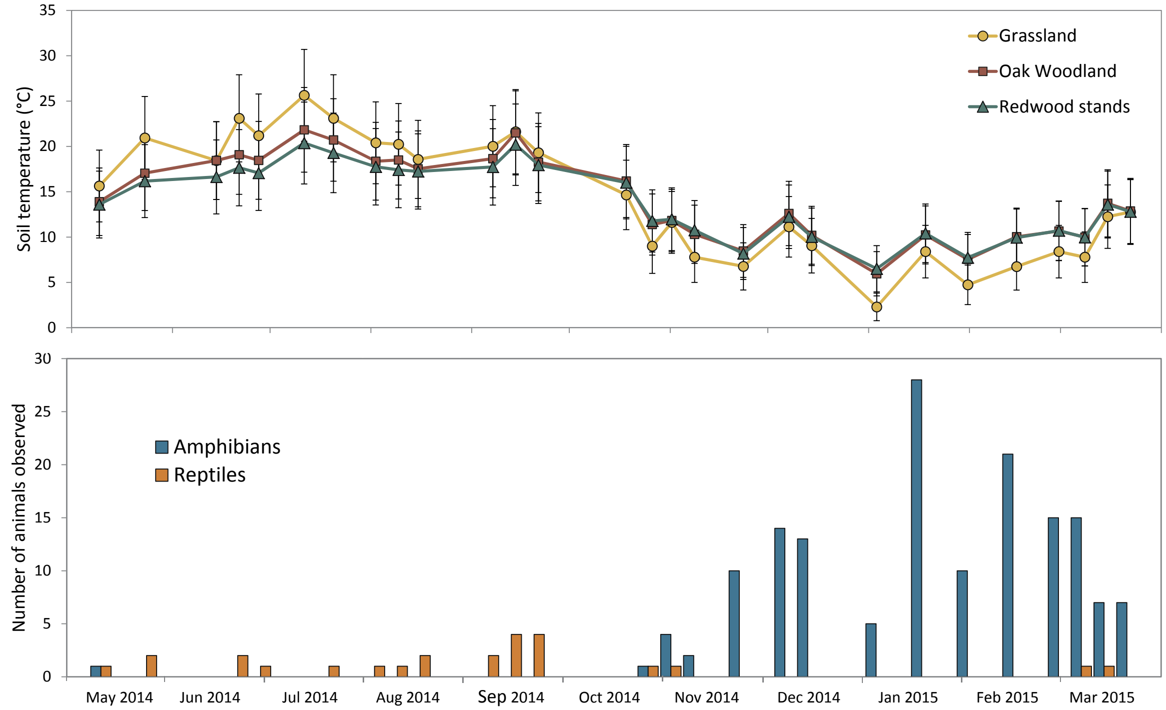
mentor, Aaron Strong, by creating a simulated rain event and comparing how much carbon dioxide was released from nitrogen-enriched and control soil.

Aaron's influence that summer was as evocative as the rain pulses. Just as increasing soil moisture immediately stimulated carbon dioxide activity, Aaron's guidance and encouraging words sparked my interest in global climate dynamics. However, unlike the soil plots, whose carbon dioxide activity calmed after a few days, my passion for seeking connections hasn't diminished. One of the many lessons Aaron taught me was no singular variable (human or otherwise) is responsible for the changes in our ecosystems, but rather one of many interacting components. My project itself was one part of Aaron's larger project, but more broadly, it was another contribution to our collective understanding of global climate change.

It's been two years since SURGE and I'm still sifting out these broader connections. I'm currently working at EcoAdapt, a non-profit providing support to make environmental planning less vulnerable and more climate savvy. Evidently, that spark Aaron set at Jasper Ridge is still going strong, with no signs of leveling off. **—TERA JOHNSON**

HERPETOFAUNA DIVERSITY ACROSS THREE ECOSYSTEMS

KARA YEUNG, '15, BS, Earth Systems



Reptiles and amphibians represent a remarkable evolutionary lineage in the animal kingdom. Their cold-blooded bodies require them to be both well adapted and sensitive to their local environments. Originally a BIO 105 project, my research on herpetofauna quickly evolved into an honors thesis for the Earth Systems program. It focused on three different communities near San Francisquito Creek: grasslands, redwood stands, and oak woodlands.

My study examined the relationships among abiotic factors such as air and soil temperature, soil moisture, and the presence or absence of herpetofauna to assess correlations between abiotic factors and the occurrence of these animals over the course of repeated surveys from May 2014 to March 2015. I wanted to confirm what species can be found at Jasper Ridge, but also to contribute new survey sites that can provide a baseline for longer-term studies on reptiles and amphibians.

Over the course of the study, I was able to observe three amphibian species: *Batrachoseps attenuatus* (slender salamander), *Ensatina eschscholtzii* (yellow-eyed ensatina), and *Taricha torosa* (California newt) and four reptile species: *Elgaria multicarinata* (California alligator lizard), *Eumeces skiltonianus* (western blue-tailed skink), *Pituophis catenifer* (gopher snake), and *Sceloporus occidentalis* (western fence lizard). The three species I observed most often were *B. attenuatus, S. occidentalis,* and *E. eschscholtzii.*

A young yellow-eyed ensatina.

During the warmer summer months, my surveys mainly encountered reptiles. They were last seen at the end of the summer months and did not reappear until the end of the winter months. By contrast, amphibian species began to dominate in the autumn months and continued to do so through the winter months. The drop in reptile sightings and increase in amphibian sightings seem to be aligned with the drop in temperature associated with each herp type's temperature range.

My study provides insight into the dynamic shifts in herpetofauna biodiversity within specific communities across a year. In the future, tagging individual organisms will provide a better method to assess the population of each species and to shed further light on the effect of the drought on moisture-dependent species.

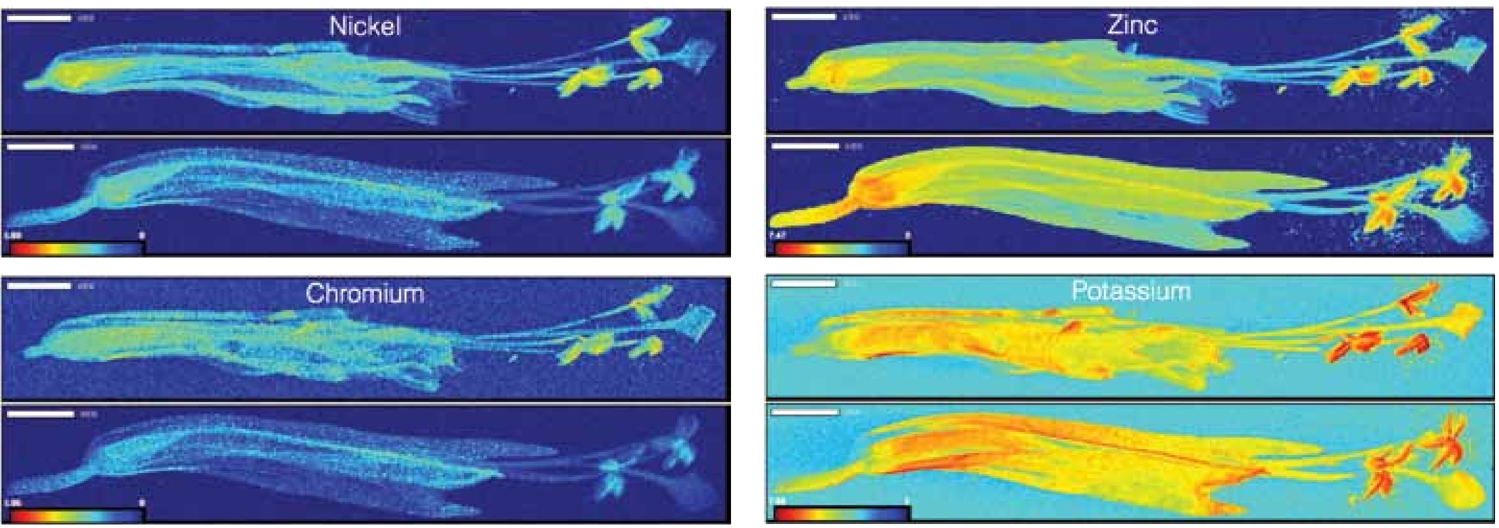
X-RAY FLUORESCENCE IMAGING OF PLANTS ORIGINATING ON AND OFF SERPENTINE

COURTNEY M. KREST and SAM WEBB, Stanford Synchrotron Radiation Lightsource

Soils originating from serpentine areas like those at Jasper Ridge are characterized by high concentrations of metals from ultramafic rocks, particularly nickel and chromium, low concentrations of macronutrients, and a low ratio of calcium (Ca) to magnesium (Mg). Despite being difficult growth conditions for some plants, species both native and invasive to California have adapted to serpentine soil, while others have not. Studying how these plants take up metals and nutrients, and what they do with them, can lend insights into why some species can thrive, or not, in serpentine. This research could also provide clues to bioremediation and plant growth in contaminated or nutrient-deficient areas.

Adjacent to JRBP is SLAC National Accelerator Laboratory including the Stanford Synchrotron Radiation Lightsource (SSRL). SSRL is uniquely capable of investigating how plants take up metals and other nutrients, and has the convenience of being just down the street from JRBP. At SSRL electrons go nearly the speed of light in a circle, forming X-rays as they turn. These X-rays can be used to probe what elements are in a sample as well as more specific information about that element, such as geometric and electronic structures, to give us insights about the chemistry and biological activity in the sample.

We recently started preliminary experiments with samples collected from JRBP. Flowers of sticky monkey flower (*Mimulus aurantiacus*) were collected from areas on and off serpentine. The petals were removed so other flower parts could be examined. The samples were placed in Mylar envelopes to preserve moisture and thus chemistry during measurement, and were mounted on a sample holder. The sample was rastered in the beam and the concentration of the elements present in the plant was measured. An image map of each element of interest was formed to represent the concentration of that element.



Maps for nickel, chromium, zinc, and potassium in Mimulus *flowers. In the pair of images for each element, the top image is the sample from serpentine and the bottom is the sample from non-serpentine. The color gradient is a log scale to better visualize both the high and low concentration areas. For nickel and chromium (left images), the serpentine sample shows a higher concentration than the non-serpentine, especially in the ovary and anthers, consistent with serpentine soils being enriched in these ultramafic metals. Zinc and elements that act as nutrients (right images), such as potassium and sulfur, display similar concentrations in both soil conditions. Flower parts are identified in the* Mimulus *photo on page 8.*

These preliminary studies show the feasibility of using synchrotron radiation to study samples from on and off serpentine areas at JRBP. In the future we will expand to larger sample sizes as well as looking at the effect of the Ca:Mg ratio on and off serpentine. We will also follow up with some controlled experiments in the lab that can more carefully vary ultramafic metal concentrations, Ca:Mg ratios, and other nutrient ratios.

EDUCATION




The 2014–15 academic year was a busy one for the Jasper Ridge education program and included classes from Stanford as well as other colleges and universities, local high schools and middle schools, teacher workshops, citizen science, public tours, continuing education events and more. All of this added up to a tremendous amount of teaching and learning in our exceptional 1,200 acre classroom!

This was all made possible by our tireless docent community, our Stanford students (freshmen to graduate students), our K-12 partners from Eastside Field Studies and the Redwood Environmental Academy of Leadership (REAL) as well as faculty, staff, and researchers. The synergistic effect of these collaborations is extensive and leads to inspiring ripples—REAL students take their JR knowledge to teach creek ecology to 6th graders at Kennedy Middle School, Stanford JRBP/SEEDS students leading the public in the annual BioBlitz and docents leading continuing education field trips to Fitzgerald Marine Reserve.

Annika Alexander-Ozinskas, Steve Barg, Jack Owicki, and Jan Talbert have kindly shared with us how a few of our programs contribute to doing, learning, and teaching ecology and environmental science both at Stanford and the greater community.
—CINDY WILBER

Far left:Bio/Esys 105 students wearing Tyvek suits walking to their field site to learn how to measure forest diversity
Top of page: Students in Bio/Esys 105 carefully observing and recording terrestrial invertebrates
Stanford students learning how to survey San Francisquito Creek with Stanford Campus Biologist, Alan Launer
Eastside College Prep 6th grader taking data in the oak ecosystem group
At left: Often spring wildflowers require close observation!

ANNIKA ALEXANDER-OZINSKAS, '13, '15
BS/MS, Earth Systems, MS, Earth System Science

The classroom at Jasper Ridge buzzes with the sound of 21 animated 6th graders at lunch. I ask "Does anyone want to share something exciting that they learned or experienced today?" Twenty-one hands shoot up in response. There are gasps of "Oo me!" One small student even stands on top of his chair to wave his arm higher.

Annika Alexander-Ozinskas sorting aquatic invertebrates with 6th grade students from Eastside College Preparatory School

This enthusiastic classroom display is only possible because of what the Eastside Field Studies students have been learning outside all spring. Every Wednesday they search for tracks of animals, argue over who will collect temperature data, and talk about new buds or new signs of herbivory on "their" plants, which they refer to by their Latin names. They learn with fervor. They are empowered by their research, by the fact that their questions often excite and stump their instructors, by the freedom to follow their curiosity, and by the immediacy of subjects that they can see, touch and hear. I once asked a group of girls what they looked forward to the most at school. They thought about it, then all answered, "This." "Coming here." "Jasper Ridge."

That's something we have in common. I look forward to every day that I can teach and learn at the Ridge. What I share most proudly with my housemates isn't my own graduate research, it's what the Eastside students are writing in their blogs: things they're learning, followed by, "I want to be a scientist."

The 2012 docent class had the same empowering effect on me that this program has on Eastside students. My individual research project as a "creek monkey" allowed me to indulge in both my curiosity and my love of being in nature by walking a 3.5 km stretch of San Francisquito Creek over several weeks. My partner and I marveled in awe at juvenile steelhead, annelids on a crayfish claw, piles of otoliths beneath boulders, and the shadows of water on tree trunks, all while contributing to a long-term study of creek biodiversity. We were also welcomed into a passionate and supportive community, where conversations are as inexhaustible as observations and questions. Students learn from students, experts from experts, and students and experts from one another.

This is the kind of learning community that I believe in—that I want to create and be a part of throughout my life. If I'd kept a blog about my past four years at Jasper Ridge, I would have written about the things I was learning, followed by, "I want to be a nature educator."

STEVE BARG, PhD candidate, Structural Engineering

I came to Stanford in 2013 after a fairly impulsive decision to return to school for my PhD after working as a structural engineer for the previous 12 years. One of the best decisions I made when I got here was to enroll in at least one class every quarter outside of the engineering program. So that means I'm always on the hunt for interesting courses, which eventually led me to the Jasper Ridge docent course. It's been a real treasure. I've always loved being outdoors and I started my undergraduate education with an Associate's degree in forestry, so this course has brought me back to that love of nature and away from my computer and desk.

The highlight of the course has been the wonderful classroom environment at the ridge. Bio105 brings together a great group of diverse students and educators. At the class, we always did something new, and always got a chance to hit the trails to see something real. I'm going to miss that from my weekly schedule.

For our class project, Laura Cussen and I examined the growth of the redwood trees in the preserve. The project allowed me to relive one of my first jobs as timber cruiser and spend time in my favorite spot on the ridge, within the largest cluster of redwoods along the San Francisquito Creek.

Our study involved taking cores from several trees within three different clusters of redwoods. Two were established clusters of second growth trees downstream from the dam, and one was the new cluster of redwoods growing in the sediment deposits along the Corte Madera that used to be open water.

The growth rate for many of the trees correlated very well with the annual flow for the creek, with each following the same undulating pattern. But what we feared we would see isn't present, and that's noticeably stunted growth in the last couple years of the current drought. This may be a good sign for the future of the redwoods at Jasper, or it may just be too soon for the effects to be seen. On the encouraging side, a recent study found that redwoods generally are doing well in the era of drought and higher temperatures, possibly due to the increased CO_2. But there may be a tipping point where conditions become too much for the redwoods, especially on this drier side of the Santa Cruz Mountains.

In my career as a research biophysicist, I've practiced science the way it is usually explained to students: Frame a hypothesis, attempt to disprove it experimentally, and interpret the experimental results as strengthening or weakening the hypothesis. As I approach retirement from my formal career, though, I find myself increasingly attracted to another style of science. That style is less hypothesis-driven and more like a voyage of discovery.

A green leaf beetle (Trirhabda flavolimbata) *feeds on coyote brush* (Baccharis pilularis). *These are among Jasper Ridge's most beautiful insects. Their dark metallic iridescent larvae are equally striking.*

My metaphorical voyage is an examination of the arthropods that live around us, for the most part unnoticed. Some kinds of organisms—birds and mammals, for example—are essentially completely described in North America. Less charismatic animals have not been nearly as well studied, and a significant fraction of the extant species remains to be described.

For some years I've tried to support these efforts in a small way with conservation photography, especially macro photos of the arachnids of the San Francisco Peninsula. I continued that photography at Jasper Ridge when I became a docent in 2014, and as my Bio105 project I chose to analyze the biodiversity of arthropods in several samples of Jasper Ridge leaf litter.

The leaf-litter project was both rewarding and chastening. I was surprised to find that one sample of just over a square foot of leaf litter under a redwood tree contained representatives of eight of the 17 extant classes of arthropods (insects, arachnids, millipedes, centipedes, springtails, proturans, diplurans, and crustaceans). On the other hand, it's been very hard to narrow the identification of many of the organisms down to family, much less to genus and species. A specimen box at the Sun Research Station holds 160 little vials of ethanol, each containing the representatives of one type of arthropod awaiting identification. Most are only 1/32″ to 1/8″ long and require a microscope for examination. I make slow progress, realizing that I grossly underestimated the skill and effort required to classify these tiny animals.

Is it important that work like identifying arthropods be done? Yes, because the ecological importance of these key members of the food chain cannot be well understood without identifying them. Nor can the world's shrinking biodiversity be well assessed without knowing what organisms exist and which are disappearing. At a time when taxonomy and taxonomists are frequently marginalized as old fashioned, my experiences at Jasper Ridge have given me renewed appreciation for the skill that is required of taxonomists and the continuing importance of the field.

SUDDEN OAK DEATH

JAN TALBERT

Sudden Oak Death, or SOD, is an exotic introduced disease that has killed millions of native oaks and tanoak trees in California. The causal agent, *Phytophthora ramorum*, is a microscopic organism distributed by wind and water during periods of relatively warm, rainy weather in Northern California.

P. ramorum was apparently introduced into California's natural landscape about 20 years ago when infected ornamental plants, such as rhododendrons and camellias were planted in landscaping. Since that time many other plants, including many native species, have been shown to be susceptible to infection. Some of these species develop lesions on their trunks and can die as a result of infection, while others develop primarily foliar lesions and become carriers, not necessarily becoming lethally infected themselves but becoming sources of spores which when dispersed are able to spread the infection.

California coast live oak, black oak, canyon live oak and Shreve's oak (all *Quercus*) are known to develop trunk lesions when infected by *P. ramorum*, and many of these oaks, particularly coast live oak, have died of the infection in California and elsewhere. In California, foliar infections on California bay laurel leaves appear to be the major source of spreading of the infection. Tanoaks (*Lithocarpus*) are highly susceptible to infection and develop both trunk and foliar lesions; many tanoaks have died of the infection.

Beginning in 2008, samples of symptomatic leaves have been collected within Jasper Ridge Biological Preserve's oak woodland as a part of the annual SOD Blitz Survey Project conducted by the Forest Pathology and Mycology Lab at UC Berkeley. During spring months interested community members are invited to attend, complete a tutorial and disperse to collect infected tissue (bay laurel leaves) over the course of one weekend. Diagnostic leaves are collected from potentially infected bay laurel trees near oak trees, locations are recorded by GPS, samples are labeled and sent on to the UCB lab for testing for the presence of the pathogen. Symptomatic bay laurel leaves show discolorations where water collects on the leaf as brown, grey or black blotches often with a yellowish "halo" line towards the healthy portion of the leaf.

The Jasper Ridge samples have returned some positive results for the presence of *P. ramorum* on bay laurel leaves near susceptible *Quercus* oaks. When *P. ramorum* infests an oak it destroys the cambium under the bark and effectively girdles the tree to cause death. The pathogen can infect leaves and trunks of its host without the need for wounds, but it does require rainfall and temperatures between 60 and 80F. Oaks normally are infected only in years with abundant spring precipitation.

The only tree that tested positive in 2014 was negative in 2015, but a previously negative tree tested positive this year. Overall, the last few years of local testing seem to indicate a slowing in the rate of new infection, perhaps as a result of continuing dry conditions. Should the 2015–16 El Niño materialize, new infestations may be on the increase, particularly with warm spring rains.

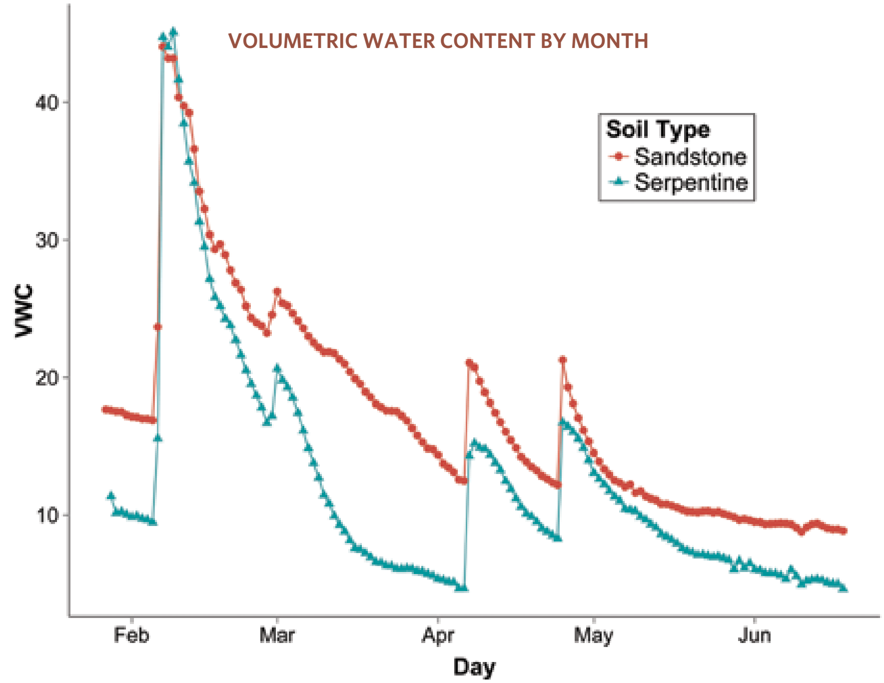
REMOTE SOIL MOISTURE SENSOR ARRAY

A NEED FOR SOIL MOISTURE DATA

Leptosiphon parviflorus (variable linanthus) is found on both serpentine and sandstone soils in the ridgetop grassland area of the preserve. On serpentine soils, Leptosiphon commonly has pink flowers. On sandstone soil, white-flowered plants are typical. This dichotomy presented an opportunity for Michigan State University Ph.D. candidate Emily Dittmar to study evolutionary mechanisms that create and maintain genetic diversity. Dittmar designed an experiment to understand whether adaptation to soil type was driving the observed variation in the two populations. As serpentine soils are known to have low water holding capacity, one important piece of the puzzle was determining to what extent differences in soil moisture contributed to each plant population's adaptation to the different soil types.

To answer this question, Dittmar needed continuous soil moisture observations over the course of the growing season. This was problematic since she could only periodically visit Jasper Ridge. Purchasing a typical remote instrumentation setup from a leading scientific instrument supplier was not feasible due to limited resources. Fortunately, I was able to design a low-cost remote soil moisture measurement system for Dittmar by leveraging Jasper Ridge's preserve-wide wireless mesh network, existing virtual machine hosting infrastructure at the Sun Field Station, and my own experience with implementing technology solutions in support of student and researcher projects at the preserve. We did an initial test deployment with four soil moisture sensors in spring 2014 and then doubled the number of sensors for the full 2014–2015 growing season.

Soil moisture probe



SOIL MOISTURE SENSOR ARRAY IMPLEMENTATION

For the 2014–2015 growing season, an array of eight soil moisture sensors were used. Two pairs of sensors were deployed near *Leptosiphon* study sites on sandstone soil and two pairs near experiment plots on serpentine soils. At each location, one of the sensor pair was located near a planted seedling plot and the other placed on undisturbed soil. The sensors use a USB (Universal Serial Bus) interface. The standardized connector type and low-power architecture of USB simplifies sensor installation and data collection as well as reducing costs associated with powering the devices in the field. Only two portable solar power stations were needed to run the entire array of eight sensors and associated wireless communication equipment — each powering four sensors at the two different soil type locations. Each soil moisture sensor was attached by cable to a USB-over-Internet Protocol hub which uploaded data to a datalogging computer via connection to the Jasper Ridge outdoor wireless mesh network. Raw soil moisture data was set to upload continuously at 5-second intervals over the entire growing season. A virtual machine on a server at the Sun Field Station was used for datalogging instead of a physical computer. This eliminates the need to purchase new computer hardware and also reduces electrical consumption.

HOW THE SOIL MOISTURE SENSORS WORK

A soil moisture sensor consists of a two-pronged probe inserted into the soil. The sensor measures the ability of the soil surrounding the buried probe to store an electrical charge. The degree to which a medium such as soil can store an electrical charge is known as capacitance. Capacitance-based soil moisture sensors determine the amount of soil moisture using a property known as the dielectric constant, which strongly correlates to soil water content. For example, the dielectric constant of dry soil ranges from 3 to 5 depending on type and texture whereas the dielectric constant of air is 1 and water is 80. An equation is then used to derive volumetric soil moisture content from the measured dielectric constant. The accuracy of the equation was improved by calibrating the sensors using sandstone and serpentine soil samples from the field prepared by Dittmar in the lab with known volumetric water content.

RESULTS

Dittmar's research is ongoing, but data so far indicate that soil moisture is an important selective agent in contributing to divergent adaptation of *Leptosiphon parviflorus* to sandstone and serpentine soils.

—TREVOR HEBERT

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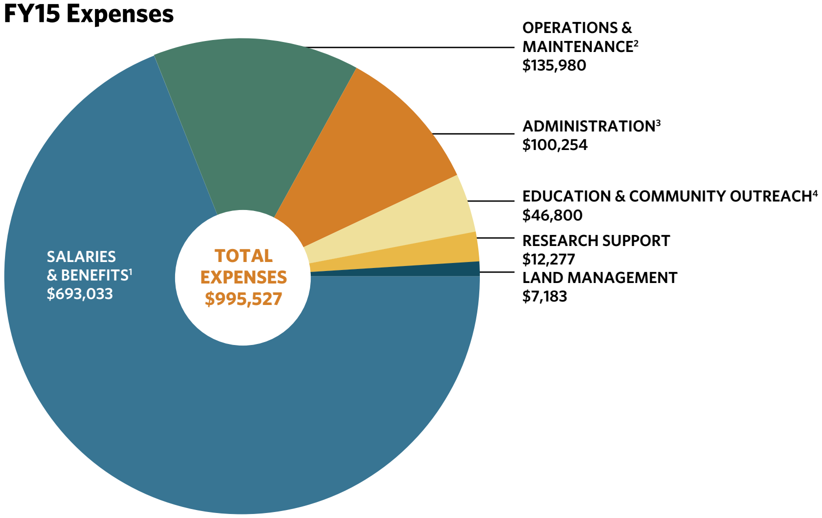
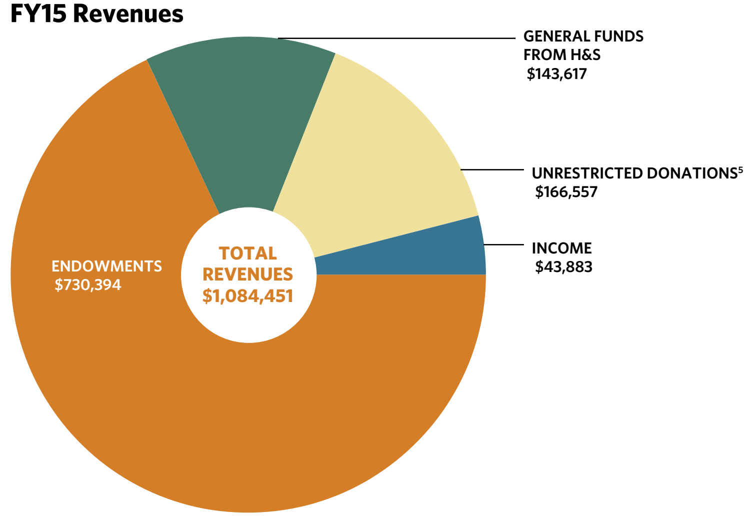
FINANCIAL SUMMARY

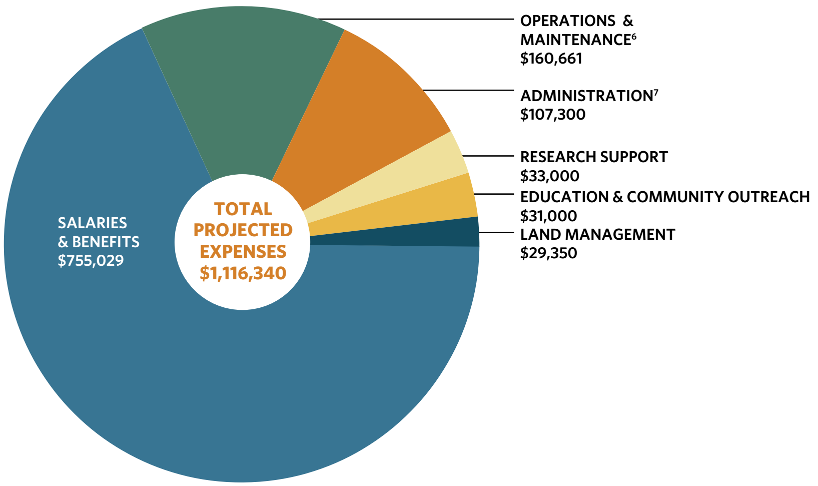
FY15 Expenses



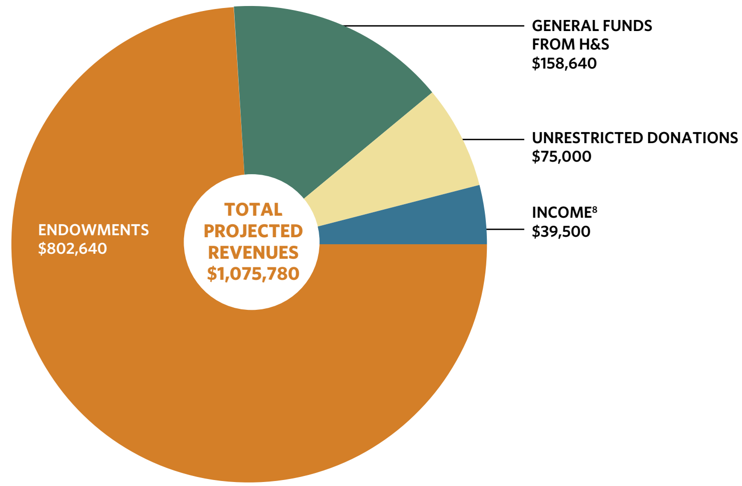
FY15 Revenues



FY16 Projected Expenses



FY16 Projected Revenues



**The projected shortfall between expenses and revenues ($40,560) to be covered by Jasper Ridge reserves. Shortfall a result of several one-time expenses: see notes 6 and 7.*

1) Some salary savings due to reliance on temp while searching for staff replacement.
2) Includes purchase of new 4-passenger electric utility vehicle.
3) Includes 50% of web redesign contract expenses.
4) Includes some material expenses to construct mobile art studio.
5) Includes $100,000 in additional donations to an existing endowment.
6) Includes purchase of a second 4-passenger electric utility vehicle and replacement of 3 ranger bikes.
7) Includes 50% of web redesign contract expenses.
8) Includes grant from Stanford Institute for the Arts for student constructed mobile art studio.

JASPER RIDGE ADVISORY COMMITTEE

A committee of Stanford faculty and graduate students that provides high-level guidance on strategy and policy.

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School of Education

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Comparative Medicine

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DAVID FREYBERG
Civil and Environmental Engineering

TADASHI FUKAMI
Biology

ERIN MORDECAI
Biology

KABIR PEAY
Biology

AARON STRONG
Graduate Student, IPER

PAULA WELANDER
Earth System Science

NONA CHIARIELLO
Ex-officio, Jasper Ridge

PHILIPPE COHEN
Ex-officio, Jasper Ridge

JASPER RIDGE COORDINATING COMMITTEE

The JRCC is composed of individuals from Stanford and non-Stanford organizations representing the broad range of groups the preserve interacts with. It provides advice and guidance to the executive director on significant management challenges facing the preserve.

JULIE ANDERSON
Midpeninsula Regional Open Space District

LEONIE BATKIN
Stanford Asset Management

ANGELA BERNHEISEL
California Department of Forestry and Fire Protection

RICK DEBENEDETTI
Woodside Trail Club

DENISE ENEA
Woodside Fire Protection District

JERRY HEARN
Acterra and Jasper Ridge docent

JEAN MCCOWN
Stanford University Government/ Community Relations

BETSY MORGENTHALER
Jasper Ridge docent

TRISH MU LVEY
Palo Alto Community Volunteer

ELLEN NATESAN
San Francisco Water Department

DIANE RENSHAW
Jasper Ridge docent

JEANNE SEDGWICK
Neighbor and Jasper Ridge docent

JOEL SILVERMAN
Midpeninsula Regional Open Space District

JESSICA SHORS
San Francisco Water Department

DAVID SMERNOFF
Acterra

MATTHEW TIEWS
Executive Director of Arts Programs H&S Dean's Office

SALLY TOMLINSON
Environmental Volunteers

SUSAN WITEBSKY
SLAC National Accelerator Laboratory

ERIC WRIGHT
Senior University Counsel

TOM ZIGTERMAN
Stanford University Water Resources & Civil Infrastructure

IN MEMORIAM

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APPENDICES

Summary of Research Activity;
Educational Use
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